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Characterization of cadets' psychophysical health in war conditions

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ABSTRACT

Aim: To investigate the investigate the impact of various types of motor activity training sessions on the mental and physical health of cadets during their wartime training.

Materials and Methods: The research, conducted during 2023-2024, involved 203 cadets from the 1st to 4th training years (male). There were five groups of cadets engaged in various sports and motor activities. Research methods included bibliosemantic, psycho-diagnostic, medical and biological, and mathematical statistics methods.

Results: In the groups of cadets who systematically practiced the chosen sport during training (groups 1-4), mental and physical health indicators at the end of the research were better than in the cadets who practiced according to the current method of motor activity (group 5). The levels of stress resilience, nervous and emotional tension, reactive anxiety, emotional state, body mass index, vital index, strength index, and Robinson's index were significantly ($p \leq 0.05$-0.001) better in groups 1-4 compared to group 5. Instead, no significant difference was found between the indicators of groups 1-4 ($p > 0.05$). The most important effect of different types of motor activity was found in the indicators of the emotional state, cardiovascular and respiratory systems of cadets.

Conclusions: This suggests that conscious training in any motor activity is effective in reducing stress, nervous tension, and anxiety, while restoring emotional balance and improving physical health indicators in cadets during wartime training.

KEY WORDS: physical health, mental health, motor activity, stress, cadets, war

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INTRODUCTION

The educational and service activities of cadets of higher educational institutions with specific learning environment (HEIs with SLE) during the war, accompanied by the negative impact of several stressors, led to the emergence of stress in cadets, which is reflected in the deterioration of their psychophysical health, the emergence of several diseases and the decline of the quality of their educational activities and the effectiveness of their performance of service tasks [1, 2]. Bressler R. A., et al. [3] note that psycho-emotional tension, which accumulates in the body under the influence of negative emotions and other stressors, leads to an increase in the level of cortisol and adrenaline hormones secreted by the adrenal glands. In small quantities, these hormones help the body cope with the adverse effects of stressful situations; however, their excess can lead to various diseases affecting different systems and bodily functions [4]. Stress manifests in multiple forms and causes a range of symptoms at both mental (emotional and intellectual) and physiological (behavioral) levels [5, 6]. The psychological symptoms of stress range from irritability, anxiety, anger, and hostility to feelings of fear, panic, disturbance, and insomnia. Psychological stress also leads to the manifestation of physical symptoms: headaches, neck and back pain, muscle strain, intestinal disorders, increased heart rate and breathing, and others. Scientists [7] note that the physiological reaction to stress can be so strong that it causes additional mental tension, closing the cause-and-effect circle.

Blumberg D. M., et al. [8] emphasize that the primary approach to counteracting stress is its prevention, which involves a preventive set of measures aimed at preventing the occurrence and spread of stress, eliminating its risk factors, mitigating its negative manifestations, and enhancing the body's stress resilience. The analysis of

the works of many scientists [9, 10] has shown that one of the simple, affordable, and, at the same time, effective means of preventing stress in cadets of HEIs with SLE, restoring their psycho-emotional state during training in war conditions, is motor activity and sports. Physical exercises are considered one of the non-drug methods of self-soothing, reducing cortisol (a stress hormone) and adrenaline in the body, while stimulating the production of endorphins, which are natural painkillers responsible for improving one's mood [11, 12]. At the same time, the issue of identifying the most effective types of motor activity to prevent stress in cadets and enhance their mental and physical well-being during wartime training remains insufficiently addressed.

AIM

The aim is to investigate the investigate the impact of various types of motor activity training sessions on the mental and physical health of cadets during their wartime training.

MATERIALS AND METHODS

PARTICIPANTS

The research involved 203 male cadets from the Lviv State University of Internal Affairs (LSUIA, Lviv, Ukraine), majoring in the specialty referred to as "Law Enforcement." To achieve the research aim, five groups of cadets from the 1st to the 4th training years depending on the type of motor activity during the hours of their sporting and mass participation events (SMPE) were formed: Group 1 (n=33) – cadets who were engaged in game-oriented sports (football, volleyball, basketball); group 2 (n=25) – cadets who attended strength-oriented sports clubs (arm wrestling, powerlifting, kettlebell lifting); group 3 (n=29) – cadets who attended martial arts (boxing, combat sambo, mixed martial arts); group 4 (n=27) – cadets who attended field-events (running at different distances, cross-country, functional all-around); group 5 (n=89) – cadets who did not participate in any of the NAIA sports clubs, and during SMPE hours were trained under the guidance of unit commanders according to existing options (accelerated movement, strength exercises on gymnastic apparatus). Group 5 consisted of equal numbers of cadets from each training year (1st-4th) with one study group per year in equal proportion. The number of hours spent on motor activity was the same in all groups. The research was conducted during the academic year 2023-2024: the beginning – September 2023, the end – June 2024.

Research methods include bibliosemantic, psycho-diagnostic, medical and biological, and mathematical statistics methods. Bibliosemantic method was used to conduct an analytical review of scientific sources on the outlined range of issues (20 sources from MedLine, Scopus, Web of Science, and Index Copernicus were analyzed). The mental health of cadets was assessed by the following indicators: stress resilience (according to the method of S. Cowan and G. Willianson), nervous and emotional tension (according to the method of T. Nemchyn), reactive anxiety (according to the scale of C. D. Spielberger, Yu. L. Khanin), emotional state (according to the method of A. Wessman, D. Ricks) [13]. The physical health of cadets was assessed using body mass index, vital, strength, and Robinson's indexes [14].

The test of self-assessment of stress resistance contains 10 questions, answering which the cadets had to choose one of the proposed answers. The answers for questions 1, 2, 3, 7, 9, and 10 were evaluated as follows: never – 0, rarely – 1, sometimes – 2, quite often – 3, frequently – 4; for questions 4, 5, 6, and 8 – never – 4, rarely – 3, sometimes – 2, quite often – 1, usually – 0. If the sum was 6.8 points or less, the level of stress resistance was considered excellent; 6.9-14.2 – good; 14.3-24.2 – satisfactory; 24.3-34.2 – poor; 34.3 and more – very poor. The method for assessing nervous and emotional stress includes 30 signs of this condition, divided into three degrees of severity (a – low degree (complete absence), b – average degree, and c – high degree). The data were processed by summing the points: for answers a – 1 point, b – 2 points, and c – 3 points. The nervous and emotional stress level was considered low if the cadets scored 30-50 points, average – 51-70 points, and high – 71-90 points. The reactive anxiety scale contains 20 statements with response options, depending on how the respondents felt during testing: no, it is not true; probably true; true; quite true. The points were calculated using the formula: $RA = \Sigma 1 - \Sigma 2 + 50$, where RA is reactive anxiety, Σ1 is the sum of the numbers on scale items 3, 4, 6, 7, 9, 12, 13, 14, 17, and 18; Σ2 is the sum of the numbers on scale items 1, 2, 5, 8, 10, 11, 15, 16, 19, and 20. The level of anxiety was assessed as low with 30 points or less, moderate with 31-45 points, and high with 46 points or more. The emotional state self-assessment method includes four sets of 10 statements each ("Calm – Anxiety," "Energy – Fatigue," "Elevation – Depression," "Self-confidence – Helplessness"), among which in each set, it was necessary to choose the one that reflected the respondent's emotional state at the time of testing. The formula determined the emotional state: $ES = (I1 + I2 + I3 + I4) / 4$, where ES is an integral indicator of the emotional state; I1, I2, I3, and I4 are individual indicators on the respective scales. The emotional state was assessed as very good at 8-10 points, good – 6-7 points, poor – 4-5 points, bad – 1-3 points.

Table 1. Dynamics of mental health indicators in cadets engaged in various types of motor activity (n = 203) during their training in war conditions, points

Groups of cadets	Research stages		Δ	t / p
	The beginning	The end		
Stress resistance				
Group 1 (n=33)	15.6±1.09	14.0±1.05*	+1.6	1.06/>0.05
Group 2 (n=25)	15.8±1.17	14.5±1.14*	+1.3	0.86/>0.05
Group 3 (n=29)	15.9±1.13	14.4±1.12*	+1.5	0.94/>0.05
Group 4 (n=27)	15.7±1.14	14.2±1.10*	+1.5	0.96/>0.05
Group 5 (n=89)	16.2±0.91	17.8±0.93	-1.6	1.25/>0.05
Nervous and emotional stress				
Group 1 (n=33)	51.7±1.74	48.3±1.69**	-3.4	1.41/>0.05
Group 2 (n=25)	52.5±2.05	49.8±2.02*	-2.7	0.94/>0.05
Group 3 (n=29)	52.2±1.98	48.9±1.95*	-3.3	1.19/>0.05
Group 4 (n=27)	51.9±2.04	48.7±2.01*	-3.2	1.12/>0.05
Group 5 (n=89)	52.8±0.88	55.1±0.93	+2.3	1.79/>0.05
Reactive anxiety				
Group 1 (n=33)	39.6±0.86	37.4±0.82***	-2.2	1.85/>0.05
Group 2 (n=25)	40.1±0.94	38.5±0.91**	-1.6	1.22/>0.05
Group 3 (n=29)	40.3±0.90	37.9±0.87***	-2.4	1.92/>0.05
Group 4 (n=27)	38.9±0.92	37.5±0.89***	-1.4	1.09/>0.05
Group 5 (n=89)	41.3±0.79	42.8±0.81	+1.5	1.33/>0.05
Emotional state				
Group 1 (n=33)	6.8±0.23	7.7±0.22***	+0.9	2.83/≤0.05
Group 2 (n=25)	6.2±0.25	7.0±0.23**	+0.8	2.35/≤0.05
Group 3 (n=29)	6.5±0.22	7.2±0.21***	+0.7	2.32/≤0.05
Group 4 (n=27)	6.4±0.24	7.2±0.23***	+0.8	2.71/≤0.05
Group 5 (n=89)	6.1±0.18	5.6±0.19	-0.5	1.91/>0.05

Legend: Δ – difference between the studied indicators; t – value of Student's t-test; p – level of statistical significance of differences; *, **, *** – statistically significant differences between the indicators of groups 1, 2, 3, 4, and group 5 at the levels of $p \leq 0.05$, $p \leq 0.01$, and $p \leq 0.001$
Source: compiled by the authors of this study

Body mass index (BMI) was determined by the ratio of body weight in kg to height in m^2, vital index (VI) was determined by the ratio of vital capacity of the lungs in ml to body weight in kg, strength index (SI) was determined in % by the ratio of dynamometry of the stronger hand in kg to body weight in kg, Robinson's index (RI) was determined in c. u. as the product of heart rate in beats/min and systolic blood pressure in ml Hg at rest.

STATISTICAL ANALYSIS

The methods of mathematical statistics were used to process the data obtained. The compliance of the sample data distribution with the Gauss' law was assessed using the Shapiro-Wilk W test. The reliability of the difference between the indicators was determined using the Student's t-test. The reliability of the difference was set at $p<0.05$. All statistical analyses were performed using SPSS software, version 10.0, adapted for medical and biological research.

ETHICS

The procedure for organizing the study and the topic of the article were previously agreed with the Committee on compliance with Academic Integrity and Ethics of the LSUIA. Also this study followed the regulations of the World Medical Association Declaration of Helsinki. Informed consent was received from all participants who took part in this study.

RESULTS

The results of the mental health indicator assessment for cadets from various groups are presented in Table 1.

The study on cadets' stress resilience levels reveals that during the research period, the cadets in groups 1-4 demonstrated improvements in stress resilience of 1.6, 1.3, 1.5, and 1.5 points, respectively. However, these changes were not statistically significant ($p > 0.05$). In group 5, in contrast to the other groups, the level of stress resilience deteriorated by 1.6 points, with no statistically significant difference ($p > 0.05$). At the end of the research, the cadets of groups 1-4 showed a statistically ($p \leq 0.05$) better level of stress resilience than the cadets of group 5, by 3.3-3.8 points, which indicates a positive effect of various types of motor activity during training to improve the level of cadets' stress resilience. This statement is confirmed by the absence of statistically significant differences ($p > 0.05$) between the indicators of cadets in groups 1-4. At the same time, it should be noted that at the end of the research only cadets of group 1 (sports games) have a good level of stress resilience, and the rest of the groups – satisfactory, which emphasizes the expediency of broader introduction of sports games into the forms of physical education of cadets to improve their psycho-emotional state, increase the level of stress resilience.

The study of the dynamics of indicators of nervous and emotional tension shows that during the research period, the level of nervous and emotional tension in the cadets who attended sports clubs, which had no statistical differences between the groups at the beginning of the research ($p > 0.05$), decreased by 2.7-3.4 points ($p > 0.05$). The level of nervous and emotional tension increased by 2.3 points ($p > 0.05$) in the cadets who practiced the current method for sporting and mass participation events. At the same time, the level of nervous and emotional tension in all groups was initially assessed as average at the beginning of the research. By the end of the research, groups 1-4 had shown a low level, which remained unchanged, and at an average level in group 5. It has also been stated that at the end of the research, in all groups of cadets who were involved in sports, the level of their nervous and emotional tension was statistically better compared to the group of cadets who did not additionally attend sports clubs training sessions by 5.3-6.8 points ($p \leq 0.05$-0.01). This suggests that any type of motor activity is effective in preventing stress, reducing nervous tension and anxiety, and restoring the emotional state of cadets in wartime conditions.

The study of the dynamics of reactive anxiety shows that during the research, the level of anxiety in the cadets engaged in various sports significantly decreased (by 1.4-2.4 points). Still, no statistically significant differences were found ($p > 0.05$). The level of reactive anxiety in the cadets who trained according to the current sporting and mass participation events methodology did not change statistically ($p > 0.05$). Still, it tended to deteriorate – the difference between the initial and final data of the research was 1.5 points. At the beginning of the research, there were no statistically significant differences among the groups ($p > 0.05$). At the end, in groups 1-4, the level of anxiety was statistically lower compared to group 5, by 4.3-5.4 points ($p \leq 0.01$-0.001), indicating a positive impact of training sessions in the chosen sport on reducing anxiety in cadets.

Evaluation of the emotional state of cadets reveals that this indicator exhibits the most pronounced positive dynamics during training in the chosen sport. Thus, the indicators of emotional state statistically improved among the cadets of groups 1-4 by 0.7-0.9 points ($p \leq 0.05$). In group 5, the indicators tend to deteriorate: the difference between the indicators at the beginning and the end of the research was 0.5 points, but it was not statistically significant ($p > 0.05$). It was found that at the end of the research, the cadets in groups 1-4 did not show statistically significant differences in the indicators of emotional state ($p > 0.05$), which confirms the effectiveness of any sport in improving the emotional state. However, compared to group 5, cadets in groups 1-4 showed statistically better indicators of emotional state by 1.4-2.1 points ($p \leq 0.001$). The best level of emotional state at the end of the research was recorded in the cadets who participated in sports games (7.7 points), which suggests that sports games can be an effective means of improving the emotional state of cadets and restoring mental energy during training in war conditions.

The study of physical health indicators in the cadets from different groups reveals that at the beginning of the academic year, there were no statistically significant differences among them in any of the studied indices. During the research period, the cadets who were additionally engaged in sports (groups 1-4) showed improvements in all indices. In contrast, group 5 showed a tendency to stabilize and, in some cases, deteriorate physical health indices (Table 2).

The BMI indices of the cadets who participated in sports games, martial arts, and all-around athletics improved by 0.19, 0.09, and 0.12 kg/m^2, respectively; however, no statistically significant differences were found ($p > 0.05$). The cadets who participated in strength sports and those who participated in the current methodology for sporting and mass participation events experienced a slight deterioration in their BMI, by 0.33 and 0.38 kg/m^2, respectively ($p > 0.05$). It was found that at the end of the research, the cadets in groups 1, 3, and 4 had a statistically better BMI than those in group 5 by 0.77-1.05 kg/m^2 ($p \leq 0.01$); no sta-

Table 2. Dynamics of physical health indicators in cadets engaged in various types of motor activity (n = 203) during their training in war conditions

Groups of cadets	Research stages		Δ	t / p
	The beginning	The end		
BMI, kg/m²				
Group 1 (n=33)	23.27±0.22	23.08±0.21**	+0.19	0.62/>0.05
Group 2 (n=25)	23.56±0.25	23.89±0.26	-0.33	0.91/>0.05
Group 3 (n=29)	23.31±0.21	23.22±0.21**	+0.09	0.30/>0.05
Group 4 (n=27)	23.06±0.24	22.94±0.23**	+0.12	0.56/>0.05
Group 5 (n=89)	23.61±0.14	23.99±0.15	-0.38	1.85/>0.05
VI, ml/kg				
Group 1 (n=33)	58.11±0.68	59.34±0.66***	+1.23	1.30/>0.05
Group 2 (n=25)	57.67±0.71	58.42±0.72*	+0.75	0.74/>0.05
Group 3 (n=29)	57.85±0.69	59.21±0.70**	+1.36	1.38/>0.05
Group 4 (n=27)	58.32±0.67	59.57±0.67***	+1.25	1.32/>0.05
Group 5 (n=89)	56.84±0.53	55.87±0.55	-0.97	1.27/>0.05
SI, %				
Group 1 (n=33)	63.78±0.58	63.93±0.59	+0.15	0.18/>0.05
Group 2 (n=25)	64.21±0.64	65.08±0.63*	+0.87	0.97/>0.05
Group 3 (n=29)	63.87±0.61	64.19±0.59	+0.32	0.38/>0.05
Group 4 (n=27)	63.72±0.63	63.86±0.64	+0.14	0.16/>0.05
Group 5 (n=89)	63.55±0.42	63.14±0.45	-0.41	0.67/>0.05
RI, c. u.				
Group 1 (n=33)	85.67±0.55	84.13±0.53***	+1.54	2.02/≤0.05
Group 2 (n=25)	86.12±0.59	85.47±0.58*	+0.65	0.79/>0.05
Group 3 (n=29)	85.78±0.57	84.65±0.55**	+1.13	1.43/>0.05
Group 4 (n=27)	85.31±0.56	83.69±0.54***	+1.62	2.08/≤0.05
Group 5 (n=89)	86.73±0.43	87.25±0.45	-0.52	0.94/>0.05

Legend: Δ – difference between the studied indicators; t – value of Student's t-test; p – level of statistical significance of differences; *, **, *** – statistically significant differences between the indicators of groups 1, 2, 3, 4, and group 5 at the levels of $p \leq 0.05$, $p \leq 0.01$, and $p \leq 0.001$

Source: compiled by the authors of this study

tistically significant differences were found between groups 3 and 5 ($p > 0.05$). The deterioration of the BMI in the cadets of group 5, as well as in group 3, is due to an increase in body weight; however, if in the cadets of group 3 this increase was due to an increase in muscle mass, in group 5, it was due to the rise in body fat mass. In groups 1, 3, and 4, the body weight of cadets undergoing intensive training aimed at developing endurance, speed, and agility tends to decrease during the training process.

The dynamics of the VI also tends to improve in the cadets of groups 1-4 due to the improvement of the functional capabilities of the respiratory system, as well as a decrease in body weight: the differences between the indicators at the beginning and the end of the research were 1.23, 0.75, 1.36 and 1.25 ml/kg, respectively, but were not statistically significant ($p > 0.05$). In group 5, in contrast to groups 1-4, there was a deterioration in the VI by 0.97 ml/kg. Statistically better indicators of the VI at the end of the research in groups 1-4, compared with group 5, were noted as 3.47 ($p \leq 0.001$), 2.55 ($p \leq 0.05$), 3.34 ($p \leq 0.01$), and 3.70 ($p \leq 0.001$) ml/kg, respectively. This confirms the more pronounced effectiveness of training in any consciously chosen sport to improve the respiratory system in cadets.

The SI indicators also tend to improve during the training process in the cadets of groups 1-4: the differences between the beginning and the end of the research were 0.15, 0.87, 0.32, and 0.14 %, respectively, but these differences were not statistically significant ($p > 0.05$). In group 5, there was a deterioration in the SI by 0.41 %, and the difference was also not statistically significant ($p > 0.05$). It was found that at the end of the research, the highest level of strength capabilities was observed in the cadets from group 2 who were engaged in strength sports (65.08 %). This value is better compared to groups 1-4 ($p > 0.05$) and group 5 ($p \leq 0.05$). In groups 1, 3, and 4, the SI indicators at the

end of the research were also better than in group 5; however, no statistically significant differences were recorded ($p > 0.05$).

The study of the dynamics of the RI shows an improvement in the functional capabilities of the cardiovascular system in the cadets who participated in sports club training sessions by 1.54, 0.65, 1.13, and 1.62 c.u., but statistically significant differences were found only in groups 1 and 4 ($p \leq 0.05$). The most pronounced changes and the best indicators of the RI at the end of the research were found in the cadets who participated in field events (group 4; 83.69 c.u.) and sports games (group 1; 84.13 c.u.). Among the cadets participating in motor activities during their sporting and mass participation events, according to the current methodology, the indicators of the RI tend to deteriorate (by 0.52 c.u.). Still, statistically significant differences between the indicators at the beginning and the end of the research in group 5 were not observed ($p > 0.05$). Comparing the indicators of the RI in groups 1-4 and group 5 at the end of the research, we found that in all groups where cadets were additionally engaged in sports, the indicators were statistically better than in group 5 by 3.12 ($p \leq 0.001$), 1.78 ($p \leq 0.05$), 2.60 ($p \leq 0.01$) and 3.56 ($p \leq 0.001$) c. u. This once again proves the effectiveness of physical exercises in wartime conditions in improving not only the mental but also the physical health of cadets.

DISCUSSION

Prevention of stressful conditions involves a systemic impact on the emotional, motivational, volitional, and behavioral components of cadets' personalities, aiming to mitigate the adverse effects of stressors and prevent the development of stressful conditions [15]. The works of scientists [16] reveal measures of primary, secondary, and tertiary stress prevention. In primary prevention, measures are taken to reduce the likelihood of external stressors. Primary prevention is a mass-based approach aimed at maintaining psychological stability and is implemented in work with individuals who are conditionally healthy [17]. The purpose of secondary prevention is to prevent the transition of a stressful state into a chronic condition, to change unconstructive behavior into constructive behavior, and to prevent stress-related disorders. In this case, various methods are employed, including training sessions and role-playing games, which facilitate effective coping with stressful situations [2, 18]. Tertiary stress prevention includes a system of measures aimed at reducing the risk of recurrence of stress disorders, post-traumatic stress disorders, and related behavioral disorders, activation of personal resources that contribute to adaptation to new environmental conditions, and the formation of adequate behavioral strategies [6].

According to scientists [19], a person's stress resilience is primarily based on their lifestyle. The basic principles of a healthy lifestyle, the observance of which contributes to the prevention of stress, according to experts [9], include good sleep, balanced nutrition, motor activity, positive emotions, communication with loved ones, etc.

In the context of the educational process in HEIs with SLE in wartime, the most effective means of preventing stress in cadets is motor activity [7]. During physical load, cadets abstract themselves from intellectual activity, unpleasant sensations, fear, excessive worry, anxiety, and entirely focus on the correctness of their physical exercises. Thanks to this switch, the nervous system remains relatively calm, which reduces the body's stress response [8].

Scientists emphasize the potential benefits of training and the health effects of physical activity on the human body; engaging in motor activity helps to alleviate stress and mitigate its impact. Statistically significant correlations have been found between the level of motor activity and the intensity of stress reactions in higher education students [20]. According to experts [11, 12], regular physical activity causes psychological relaxation. It helps overcome emotional overload, serving as a guarantee of psychophysical well-being and an essential factor in ensuring the successful assimilation of knowledge and the development of an adequate level of stress resilience among young people. Our research revealed positive dynamics in mental and physical health indicators among cadets who consciously practiced various sports during wartime training, compared to the group of cadets who practiced according to the traditional sporting and mass participation events methodology. Our results confirm the conclusions of many scientists about the effectiveness of conscious motor activity in improving the mental and physical health of young people during war.

CONCLUSIONS

The research shows that in groups where the cadets systematically practiced the chosen sport during training (groups 1-4), at the end of the research, better indicators of mental and physical health were found than in the cadets who practiced the current methodology for physical activity during sporting and mass participation events (group 5). Thus, the levels of stress resilience, nervous and emotional tension, reactive anxiety, emotional state, body mass index, vital index, strength index, and Robinson's index are significantly better in groups 1-4 compared to group 5. Instead, no significant difference

was found between the indicators of groups 1-4. At the same time, groups 1-4 showed a more pronounced improvement in all the studied indicators compared to group 5. This suggests that conscious training in any type of motor activity is effective in preventing stress, reducing nervous tension and anxiety, restoring emotional balance, and improving physical health indicators among cadets during their training under war conditions. The most significant effect of training in various types of motor activity was found in the indicators of the emotional state, cardiovascular, and respiratory systems of cadets.

PROSPECTS FOR FURTHER RESEARCH

It is planned to investigate the level of stress and the frequency of its symptoms manifestation in cadets who were engaged in various types of motor activity during their training in war conditions.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

The influence of physical activity training sessions in the natural environment on high schoolers' physical health

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ABSTRACT

Aim: To experimentally test the influence of orienteering training sessions on high schoolers' physical health.

Materials and Methods: The research involved 177 high schoolers aged 16-17 (grades 10-11), including 84 boys and 93 girls. The experimental (EG) and the control (CG) groups were formed, which included 89 persons (42 boys and 47 girls) and 88 persons (42 boys and 46 girls), respectively. The EG high schoolers were engaged in orienteering in the natural environment, while the CG high schoolers were involved in physical exercises in the gym during their physical education. Physical health was studied by the body mass, strength, vital, Robinson and Rufier indices.

Results: It was found that in the process of orienteering training sessions, both boys and girls of the EG showed significant ($p \leq 0.05$-0.001) improvement of their vital index, Robinson index, and Rufier index. The changes were not significant ($p > 0.05$) in the CG. Both groups had no statistically significant changes in body mass index and strength index. Also, the vital, Robinson, and Rufier index indicators were significantly ($p \leq 0.05$–0.01) better in the EG than in the CG at the end of the research, which proves the expediency of using orienteering training sessions in the physical education of senior high schoolers for their health improvement.

Conclusions: After orienteering training sessions, the EG high schoolers showed a significant improvement in physical health indicators, which confirms the enhanced health-improving effect of this type of motor activity in the natural environment.

KEY WORDS: high schoolers, physical health, motor activity, orienteering, natural environment

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INTRODUCTION

At the current stage of development of national school education in Ukraine, an important strategic task of reforming its content is preserving the physical and mental health of high schoolers, taking into account the needs of personality-oriented education and fostering high schoolers, and establishing the priorities of a healthy lifestyle [1, 2].

It is essential to state that a new quality of education and preserving the health of high schoolers can be achieved only if various means of physical education are used to ensure that high schoolers adhere to the principles of a healthy lifestyle. This requires a profound restructuring of the educational process at school, the search for new forms and methods of physical education for high schoolers, effective health-improving and developmental technologies that will contribute to the training of a fully developed and creative personality who is able and willing to defend their country [3, 4].

According to many scientists [5, 6], orienteering, which is carried out mainly in the natural environment, opens up vast opportunities for teachers and high schoolers, especially those of senior school age. Accessibility and efficiency of orienteering in organization and conducting physical culture classes with senior high schoolers allows solving problematic issues typical for modern school [7]. Orienteering is a modern sport in which competitors independently cover distances to control points on the terrain, using only a map and compass and applying many technical and tactical techniques while running on rough terrain. That is why the results in orienteering depend equally on the physical and mental abilities of the participant [8]. Orienteering training sessions help improve physical development,

functional state, and health, fostering volitional and moral qualities, improving mental cognitive processes, and intellectual working capacity of those engaged [9, 10]. At the same time, the issue of studying the health-improving effect of orienteering in physical education lessons is not sufficiently covered in modern educational and methodical literature. This explains the relevance of the research topic, which is associated with the need to solve a scientific problem of significant theoretical and practical importance for improving the high schoolers' physical education system.

AIM

The aim is to experimentally test the influence of orienteering training sessions on high schoolers' physical health.

MATERIALS AND METHODS

PARTICIPANTS

The research involved 177 high schoolers aged 16-17 (grades 10-11) from Lesia Ukrainka Gymnasium No. 117 (Kyiv, Ukraine), including 84 boys and 93 girls. The experimental (EG) and the control (CG) groups were formed from the total contingent of high schoolers, which included 89 (42 boys and 47 girls) and 88 high schoolers (42 boys and 46 girls), respectively. The EG high schoolers were engaged in orienteering in the natural environment. In contrast, the CG high schoolers were involved in physical exercises mainly in the gym according to the curriculum during their physical education. There was no special selection for the groups; two 10^{th} and two 11^{th} grades of the gymnasium were included in the EG and the CG. The mandatory criterion for involving high schoolers in the experiment was that they had no contraindications for physical exercise and were assigned to the main medical group for health reasons. Also, each EG and CG high schooler provided written consent to participate in the experiment. The number of hours spent on physical education for the EG and the CG high schoolers was the same. Extracurricular motor activity of the EG and the CG high schoolers was not considered. Classes in the EG were conducted by orienteering coaches, in the CG – by gymnasium physical education teachers.

Research methods include the analysis and generalization of literary sources, as well as medical and biological methods, and statistical methods. The analysis and generalization of literary sources were employed to substantiate the theoretical problem (24 sources from scientometric databases MedLine, Scopus, Web of Science were analyzed). The medical and biological methods allowed us to assess the physical health indicators of high schoolers.

The physical health of high schoolers was assessed by body mass index, which is the ratio of body weight to body length; strength index, which reflects the development of muscle strength relative to body weight; vital index, which allows to assess the reserve capacity of the respiratory system; Robinson index and Rufier index, which characterize the functional capacity of the cardiovascular system of the high schooler's body.

Body mass index (BMI) was determined by the formula: BMI = body weight (kg) / body length (m^2); strength index (SI): SI = hand dynamometry (kg) / body weight (kg); vital index (VI): VI = vital capacity of the lungs (ml) / body weight (kg); Robinson index (RI): RI = systolic blood pressure (mm Hg) x resting HR (bpm) / 100; Rufier index (RfI): RfI = (4 x (HR1 + HR2 + HR3) – 200) / 100, where HR1 is the resting HR for 15 s, HR2 and HR3 are the HRs of the first and last 15 s of the first minute of recovery after 30 squats for 45 s.

The study of high schoolers' physical health indicators was conducted at the beginning (September) and end (May) of the academic year 2024-2025.

STATISTICAL METHODS

At the beginning of the pedagogical experiment, the homogeneity of all indicators of the EG and the CG high schoolers was determined, i.e., the absence of a significant difference in the studied indicators ($p>0.05$), and it was found that the distributions of the EG and the CG are normal, which allowed us to assess the reliability of the results using Student's t-test. The reliability of the difference was set at $p \leq 0.05$. All statistical analyses were performed using SPSS software. The results were presented as $X \pm m$, where X is the arithmetic mean and m is the standard error of the arithmetic mean.

ETHICAL STANDARDS

The process of research implementation is built following the requirements of scientific ethics. The Academic Ethics Commission of the Ukrainian State Dragomanov University approved the research. The pedagogical experiment was open, and its participants were informed about the aim and tasks of the research, and they voluntarily participated in it.

RESULTS

At the beginning of the research, we conducted the comparative analysis of physical health indicators of

Table 1. Characteristics of physical health indicators of senior male high schoolers at the beginning of the experiment

Physical health indicators	16-year-old boys	Level following the age norm	17-year-old boys	Level following the age norm	Reliability of the difference, t; p
BMI, kg/m^2	20.3 ± 0.28	average	21.1 ± 0.31	average	1.92; > 0.05
SI, %	50.1 ± 0.74	below normal	51.9 ± 0.69	average	1.78; > 0.05
VI, ml/kg	48.4 ± 0.81	below normal	48.5 ± 0.76	below normal	0.09; > 0.05
RI, c. u.	84.5 ± 0.58	average	83.9 ± 0.62	average	0.71; > 0.05
RfI, c. u.	9.8 ± 0.11	average	9.7 ± 0.12	average	0.61; > 0.05

Legend: t – Student's t-test value, p – statistical significance indicator
Source: compiled by the authors of this study

Table 2. Characteristics of physical health indicators of senior female high schoolers at the beginning of the experiment

Physical health indicators	16-year-old girls	Level following the age norm	17-year-old girls	Level following the age norm	Reliability of the difference, t; p
BMI, kg/m^2	19.6 ± 0.25	average	20.1 ± 0.26	average	1.39; > 0.05
SI, %	44.6 ± 0.77	below normal	45.3 ± 0.79	below normal	0.63; > 0.05
VI, ml/kg	47.4 ± 0.73	below normal	48.0 ± 0.76	below normal	0.57; > 0.05
RI, c. u.	82.0 ± 0.64	average	81.9 ± 0.68	average	0.11; > 0.05
RfI, c. u.	8.9 ± 0.09	average	9.0 ± 0.10	average	0.74; > 0.05

Legend: t – Student's t-test value, p – statistical significance indicator
Source: compiled by the authors of this study

high schoolers in grades 10 and 11 (16 and 17 years old). We assessed the compliance of the studied indicators with age norms. The results are presented in Table 1 (boys) and Table 2 (girls).

It was found that the indicators of the vital and strength indices in boys aged 16 and the indicators of the vital index in boys aged 17 do not correspond to the age norm; they are below normal. Statistical evaluation of the differences between the studied groups of the boys aged 16 and 17 showed no significant difference between their physical health indicators ($p > 0.05$).

It was found that the vital and strength indicators in the girls aged 16 and 17 do not correspond to the age norm and are below normal. Statistical evaluation of the differences between the studied groups of the girls aged 16 and 17 showed no significant difference between their physical health indicators ($p > 0.05$). The results also indicate insufficient physical health among high schoolers and the need to find effective ways to maintain and strengthen it with modern and effective means of physical education.

During the academic year, in the EG, high school physical education classes used orienteering, which involved teaching boys and girls to navigate the terrain with a map and compass and to find the fastest possible control points in the natural environment. The organic combination of physical and mental activity in the school playground, park, urban forest, and forest has a positive effect not only on the physical but also on the emotional state of high schoolers.

Orienteering, unlike many other sports, has several significant advantages that can be successfully used in the school environment. The availability of different types of orienteering, accessibility of use in rural and urban areas open up vast opportunities for the development of physical (speed, agility, endurance, strength, flexibility as well as speed and strength qualities), mental (memory, attention, thinking) and emotional and volitional (initiative, confidence, balance, perseverance, determination and other) qualities. To improve the learning process and increase the class's motor density, the experimental classes' theoretical material was organically combined with the content of practical activities. In particular, the study and consolidation of knowledge about the conventional signs of sports maps was mixed with various relay races and outdoor activities.

Exercises and motor actions used in orienteering are pretty diverse. For example, the main ones are alternating running and jumping. However, orienteering is not just a cross-country run in a particular area (park, forest). The high schooler must perform technical actions related to reading a map and using a compass, marking at a control point (CP), etc. The time spent performing these actions determines the level of technical and tactical preparedness of high schoolers and significantly affects the final result when overcoming the distance. The following motor tasks were used in orienteering classes: exercises aimed at forming and improving the ability to read a map; exercises aimed

Table 3. Dynamics of physical health indicators of high schoolers in the conditions of the pedagogical experiment

Physical health indicators	Groups	Stages of the research		The difference	Reliability of the difference, t; p
		Beginning	End		
Boys (EG: n = 42; CG: n = 42)					
BMI, kg/m^2	CG	21.8±0.32	22.1±0.33	0.3	0.65; >0.05
	EG	21.7±0.29	21.8±0.28	0.1	0.25; >0.05
SI, %	CG	51.2±0.63	52.8±0.67	1.6	1.74; >0.05
	EG	51.0±0.71	52.7±0.69	1.7	7.72; >0.05
VI, ml/kg	CG	48.5±0.68	49.3±0.72	0.8	0.81; >0.05
	EG	48.4±0.70	52.9±0.74**	4.5	4.42; ≤0.001
RI, c. u.	CG	84.4±0.52	83.9±0.54	0.5	0.65; >0.05
	EG	84.5±0.59	81.6±0.63*	2.9	3.36; ≤0.01
RfI, c. u.	CG	9.8±0.10	9.6±0.11	0.2	1.35; >0.05
	EG	9.7±0.11	9.1±0.09**	0.6	4.22; ≤0.001
Girls (EG: n = 47, CG: n = 46)					
BMI, kg/m^2	CG	19.7±0.29	20.2±0.30	0.5	1.20; >0.05
	EG	19.8±0.27	20.0±0.29	0.2	0.50; >0.05
SI, %	CG	44.7±0.71	45.9±0.73	1.2	1.18; >0.05
	EG	44.5±0.75	45.4±0.76	0.9	0.84; >0.05
VI, ml/kg	CG	47.9±0.59	49.1±0.61	1.2	1.41; >0.05
	EG	47.8±0.57	51.5±0.58*	3.7	4.55; ≤0.001
RI, c. u.	CG	83.8±0.54	82.7±0.51	1.1	1.48; >0.05
	EG	84.0±0.52	81.5±0.49*	2.5	3.50; ≤0.01
RfI, c. u.	CG	9.1±0.11	9.0±0.11	0.1	0.64; >0.05
	EG	9.0±0.10	8.6±0.09*	0.4	2.97; ≤0.05

Legend: t – Student's t-test value, p – statistical significance indicator; *, ** – reliability of the difference between the EG and the CG at the end of the research at the level of $p \leq 0.05$, $p \leq 0.01$

Source: compiled by the authors of this study

at correct map orientation; exercises aimed at rational choice of objects (landmarks) that allow to find the CP without mistakes; exercises aimed at determining the distance between objects; types of distances and the sequence of their use in classes; exercises aimed at mastering the work with a compass; exercises aimed at choosing the right movement options; exercises aimed at forming the ability to select rational reference points (anchors); exercises aimed at developing memory; exercises aimed at developing attention; quests (adventure tasks); special running and jumping exercises; exercises for developing flexibility; exercises aimed at developing general and special endurance; exercises for developing agility; exercises for developing speed; exercises aimed at strengthening the muscle corset.

The CG high schoolers were engaged in other types of physical exercises in the gym. In particular, they used general developmental exercises, gymnastic exercises, and sports games.

To study the influence of orienteering classes on the physical health indicators of senior high schoolers, we evaluated the dynamics of the body mass, vital, strength, Robinson and Rufier indices (Table 3).

The obtained results show that at the end of the academic year there is a positive dynamics of physical health indicators of boys and girls of both groups, but statistically significant are changes in the indicators of vital index, Robinson index and Rufier index in high schoolers of both sexes only in the EG ($p \leq 0.05$-0.001). The body mass and strength indices in the EG have no significant difference between the initial and final data of the experiment ($p > 0.05$). There were no substantial changes in the CG, both boys and girls ($p > 0.05$). The comparative analysis of the EG and the CG indicators at the beginning of the experiment showed no significant difference between the studied indices. Still, at the end of the research significantly better indicators were found in the EG compared to the CG by the following indices: vital index – by 3.6 ml in boys ($p \leq 0.01$) and by 2.4 ml in girls ($p \leq 0.05$); Robinson index – by 2.3 c. u. in boys ($p \leq 0.05$) and by 1.2 c. u. in girls ($p \leq 0.05$); Rufier index – by 0.5 c. u. in boys ($p \leq 0.01$) and by 0.4 c. u. in

girls ($p \leq 0.05$). The obtained data confirm the expediency of using orienteering in the practice of physical education of senior high schoolers with the purpose of their health improvement.

DISCUSSION

Scientists [11, 12] note that realizing educational tasks in physical education lessons is impossible without solving health problems. Health-promoting tasks include applying health-improving and preventive measures during physical culture lessons, improving physical condition indicators, and developing high schoolers' motor skills. In orienteering classes, we paid special attention to improving the health and functional capabilities of the main body systems of high schoolers, due to the nature of motor activity, which includes mainly aerobic exercises in the natural environment. The organization of orienteering classes in the open air helps to harden the bodies of high schoolers and increase their immunity. Similar conclusions have been drawn in studies by other scientists [13].

Experts [1, 14, 15] argue that even though the healing forces of nature (hardening by air, sunlight, water) and hygienic factors (daily routine, rational nutrition, hygiene of places of study, personal hygiene, etc.) are auxiliary means of physical education, their role is no less critical in organizing motor activity of high schoolers than the use of physical exercises. Given that most orienteering classes in the EG took place in natural conditions, the impact of nature's healing powers on high schoolers' bodies has also increased.

The functional state of high schoolers' cardiovascular and respiratory systems is one of the most essential characteristics of physical health. They play an important role in the body's adaptation to motor activity and are one of the leading indicators of its viability [16]. Diagnostics of an organism's functional state during physical exercises are essential for assessing the degree of influence of motor loads on an organism and its correspondence to gender, age, and individual capabilities of high schoolers [17].

It should be noted that the specificity of functional diagnostics of practically healthy people involves assessing not so much the nature and degree of disorder of a particular system or organ but the current level of their functioning or functional reserve [18]. In our research, the following functional parameters of high schoolers were determined to characterize the state of the cardiovascular and respiratory systems by the Robinson, Rufier, and vital indices: resting heart rate, blood pressure (systolic and diastolic), and vital capacity of the lungs. As a result of assessing the functional state of the cardiovascular and respiratory systems of senior high schoolers before the experiment, we found that the average group values of these indices are at low (below normal) and average levels. This may indicate an insufficient level of general endurance development and the need to improve high schoolers' respiratory function. It should be taken into account that heart rate and blood pressure, even in practically healthy people, can change under different circumstances, including emotional ones caused by current living conditions during the war in Ukraine [19].

Orienteering combines orienteering skills, physical endurance, and the ability to make quick decisions. Through specialized motor activities of a predominantly aerobic nature, it contributes to improving the functional state of the cardiorespiratory system and strengthening one's health [7, 9].

Thus, our research is consistent with the results of other studies on the health effects of orienteering on the body of those involved [8, 10, 20] and is an effective means of combined development of high schoolers' motor skills and cognitive abilities [21]. Running on rough terrain with simultaneous orienteering using a map compares favorably with ordinary running in the absence of monotony, which, from a psychological point of view, is an essential factor that increases the working capacity of those engaged. The constant change of external conditions, positive emotions, and the possibility of alternating running attract young people to such activities [22].

The content of motor loads in orienteering classes is characterized by the influence on the functioning of the musculoskeletal system and muscles, which contributes to an increase in the content of endorphins in the blood, which causes positive emotions in a person, while increasing strength, mobility, and balance of nervous processes [23, 24]. Therefore, it can be argued that orienteering can affect not only the physical and mental health of high schoolers, which is essential during the war. Health-promoting orienteering and its applied nature determine their introduction into the physical education system of high schoolers.

CONCLUSIONS

1. Orienteering, unlike many other sports and motor activities, has several significant advantages that can be successfully used in the school environment. Orienteering is distinguished by its accessibility in rural and urban areas, the possibilities of combined development of motor skills and cognitive abilities of high schoolers, and the unique health-improving effect of combining physical exercises of a predom-

inantly aerobic nature and the healing powers of nature.

2. The effectiveness of the implementation of orienteering classes in school physical culture lessons was based on the assessment of the physical health indicators and the dynamics of senior high schoolers. At the end of the research, statistically significant increases of indicators of the vital index, Robinson and Rufier indices in the boys and girls of the EG were fixed ($p \leq 0.05$-0.001). The body mass index and strength index in the EG do not show a significant difference between the initial and final data of the experiment ($p > 0.05$). In the CG, both in boys and girls, there were no significant positive changes in the studied indicators ($p > 0.05$). The comparative analysis of the EG and the CG indicators at the end of the research showed significantly better indicators in the EG compared to the CG: vital index – by 3.6 ml in boys ($p \leq 0.01$) and by 2.4 ml in girls ($p \leq 0.05$); Robinson index – by 2.3 c. u. in boys ($p \leq 0.05$) and by 1.2 c. u. in girls ($p \leq 0.05$); Rufier index – by 0.5 c. u. in boys ($p \leq 0.01$) and by 0.4 c. u. in girls ($p \leq 0.05$). The obtained data confirm the expediency of using orienteering in the practice of physical education of high schoolers with the purpose of their health improvement.

PROSPECTS FOR FURTHER RESEARCH

Prospects for further research will be aimed at studying the impact of orienteering on improving the emotional state and increasing the stress resilience of high schoolers.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Mental cognitive processes and intellectual working capacity in cadets who were engaged in different types of physical activities

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ABSTRACT

Aim: To investigate the mental cognitive processes and intellectual working capacity of cadets who were engaged in different types of physical activities.

Materials and Methods: The research involved 346 male cadets aged 20-22 years who were engaged in different types of physical activities (orienteering, military pentathlon, polyathlon, hand-to-hand combat, kettlebell lifting, crossfit, arm-wrestling, powerlifting, sports games). Research methods: theoretical analysis and generalization of literary sources, psychodiagnostic testing, and methods of mathematical statistics. Psychodiagnostic testing involved the use of a set of techniques to assess the basic mental cognitive processes (attention, memory, thinking) and intellectual working capacity of cadets.

Results: The positive effect of different types of physical activities on the mental cognitive processes and intellectual working capacity in cadets was established. According to most of the studied parameters, the indicators of cadets engaged in orienteering were significantly ($p \leq 0.05$-0.001) better than those of the representatives of other sports. This is due to the specifics of the sport, which involves intense intellectual activity and requires a high level of development of such mental cognitive processes as attention, memory, and thinking, as well as intellectual working capacity.

Conclusions: The results obtained allow us to conclude that orienteering training can have a positive effect on both the indicators of cadets' academic and their future professional and combat activities.

KEY WORDS: mental cognitive processes, intellectual working capacity, cadets, physical activities, sport

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INTRODUCTION

The current conditions of warfare on the territory of Ukraine, and the level of improvement of combat materiel, military tactics, and martial arts require high-quality professional training of future military specialists [1, 2]. This trend involves the inclusion of modern military-applied sports in the content of physical training programs for cadets of HMEIs, which can ensure the formation of a high level of not only physical but also psychological readiness, as well as improve the dynamics of mental cognitive processes and intellectual working capacity [3, 4]. In modern conditions, orienteering is the most effective means of forming cadets' military-applied motor skills in combination with the development of their physical and psychological qualities, as well as improving intellectual working capacity that contributes to the formation of their psychophysical readiness to perform assigned tasks.

Orienteering is a modern military-applied sport in which competitors independently cover distances to control points on the terrain using only a map and compass while applying a large number of technical and tactical techniques as far as they run on rough terrain [5]. That is why the results in orienteering depend equally on the physical and intellectual abilities of those involved [6]. The results of scientific research [7] show that orienteering training helps to improve the functional state of the cardiorespiratory system, strengthen the body as a whole, increase the speed of action and thinking, and more effectively develop physical qualities, especially endurance. Unlike cross-country running, orienteering is not monotonous. From a

psychological point of view, it is an important factor in improving human working capacity [8]. Productive intellectual activity in orienteering requires the development and improvement of such mental cognitive processes as the perception of spatial and temporal processes, attention, short-term and long-term memory, and operational thinking [9, 10].

AIM

The aim is to investigate the mental cognitive processes and intellectual working capacity of cadets who were engaged in different types of physical activities.

MATERIALS AND METHODS

PARTICIPANTS

The research was conducted at the S. P. Koroliov Zhytomyr Military Institute (Ukraine). To solve the first task of the research, 479 cadets of different training years were involved in the survey. To solve the second task of the research, 346 cadets aged 20-22 years were involved, who were engaged in orienteering (n = 32) and other sports (n = 314) during their training: military pentathlon (n = 34), polyathlon (n = 36), hand-to-hand combat (n = 41), kettlebell lifting (n = 42), crossfit (n = 30), arm-wrestling (n = 37), powerlifting (n = 32) and sports games (football, volleyball, basketball, n = 62).

RESEARCH METHODS

To achieve the aim of the research, we used the following research methods: theoretical analysis and generalization of literary sources, psychodiagnostic testing, and methods of mathematical statistics. Theoretical analysis and generalization of literary sources and Internet data were used to clarify the current state of the problem under study and systematize and summarize information on the research topic. 25 sources from the databases Scopus, PubMed, Web of Sciences Core Collections and others were investigated.

Psychodiagnostic testing involved the use of a set of techniques to assess the basic mental cognitive processes (attention, memory, thinking) and intellectual working capacity of cadets: the method for studying the switching of attention referred to as the "A. H. Ivanov-Smolenskyi's Correction Task", the method for studying stability and concentration of attention referred to as the "Tangled Lines", the method for studying visual operative memory referred to as the "Operative Memory", the method for studying short-term memory capacity referred to as the "Jacobson's Method", the method for studying the peculiarities of thinking referred to as the "Identification of Essential Features", the method for studying intellectual working capacity referred to as "V. Ya. Anfimov's Correction Task".

The essence of the "A. H. Ivanov-Smolenskyi's Correction Task" was to work through a letter table in 8 minutes, in which the first 4 minutes were given to cross out the letter "A" and underline the letter "K", and the remaining 4 minutes were allocated to underline the letter "A" and cross out the letter "K". The evaluation was based on a nine-point scale, taking into account the total number of letters reviewed, the number of errors made, and the number of letters correctly marked. The "Tangled Lines" method involved the cadet working with a form containing 25 tangled lines and the task of tracking the course of each line using only visual control. The maximum number of traced lines was evaluated. The test took 7 minutes to complete. The "Operative Memory" method consisted of the experimenter reading out numbers (15 series of 5 numbers in each) and the cadets memorizing these 5 numbers in the order in which they were read out. Then they mentally added the first number to the second, the second to the third, the third to the fourth, the fourth to the fifth, and wrote the four sums in the appropriate line of the form. After that, the number of correctly found amounts was calculated (the maximum number was 60). The norm for an adult is 30 and above. The "Jacobson's Method" contains four similar series. In each of them, one of the given sets of digital series was read out to the cadets with an interval of 1 s. After reading each series, after 2-3 s, the subjects of interest reproduced the elements of the series on a sheet of paper in the sequence with which they were read by the experimenter. The results were processed to determine the series that were reproduced in full and in the sequence with which they were read out by the experimenter; the maximum length of the series that the cadet reproduced correctly in all sets; the number of correctly reproduced series. The indicator of short-term memory was assessed on a 10-point scale. The "Identification of Essential Features" method was used to study the peculiarities of cadets' thinking and was aimed at identifying essential and secondary features of objects and phenomena. The nature of the identified features can be used to judge the dominance of an abstract or concrete type of thinking. The cadets were given a text in which one word was out of parenthesis and the rest of the words were in-between parenthesis. All words in-between parenthesis were related to the word out of parenthesis. The task was to choose only two words that were most related to the word out of parenthesis. The cadets' thinking skills were assessed on a 9-point scale. The "V. Ya. Anfimov's Correction Task" involved cadets

working with a correction table for 5 minutes, where they had to cross out the letters D and V. To process the results, the total number of characters reviewed, the number of letters crossed out, the total number of letters to be crossed out in the reviewed text, and the number of mistakes made were calculated. Based on these indicators, the level of cadets' intellectual working capacity was determined.

PROCEDURE

The research was conducted in 2021-2025 in two stages: the first stage (2021) involved processing the literature on the research topic and summarizing the experience of military personnel in combat operations to clarify the role and importance of orienteering in ensuring the physical readiness of servicemen to perform assigned tasks in modern combat operations. The second stage (2022-2025) provided for a comparative analysis of indicators of mental cognitive processes and intellectual working capacity in the cadets (in the 5th training year) who were engaged in orienteering and the cadets who were engaged in other sports in the HMEI. The study of indicators of mental cognitive processes and intellectual working capacity in cadets was conducted with the involvement of specialists from the Institute's Psychological Department in compliance with all the requirements for psychological and sociological research.

STATISTICAL ANALYSIS

The mathematical and statistical methods were used to process the experimental data obtained. The compliance of the sample data distribution with the Gauss' law was assessed using the Shapiro-Wilk W test. The reliability of the difference between the indicators was determined using the Student's t-test. The results were presented as $M \pm m$, where M is the arithmetic mean, m is the error of the arithmetic mean. The reliability of the difference for all statistical tests was set at $p < 0.05$. All statistical analyses were performed using STATISTICA 6.1 software package (number AGAR909E415822FA), adapted for medical and biological research.

ETHICS

This research complies with the ethical standards of the Order of the Minister of Defense of Ukraine "On Approval of the Regulation on the Organization of Scientific and Technical Activity in the Armed Forces of Ukraine" No. 385 dated 27.07.2016. The procedure for organizing the study, the stages, the venue, and the permission for the involvement of cadets in the research were previously agreed with The Committee on Compliance with Academic Integrity and Ethics of the S. P. Koroliov Zhytomyr Military Institute (Protocol No. 12 dated 30.08.2019). Also this research followed the regulations of the World Medical Association Declaration of Helsinki and ethical principles for medical research involving human subjects. Informed consent was received from all cadets who took part in this research.

RESULTS

Systematic physical exercises have a positive effect on the mentality of those who exercise, improving brain function. A high level of physical fitness reduces fatigue and delays its onset, thereby increasing the body's resistance to specific adverse effects. Exercise can either stimulate intellectual working capacity or inhibit such processes, depending on the intensity of physical activity. Optimal physical activity activates perception and improves the efficiency of information processing and assimilation. Given the high level of mental stress that cadets receive in the face of increasing amounts of information in the process of training at HMEIs and further professional and combat activities, the requirements for the level of development of mental cognitive processes (attention, memory, and thinking), as well as the level of their intellectual working capacity, are increasing.

Attention plays a significant role in cognitive processes. Any intellectual activity is accompanied by a strain of human attention. Attention means the focus and concentration of mental activity on a particular object. Attention is one of the most important mental functions that ensures optimal training and education of cadets. The success of cadets' academic activities depends on the development of attention, and knowledge of the structure of attention makes it possible to control it. Analyzing the results of the study of attention switching in cadets, significant differences in the studied indicators of cadets engaged in orienteering compared to cadets of other sports specializations were found. The results of the "A. H. Ivanov-Smolenskyi's Correction Task" showed that the cadets who were engaged in orienteering training had significantly better indicators than the representatives of strength sports: kettlebell lifting, crossfit, arm-wrestling and powerlifting by 2.03 ($p \leq 0.001$), 1.19 ($p \leq 0.01$), 0.82 ($p \leq 0.05$) and 2.06 ($p \leq 0.001$) points respectively (Table 1). Compared to the cadets who were engaged in military sports all-around (pentathlon, polyathlon), the indicators of attention switching were also better in orienteers, but no significant difference was found between them ($p > 0.05$). It was also found that the cadets who were engaged in hand-to-hand combat and game sports had better attention indi-

Table 1. Comparative analysis of indicators of switching and stability and concentration of attention in the cadets who were engaged in orienteering and other sports (M±m)

Kind of sports	n	Switching of attention, points	t	Stability and concentration of attention, c. u.	t
Orienteering	32	7.15±0.22	-	18.31±0.63	-
Military pentathlon	34	6.93±0.25	0.6606	16.21±0.50	2.6110
Polyathlon	36	6.82±0.24	1.0136	15.28±0.52	3.7092
Hand-to-hand combat	41	7.18±0.20	0.1009	19.63±0.62	1.4934
Kettlebell lifting	42	5.12±0.29	5.5768	16.87±0.51	1.7766
Crossfit	30	5.96±0.31	3.1305	15.35±0.66	3.2441
Arm-wrestling	37	6.33±0.23	2.5764	19.51±0.68	1.2945
Powerlifting	32	5.09±0.32	5.3048	16.79±0.73	1.5763
Game sports	62	7.29±0.18	0.4925	18.54±0.59	0.2665

Note: n - number of cadets; M - the arithmetic mean; m - the error of the arithmetic mean; t - the reliability of the difference between the cadets' indicators determined using the Student's t-test
Source: compiled by the authors of this study

Table 2. Comparative analysis of indicators of visual operative memory and short-term memory capacity in the cadets who were engaged in orienteering and other sports (M ± m)

Kind of sports	n	Visual operative memory, points	t	Short-term memory capacity, points	t
Orienteering	32	51.81±1.21	-	8.26±0.29	-
Military pentathlon	34	48.27±1.25	2.0348	7.06±0.23	3.2421
Polyathlon	36	46.29±1.13	3.3341	6.92±0.20	3.8038
Hand-to-hand combat	41	48.91±1.15	1.7516	7.96±0.17	0.8924
Kettlebell lifting	42	47.83±1.22	2.3163	6.82±0.18	4.2189
Crossfit	30	42.05±1.29	5.5183	5.97±0.31	5.3946
Arm-wrestling	37	38.67±1.20	7.7106	5.69±0.21	7.1778
Powerlifting	32	39.04±1.27	7.2799	5.22±0.26	7.8051
Game sports	62	53.12±1.18	0.7751	8.17±0.16	0.2717

Note: n - number of cadets; M - the arithmetic mean; m - the error of the arithmetic mean; t - the reliability of the difference between the cadets' indicators determined using the Student's t-test
Source: compiled by the authors of this study

cators compared to orienteers by 0.3 and 0.11 points, respectively, but the difference between them was not significant ($p>0.05$). In general, the representatives of orienteering, hand-to-hand combat and game sports showed a high level of indicators of attention switching, while the rest had a satisfactory level.

Attention concentration is the ability to focus on one object or action while being distracted by other objects or actions for a certain period. It is thanks to a high level of concentration of attention that tasks requiring accuracy can be performed without errors. A high level of concentration is a professionally important quality for servicemen: the higher the level of concentration, the more successfully they can perform tasks that require accuracy and concentration. The analysis of indicators of attention concentration and span in cadets engaged in various sports showed that the indicators of cadets engaged in orienteering differ in a certain way from those shown by cadets who specialized in other sports due to the error-free performance of a task that required accuracy and concentration on the content of the task. Thus, the test results of orienteering cadets (18.31 c. u.) were significantly better compared to the cadets who were engaged in military pentathlon – by 2.10 c. u. ($p \leq 0.05$), polyathlon – by 3.03 c. u. ($p \leq 0.01$), crossfit – by 2.96 c. u. ($p \leq 0.05$) (Table 1). The results of cadets-orienteers turned out to be somewhat better in comparison with kettlebell lifters and powerlifters, but the difference between them was unreliable ($p > 0.05$). The best test results and, accordingly, the level of attention concentration and span (above average) were found in cadets who were engaged in hand-to-hand combat (19.63 c. u.), arm-wrestling (19.51 c. u.), game sports (18.54 c. u.) and orienteering (18.31 c. u.). The

Table 3. Comparative analysis of indicators of peculiarities of thinking and intellectual working capacity in the cadets who were engaged in orienteering and other sports (M ± m)

Kind of sports	n	Peculiarities of cadets' thinking, points	t	Intellectual working capacity, c. u.	t
Orienteering	32	18.61±0.56	-	961.17±10.53	-
Military pentathlon	34	16.83±0.52	2.3292	934.77±10.31	1.7914
Polyathlon	36	15.93±0.48	3.6336	918.77±9.81	2.9462
Hand-to-hand combat	41	15.28±0.35	5.0426	920.81±8.43	2.9921
Kettlebell lifting	42	16.07±0.37	3.7843	933.13±8.21	2.1000
Crossfit	30	14.73±0.63	4.6031	922.34±11.43	2.4985
Arm-wrestling	37	14.02±0.45	6.3892	909.46±10.98	3.3990
Powerlifting	32	14.21±0.57	5.5065	906.42±11.46	3.5179
Game sports	62	17.02±0.31	2.4841	942.34±7.65	1.4467

Note: n - number of cadets; M - the arithmetic mean; m - the error of the arithmetic mean; t - the reliability of the difference between the cadets' indicators determined using the Student's t-test

Source: compiled by the authors of this study

representatives of other sports had an average level of attention concentration and span.

Memory is a mental cognitive process that helps to organize and preserve experience; a process that reflects the functions of storage, memorization, and reproduction. The analysis of the cadets' visual operative memory indicators showed that the best values were found in cadets who were engaged in game sports (53.12 points), orienteering (51.81 points), and hand-to-hand combat (48.91 points). No significant difference was found between the memory indicators of cadets in these sports ($p > 0.05$). Significantly better indicators of visual operative memory were found in cadets-orienteers compared to the representatives of such sports as military pentathlon ($p \leq 0.05$), polyathlon ($p \leq 0.01$), kettlebell lifting ($p \leq 0.05$), crossfit ($p \leq 0.001$), arm-wrestling ($p \leq 0.001$) and powerlifting ($p \leq 0.001$) (Table 2). The development of memory is significantly influenced by academic activities and solving intellectual tasks during the training process. This was most clearly manifested in the representatives of game sports and orienteering. In general, the level of indicators of operative memory in cadets specializing in different sports was within the normal range.

Short-term memory is a type of memory that is characterized by very short-term storage and immediate reproduction (recovery) of perception. This memory stores what attention is directed to and is unchanged in terms of modality. This makes it possible to control the duration of the stored traces through repetition. The analysis of the cadets' short-term memory capacity showed the best results for the cadets who were involved in the orienteering training compared to the cadets who specialized in other sports (Table 2). Thus, the test results of the cadets who were involved in orienteering were significantly better than those of the cadets who were engaged in military pentathlon – by 1.20 points ($p \leq 0.01$), polyathlon – by 1.34 points ($p \leq 0.01$), kettlebell lifting – by 1.44 points ($p \leq 0.001$), crossfit – by 2.29 points ($p \leq 0.001$), arm-wrestling – by 2.57 points ($p \leq 0.001$) and powerlifting – by 3.04 points ($p \leq 0.001$). No significant difference was found between the indicators of the cadets who were engaged in orienteering, hand-to-hand combat, and game sports ($p > 0.05$). It should be noted that a high level of indicators of short-term memory was found in the representatives of such sports as orienteering, game sports, and hand-to-hand combat: an average level – in the representatives of military pentathlon, polyathlon, and kettlebell lifting; a low level – in the cadets who were engaged in crossfit, arm-wrestling, and powerlifting. The analysis of short-term memory capacity confirms our previous conclusions about the positive impact of orienteering training on improving the level of development of mental cognitive processes in cadets during their training.

Any intellectual activity is accompanied by such a mental cognitive process as thinking. Thinking is the basis for the successful acquisition of new knowledge, skills, and abilities by cadets during their training at a HMEI. That is why it is so important to develop the skills of imaginative and logical thinking in future military professionals. While studying the peculiarities of cadets' thinking, we found a similar trend to the previous indicators i. e. a high level of indicators among cadets who were engaged in orienteering. Thus, cadets-orienteers had the best indicators of thinking peculiarities among the representatives of all other sports (18.61 points), which corresponds to the abstract-logical style of thinking (Table 3). This value turned out to be

significantly ($p \leq 0.05$-0.001) better than among the representatives of all other studied sports, which eloquently testifies to the effectiveness of orienteering training. According to the interpretation of errors, the cadets who received low scores in the research adhered mainly to erroneous judgments, which indicates the dominance of the concrete-logical style of thinking over the abstract-logical one.

Intellectual work reflects the perception and processing of information by the brain. It is characterized by a significant increase in the function of certain sensory systems, concentration, memory and thinking. When new information is received, it is compared with previously learned and existing information and integrated. Integration of information enriches memory and helps build a program of action and decision-making. In the process of performing intellectual work, attention and memorization increase. The analysis of cadets' intellectual working capacity showed that cadets-orienteers had significantly better indicators ($p \leq .05$-$.001$) compared to the representatives of most sports, except for military pentathlon and game sports (Table 3). The level of development of intellectual working capacity in cadets representing all sports was assessed as good. The obtained results indicate that orienteering training had a positive impact on the level of development of mental cognitive processes and intellectual working capacity of cadets in the process of their training in the HMEI.

DISCUSSION

Scientists [11] note that orienteering is a sport in which participants act completely independently, out of sight of rivals, spectators, judges, and even coaches. Therefore, in this sport, in addition to physical, functional, technical, and tactical training, thorough psychological preparation, perseverance, courage, and determination are required to achieve the goals. Scientists [8] argue that during orienteering training, the scope of attention increases, and the attention is switched, the problems of inability to control one's emotions and mood are solved, as the success of athletes of any level in orienteering competitions often depends on this.

Scientists [12] argue that under the influence of orienteering training, concentration, and attention switches, as well as visual memory, are significantly developed. Orienteering is characterized by the most organic combination of motor and intellectual qualities and has an extraordinary impact on relieving nervous stress from the human body, as well as a means of improving health for people of all ages [13, 14]. According to scientists [15], such moral and volitional qualities in orienteering as perseverance in achieving goals, courage, discipline, and independence acquire their specific manifestations. Scientists [8, 9,16] assures that in the process of orienteering training such qualities as determination, ability to control oneself, thinking effectively in conditions of high physical and mental stress, and ability to self-organization. Orienteering is often characterized by the fact that to fulfill a given plan of action, great willpower is required to find the optimal solution (solving a problem that arises unexpectedly), which is associated with the occurrence of stressful situations. The effects of stress can occur when athletes are in unfamiliar territory, away from other people, without access to advice or support. Formation and strengthening of moral qualities, readiness to provide necessary assistance to teammates or, under certain conditions, to rivals, as well as respect for the environment, and the desire to learn about and protect nature, contribute to the harmonious development of the individual. Military personnel also face similar conditions in their professional and combat activities, which determines the relevance of the chosen area of research. The above conditions contribute to the rapid processing of a large amount of specific information, which is associated with the development of the ability of servicemen to maintain intellectual working capacity under the influence of various negative factors of activity [17]. It is worth noting that orienteering requires activation of the mind, a series of actions that provide the ability to move around the area with the help of a map and compass, to implement the planned path on the terrain, while developing operative thinking, to predict the course of future events, to choose the right algorithm for solving difficult situations [18, 19]. Scientists [2, 4, 20] connects the development of the orienteer's mental functions with the operation of images in a specific space, with the suddenness of decision-making in emerging situations. Therefore, the issue of introducing orienteering into the physical training of cadets of HMEIs as a means of developing their motor skills and forming military-applied skills to increase the effectiveness of their future professional and combat activities is timely and relevant. This conclusion is confirmed by the practice of training military personnel of the armies of the leading NATO countries, where terrain orientation skills are one of the most important military-applied skills of military personnel of all specialties, both soldiers and officers [21, 22]. The authors [2] of are convinced that the ability to navigate the terrain is mandatory for all military personnel, without exception, which directly affects the level of combat capability of the army. The results of our research complement and extend the findings of other scientists [5, 7, 11, 12, 23-25].

CONCLUSIONS

The positive effect of different types of physical activities on the mental cognitive processes and intellectual working capacity in cadets was established. According to most of the studied parameters, the indicators of cadets engaged in orienteering were significantly ($p \leq .05$-$.001$) better than those of the representatives of other sports. This is due to the specifics of the sport, which involves intense intellectual activity and requires a high level of development of such mental cognitive processes as attention, memory, and thinking, as well as intellectual working capacity.

The development and improvement of these processes in cadets during orienteering training will help to ensure the effectiveness of their academic and future professional and combat activities, and the formation of skills of quick decision-making against the background of great physical and mental stress. This determines the expediency of introducing orienteering to physical training in HMEIs not only to develop motor skills and form military-applied skills in cadets but also to ensure the effective course of their mental cognitive processes in the process of their future professional and combat activities.

PROSPECTS FOR FURTHER RESEARCH

The prospect of further research is to develop a methodology for the development of motor skills and cognitive abilities in cadets through orienteering during training at a HMEI under martial law.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Motor activity regimen and daily energy expenditure of cadets and employees in practical units

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ABSTRACT

Aim: To conduct a comparative analysis of the motor activity regimen and daily energy expenditure of cadets and employees in police investigative units.

Materials and Methods: The research involved cadets of the 1st-4th training years (n = 86) and employees of police investigative units (n = 64). To establish the levels of motor activity and daily energy expenditure of cadets and employees in police investigative units, the Framingham method was used based on the registration of activities during the day.

Results: A significant difference in cadets' motor activity index and daily energy expenditure during their educational activities and police investigators during their service activities ($p < 0.001$) was found. It was found that during the day, the cadets consumed 2658.8 ± 39.6 kcal in the process of their educational activities with their motor activity index at 34.43 ± 0.32 points. The employees showed 2412.4 ± 35.1 kcal of daily energy expenditure with their motor activity index at 31.18 ± 0.29 points.

Conclusions: The results obtained are due to the specifics of the educational activities of cadets and the peculiarities of the service activities of police investigators, which are determined by an extended stay in a forced position and a low level of physical activity. The results of the conducted research should be taken into account when organizing the physical training of police investigators in the course of their service activities.

KEY WORDS: motor activity regimen, daily energy expenditure, motor activity index, cadets, employees in police investigative units, physical training

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INTRODUCTION

Human health is the highest value and asset of the state. The primary goal of state institutions and organizations, particularly educational institutions, is to form a harmoniously developed personality that will value health, promote its development in the learning environment and preserve it during professional activities [1].

In modern conditions, the problem of health is becoming especially relevant, as the full-scale war in Ukraine, pandemics of recent years, unhealthy diet, low level of physical activity, bad habits, and increased nervous and mental stress lead to its deterioration [2]. Scientific studies show that physical health is determined by 10 % by the availability and quality of medical care; 20 % by the quality of the environment; 20 % by heredity; and 50 % by conditions and lifestyle [3]. The concept of a "healthy lifestyle" covers a variety of factors related to all areas of health. One of the key factors is an optimal motor regimen, which involves a certain amount of physical activity. The proper amount of physical activity contributes to the quality functioning of the body, prevents diseases of the cardiovascular system, supporting-motor apparatus, creates the necessary conditions for the manifestation of physical abilities and promotes faster mastery of various motor actions [4]. Any physical activity involves muscle activity, which stimulates the functional activity of almost all organs and tissues and causes positive changes in the body. A prolonged decrease in motor activity leads to persistent disorders that gradually become irreversible and cause various diseases, including hypertension, atherosclerosis, coronary heart disease, leg joint diseases, posture disorders with damage to the musculoskeletal system, metabolic processes, increased adipose tissue, etc. [5-7].

The problem of adequate physical activity is particularly acute for cadets of higher educational institutions

(HEIs) of the Ministry of Internal Affairs (MIA) of Ukraine and employees of specific practical police units, including investigative units. Thus, according to research by scientists [8], cadets spend 80 % of their time sitting, and as a result, some organs and systems lose their ability to function correctly. Scientists [9] distinguish between domestic (addiction to a sedentary lifestyle, reduced motor initiative, domestic comfort, dismissive attitude to physical fitness) and educational causes of hypokinesia (irrational organization of the educational process, overload of training sessions, ignoring physical education, lack of free time). In addition, prolonged stay in shelters during the announcement of the "Air Alert" signal leads to a critical decrease in physical activity [10].

In scientific works [11-13], negative factors in investigators' service activities that adversely affect their health are identified, namely: significant neuropsychological tension (39 %); irregular working hours (35 %); increased emotional stress (35 %); sedentary work in a forced position (25 %); and permanent contact with the criminal contingent (18 %).

Thus, the need to study and analyze the levels of physical activity of cadets and employees of police investigative units to develop and implement scientifically based forms of physical activity in the educational process and the police training system that would increase their level of physical fitness and health and promote awareness of the importance of its preservation actualizes the chosen area of scientific research.

AIM

The aim is to conduct a comparative analysis of the motor activity regimen and daily energy expenditure of cadets and employees in police investigative units.

MATERIALS AND METHODS

The research involved cadets of the National Academy of Internal Affairs (NAIA) of the 1st-4th training years who entered the Academy in 2021-2024 and specialize in Law (n = 86) being trained as specialists for pre-trial investigation bodies (future police investigators) and employees of police investigative units (n = 64) who took advanced training courses at the NAIA.

To achieve the research aim, a set of modern general scientific methods was used, namely theoretical, empirical, and mathematical statistics methods. Theoretical methods were used to systematize and summarize information on the research topic and compare existing theoretical approaches and strategies for determining physical activity and energy expenditure levels. 21 sources from MedLine, Scopus, Web of Science, and Index Copernicus were analyzed.

To establish the index of motor activity and daily energy expenditure of cadets and employees in police investigative units, the Framingham method was used based on the registration of activities during the day [14]. This method determined the duration of a specific type of activity and rest, the combination of physical activity of different intensity, the total duration of various types of activity, and the amount of energy expenditure. The numerical value is in the motor activity index (MAI) and daily energy expenditure (DEE) volume. According to this method, a person's motor activity is divided into five levels: basic; sedentary; small; average; high. Certain types of physical activity determine each level and, accordingly, have an energy value depending on the kcal expended, which makes it possible to calculate the daily energy expenditure of each person. To determine the amount of time spent on each type of motor activity, the daily timekeeping of activities lasting more than 5 minutes was performed. Various kinds of physical activity were recorded in a special form.

Methods of mathematical statistics were used to process the data correctly. The compliance of the sample data distribution with the Gauss' law was assessed using the Shapiro-Wilk W test. The reliability of the difference between the indicators was determined using the Student's t-test. The reliability of the difference was set at $p<0.05$. All statistical analyses were performed using SPSS software, version 10.0, adapted for medical and biological research.

The procedure for organizing the study and the topic of the article were previously agreed with the Committee on compliance with Academic Integrity and Ethics of the NAIA. Also this study followed the regulations of the World Medical Association Declaration of Helsinki. Informed consent was received from all participants who took part in this study.

RESULTS

The analysis of the obtained results gave grounds to state a significant difference ($p < 0.001$) in the MAI and daily energy expenditure of cadets and employees in police investigative units. In particular, cadets spent an average of 2658.8 ± 39.6 kcal per day during their educational activities. At the same time, the MAI was 34.43 ± 0.32 points. In the conditions of service activities, the daily energy expenditure of police investigators was recorded in the range of 2412.4 ± 35.1 kcal, and the MAI was 31.18 ± 0.29 points.

A thorough analysis of the levels of motor activity showed that in the process of the cadets' educational activities during the day, the basic level (sleep,

Table 1. Indicators of motor activity regimen and daily energy expenditure of cadets (n=86) and employees in police investigative units (n=64)

Motor activity levels	Amount of time spent on motor activity, min	MAI, points	DEE, kcal
Indicators of daily motor activity of cadets (n=86)			
Basic	613.1±9.7	10.22±0.16	766.4±12.1
Sedentary	238.1±3.3	4.37±0.06	333.4±4.6
Small	405.3±5.9	10.13±0.15	830.8±12.1
Average	128.7±7.0	5.15±0.28	386.0±21.1
High	54.8±4.5	4.56±0.38	342.2±28.4
Amount	1440	34.43±0.32	2658.8±39.6
Indicators of daily motor activity of employees in police investigative units (n=64)			
Basic	508.6±6.5	8.48±0.11	635.7±8.1
Sedentary	486.9±9.1	8.93±0.17	681.6±12.7
Small	351.1±8.1	8.78±0.20	719.7±16.5
Average	64.2±2.8	2.57±0.11	192.7±8.5
High	29.2±4.1	2.43±0.34	182.6±25.6
Amount	1440	31.18±0.29	2412.4±35.1
t/p $MAI_{cadets\text{-}employees}$		t=7.52 / p<0.001	
t/p $DEE_{cadets\text{-}employees}$		t=4.66 / p<0.001	

Note: MAI – motor activity index, DEE – daily energy expenditure, t – value of Student's t-test; p – level of statistical significance of differences
Source: compiled by the authors of this study

lying down) accounted for 613.1 ± 9.7 minutes, the MAI at this level was 10.22 ± 0.16 points, the DEE – 766.4 ± 12.1 kcal. Based on the processing of physical activity forms, it was found that future law enforcement officers spent an average of 472 minutes sleeping, and the rest of the time resting lying down (using gadgets, watching videos, TV programs, etc.). The volume of the basic level of motor activity was recorded in the investigative police units by 104.5 minutes less than in the cadets – 508.6 ± 6.5 minutes, the MAI reached 8.48 ± 0.11 points, the DEE amounted to 635.7 ± 8.1 kcal (Table 1). The results obtained are explained by the specifics of the service activities of the employees of the practical unit and the determined daily routine of cadets, according to which at least 8 hours should be allocated for sleep.

In case of future investigators, their sedentary level of motor activity, which involves traveling in transport, reading, working at the computer, and eating, is 238.1 ± 3.3 minutes. The MAI at this level is 4.37 ± 0.06 points, the DEE – 333.4 ± 4.6 kcal. Among the types of sedentary motor activity, the most significant proportion was reading and preparation for training sessions – 105 minutes; traveling in transport – 54 minutes; eating – 46 minutes; working at the computer – 33 minutes. Police employees of the investigative units spent much more time on this level of motor activity – 486.9 ± 9.1 minutes. At the same time, the MAI was 8.93 ± 0.17 points, the DEE – 681.6 ± 12.7 kcal per day. The distribution of time by types of motor activity in conditions of service activities differs. In particular, longer work at the computer was noted (on average 306 min); the time of movement in transport was 140 min; other (sitting/standing, etc.) – within 40 min.

On average 405.3 ± 5.9 minutes were spent on physical activity of low level in cadets during a day. Accordingly, the MAI was 10.13 ± 0.15 points, the DEE – 830.8 ± 12.1 kcal. Such results are conditioned by the specifics of educational activities, as this level includes educational training sessions (except for physical training), walking (to educational training sessions, public transport stop, etc.), and personal hygiene. Among the main types of motor activity at this level, the most significant percentage is accounted for by educational training sessions – 336 minutes; walking – 25 minutes; hygiene procedures – 24 minutes; 20 minutes – other types of physical activity that are low in energy expenditure (moving around the dormitory, lining up, some types of household work, etc.). The amount of motor activity that belongs to the low level was 351.1 ± 8.1 min in the employees of police investigative units. The MAI and the DEE, respectively, were 8.78 ± 0.20 points and 719.7 ± 16.5 kcal. Among other things, the most extended period is spent at the workplace and performing service tasks that require more energy than at a sedentary level – 197 minutes; walking (delivery of official documents to various institutions and organizations, etc.) – 86 minutes, driving – 35 minutes; hygiene procedures – 33 minutes.

During the cadets' educational activities, much less time was recorded for average-level motor activity (morning gymnastics, housework, walking, low- and medium-intensity mass sport participation events, etc.) – 128.7 ± 7.03 minutes. Among the list of activities that belong to this level, the most significant proportion is household chores, household work (38 min); low- and medium-intensity mass sport participation events (30 min), morning physical exercises (28 min), walks (22 min), other (11 min). The MAI was 5.15 ± 0.28 points, respectively, and the DEE was 386.0 ± 21.1 kcal. The average level of motor activity of police employees in investigative units was much less time – 64.2 ± 2.8 min. The MAI and the DEE amounted to 2.57 ± 0.11 points and 192.7 ± 8.5 kcal, respectively. Among the activities, homework took the most time.

A high level of motor activity includes specially organized physical exercises and active recreation (intensive games, running, cycling, etc.). During educational activities, the cadets i. e. future investigators had only 54.8 ± 4.5 minutes of high level of motor activity. The MAI at this level was 4.56 ± 0.38 points, the DEE – 342.2 ± 28.4 kcal. Mainly, a high level of motor activity is represented by training sessions on special physical training, independent physical exercises (attending sports sections and the gym), participation in mass sport and recreational activities. Police employees of the investigative units had a high level of motor activity on average of 29.2 ± 4.1 minutes. The MAI – 2.43 ± 0.34 points, the DEE – 182.6 ± 25.6 kcal. These results are due to a lack of time and desire to exercise. The survey shows that only 18 % of employees allocate time for their independent physical training and try to take care of their health.

DISCUSSION

Scientists [15] argue that the human body's motor activity needs are always individual, depend on several physiological, socioeconomic, and cultural factors, and are primarily determined by hereditary and genetic characteristics. Scientists have proven that prolonged sitting at a desk causes a wide range of bodily complications, from minor adaptation and physiological to pathological, and rational systematic physical activity positively impacts health [16].

According to scientists [17], the specifics of police investigators' service activities lead to several somatic disorders, including: fatigue (50 %); low back pain (15 %); headache (15 %); weakness (15 %); decreased attention (15 %); irritability (15 %). As a result, such activities lead to diseases of the cardiovascular system (5 %), respiratory system (15 %), gastrointestinal tract (30 %), vegetative-vascular dystonia (5 %), diabetes mellitus (5 %), sciatica (10 %), nervous system diseases (15 %), diseases of the ear, throat, nose (5 %), and other diseases (5 %).

Rational systematic physical activity experienced by higher education students during educational and independent physical training sessions positively impacts their health [18]. According to scientists, motor activity is a physiological human need, and the optimal amount of motor activity for young people should be 12-14 hours a week, with sufficient physiological load. Given these postulates, experts around the world [19] are concerned about the discrepancy between the actual amount of motor activity and the biological norms necessary for the full development of a person, especially during the period of incomplete sexual development. Rationally organized motor activity is the key to preventing diseases and gaining strong immunity. At the same time, its insufficiency disrupts the normal functioning of body systems, reduces resistance, worsens adaptation to physical loads, overweight, increases blood cholesterol levels, etc. [20]. The analysis of recent studies shows that increased motor activity is an effective means of not only growing working capacity, but also improving the quality of life, preventing neuropsychiatric conditions, and strengthening physical and mental health. However, a sedentary lifestyle carries at least twice the risk of serious illness and premature death [4, 6, 10].

The obtained results confirm the findings of many scientists [6, 9, 15, 18, 21] and extend them, in particular in the direction of a rational combination of mental and physical labor during the educational activities of cadets and the service activities of employees who are sedentary for an extended period and have low energy expenditure; the need to increase the level of motivation for physical exercise and a conscious attitude to maintaining their physical health at the proper level.

CONCLUSIONS

A comparative analysis of the motor regimen, the MAI and the daily energy expenditure of cadets of higher educational institutions of the Ministry of Internal Affairs of Ukraine and employees of police investigative units was carried out. A significant difference in cadets' MAI and daily energy expenditure during their educational activities and police investigators during their service activities ($p < 0.001$) was found. It was found that during the day, the cadets consumed 2658.8 ± 39.6 kcal in the process of their educational activities with their MAI at 34.43 ± 0.32 points. The employees in police investigative units showed 2412.4 ± 35.1 kcal of daily energy expenditure with their motor activity index at 31.18 ± 0.29 points. The results obtained are due to the specifics of the educational activities

of cadets and the peculiarities of the service activities of police investigators, which are determined by an extended stay in a forced position and a low level of physical activity. The results of the conducted research should be taken into account when organizing the physical training of police investigators in the course of their service activities.

PROSPECTS FOR FURTHER RESEARCH

Prospects for further research include developing and introducing scientifically based forms of physical activity into the police service training system, which would increase their physical fitness and health and promote awareness of the importance of its preservation.

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The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Mothers' lived experiences of autistic adults' challenges, community support gaps, and pathways to independence – A phenomenological study

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ABSTRACT

Aim: To investigate the obstacles encountered by Saudi mothers with adult autistic children in promoting autonomy and meaningful relationships. Additionally, it aimed to assess the available community resources and assistance for these mothers, as well as gather their recommendations for enhancing support systems.

Materials and Methods: A phenomenological study design was used among 17 autistic mothers who were conveniently selected. The Focus group discussion guide included four open-ended questions to define mothers' challenges, as well as their coping and adaptation strategies for autistic adults' independent lives.

Results: The thematic analysis highlighted six main themes and their subthemes. The subjects' response themes started with autism detection among children and went behind challenges and adaptation and coping mechanisms to create an independent living approach for autistic adults.

Conclusions: Mothers emphasized the need for comprehensive support systems, including early intervention, specialized resources, and trained caregiver. In addition, community engagement, acceptance and comprehensive family support are crucial.

KEY WORDS: phenomenological, navigation, mothers, independent live, autistic, community services, support system

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INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by difficulties in social interaction, communication, and repetitive behaviors [1]. Globally, ASD affects approximately 1 in 100 children, with its prevalence steadily rising, emphasizing the need for improved support systems [2]. However, as autistic individuals transition into adulthood, they encounter significant challenges, including limited access to healthcare, vocational training, and opportunities for social integration [3]. Early intervention services are often discontinued in adulthood, creating a critical gap that negatively impacts the quality of life for autistic adults and their families [4].

In Saudi Arabia, ASD prevalence is estimated at 1 in 146 children, yet there remains a significant shortage of services, particularly for adults [5]. Saudi mothers of autistic adults face unique challenges due to cultural barriers, social stigma, and a lack of specialized adult services [6,7]. Societal perceptions of autism contribute to stigma and social isolation, reducing awareness and acceptance [8]. This fear of stigma further deters families from seeking necessary support, exacerbating existing service gaps [9].

Currently, autism-related services in Saudi Arabia predominantly focus on children, with limited provisions for adults. Compared to Western nations, community-based support systems for autistic adults remain underdeveloped. Expanding vocational training, life skills programs, and social integration initiatives could significantly improve independent living and overall well-being for autistic adults and their families [10].

Disparities in community services exist between urban and rural regions in Saudi Arabia, making it difficult for many families to access adequate support [11,12]. Despite government efforts to enhance autism services through funding and specialized centers, these initiatives remain insufficient and require further expansion [13]. Non-governmental organizations (NGOs) play a crucial role in supporting autistic individuals and their families [14].

AIM

To investigate the obstacles encountered by Saudi mothers with adult autistic children in promoting autonomy and meaningful relationships. Additionally, it aimed to assess the available community resources and assistance for these mothers, as well as gather their recommendations for enhancing support systems.

SPECIFIC OBJECTIVES

1 Exploring the obstacles encountered by Saudi mothers of adult autistic individuals in fostering independence and meaningful relationships.
2. Assess the availability and adequacy of community support services in helping these mothers achieve their aims of maintaining fulfilling relationships and a normal lifestyle.
3. Explore and examine recommendations for enhancing services to support autistic adults in achieving independent living and marriage.

MATERIALS AND METHODS

SIGNIFICANCE OF THE STUDY

This study addresses critical gaps in supporting autistic adults in Saudi Arabia by focusing on improving healthcare services, policies, and societal attitudes toward autism. It identifies unmet needs in community services, providing valuable insights to guide effective interventions [15]. The research highlights the experiences of mothers, empowering them to strengthen support networks and advocacy efforts [16]. Additionally, it offers actionable recommendations for policymakers and service providers to enhance support for autistic adults and their families [17].

By focusing on Saudi Arabia, the study contributes to the limited research on autism in non-Western contexts, offering culturally relevant perspectives on these challenges [18]. Its emphasis on promoting independent living underscores the need for programs that foster autonomy and improve the quality of life for autistic adults [19].

STUDY DESIGN

A descriptive phenomenological study design was used to explore the lived experiences of participants. This approach seeks to describe a phenomenon from the perspective of those who have directly experienced it, emphasizing both the nature of the experience and how it was encountered. This method offers deeper insights into the challenges and positive aspects faced by individuals, contributing to a more comprehensive understanding of their experiences [20].

STUDY AREA/SETTING

The study was conducted at the Comprehensive Rehabilitation Center in Jazan, a government-affiliated institution that provides services to individuals with multiple disabilities across various age groups. Situated along the southern Red Sea coast near Yemen, the center focuses on delivering care, rehabilitation, and empowerment programs to individuals with special needs, with the aim of enhancing their independence and overall well-being [21].

STUDY PARTICIPANTS AND SAMPLE SIZE

A nonprobability convenient sampling technique was used.to recruit 17 mothers and caregivers of autistic adults, with each focus group consisting of 5 to 8 participants.

INCLUSION CRITERIA

Participants, including both mothers and caregivers, were selected based on having at least one year of experience caring for autistic adults. A non-probability convenient sampling technique was used. Inclusion criteria included being an adult (male or female), displaying a cooperative attitude, and agreeing to participate in the study.

DATA COLLECTION METHODS

The research employed a focus group discussion guide (FGG) to gather the information required for the study. Researchers have developed the FGG to obtain qualitative data after examining recent literature. The guide aimed to investigate participants' views on the capabilities and constraints of adult individuals with autism spectrum disorder (ASD), assess its influence on developing autonomy and fulfilling relationships, and identify participants' recommendations and requirements to assist ASD adults in achieving their objectives and leading normal lives with satisfactory relationships. FGG comprises the following stages:

PHASE I

Introductory stage: During this phase, the researchers present themselves (name, profession), clarify the study's objectives, and ensure data confidentiality. They enquired about the participants' personal details (age,

autism discovery time, duration of caring for autistic adults, occupation, marital status, educational background, and specialization).

PHASE II

Engagement stage (icebreaker queries). These questions were designed to help participants feel at ease in the discussion and freely express their opinions, such as their knowledge of ASD symptoms and diagnoses, their feelings about managing ASD, and the health services and resources available to them.

PHASE III

Exploration stage (Core questions) which addresses the primary issues the researcher aimed to cover in the FGDs session, including Examining ASD abilities and limitations regarding developing an independent life and satisfactory relationships. Participants' perspectives on the challenges faced by adults' individuals and their impact on independent living and satisfactory relationships. Investigating the challenges encountered by caregivers and adults with autism in achieving satisfactory relationships and independent life skills. Assessing participants' coping strategies and suggestions for reducing challenges.

PHASE IV

Concluding stage (final question): Do you have any additional comments.

DATA COLLECTION PROCEDURE

Researchers conducted three virtual focus group discussions (FGDs) via Zoom with 5-8 family members of autistic adults, following approval from KAIMRC and the IRB. A mock session was held beforehand to refine the focus group guide. Participants were recruited from a rehabilitation center, and informed of the study's purpose, and confidentiality was ensured through identification numbers. Each Zoom session, lasting 1.5 to 2 hours, included introductions, ice-breaking, and open-ended questions. Discussions continued until data saturation was achieved, and all sessions were audio-recorded with consent. Exit questions and participant acknowledgments concluded each session.

DATA MANAGEMENT AND ANALYSIS PLAN

After data collection, all audiotaped sessions were transcribed verbatim to ensure the exact words and phrases expressed by participants were captured. Transcripts were thoroughly proofread and compared against the audio recordings to ensure accuracy. Sensitive information, such as accidental mentions of names, was replaced with participant IDs to maintain confidentiality.

The data was organized and analyzed by clustering findings and relevant quotations into overarching themes, which served as the main headings for the results. To ensure the trustworthiness and quality of the qualitative data, several strategies were used, including triangulation, member checking, peer debriefing, inquiry audits, and the use of thick descriptions.

ETHICAL CONSIDERATIONS

Informed consent for the study was obtained through formal approval from the research unit at the College of Nursing, KAIMRC, and the IRB (NRJ22J/048/02). A letter of approval and a brief explanation of the study's purpose and procedures were provided to the relevant setting. Participants were informed that their participation was voluntary and that they could withdraw at any time without any negative consequences. The Principal Investigator (PI) ensured secure storage of both hard and electronic data on MNGHA premises, with access restricted to the research team. Throughout the study, anonymity, confidentiality, and privacy were upheld. Participants received the informed consent form electronically and provided consent by agreeing to participate, after which they were invited to join focus group discussions.

RESULTS

Table 1 shows maternal sociodemographic characteristics that a substantial portion (64.7%) were aged 30 years or above, with the majority possessing a university degree (58.8%) and not engaged in employment (70.6%). A large percentage (82.4%) were married, while 29.4% indicated consanguineous unions with their spouses. The age at autism diagnosis in their offspring was fairly evenly distributed among ages 2, 3, and 4 years. Regarding adult sociodemographic data, 57.1% were below 30 years of age and a significant majority (71.4%) reported no parental consanguinity. These observations suggest a pattern wherein mothers of autistic children tend to be older, highly educated, and predominantly unemployed, with a notable incidence of consanguinity, which could be significant for the genetic aspects of autism studies.

Fig.1. illustrates these six primary themes. The initial theme, autism detection in children, encompasses several subthemes: early identification and typical

Table 1. Distribution of studied sample according to their demographic data (N=17)

Variables	No.	%
Mother's sociodemographic data	**no.17**	
Age (Years)		
Less than 30	6	35.3
30 and more	11	64.7
Educational level		
Middle	3	17.6
High	4	23.5
University	10	58.8
Occupation		
Working	5	29.4
Non-working	12	70.6
Marital status		
Married	14	82.4
Widow	3	17.6
Husband consanguinity		
Yes	5	29.4
No	12	70.6
Age of the child's diagnosis of autism (Years)		
2	5	29.4
3	6	35.3
4	6	35.3
Adult sociodemographic data	**no.7**	
Age		
Less than 30	4	57.1
30 and more	3	42.9
Mother/Father consanguinity		
Yes	2	28.6
No	5	71.4

Source: compiled by the authors of this study

symptoms, delayed diagnosis, impact of appropriate referral, autism causes, acceptance from other family members, and factors influencing early detection. The second theme, perceptions of autism service, includes subthemes such as insufficient educational resources and facilities, shortage of human resources and special needs educators, limited child progress, and the requirements of mothers with autistic children. The third theme addressed barriers in managing children with autism, highlighting subthemes such as attachment to a single individual, dependency, overprotective mothers, and family support systems as secondary care providers. The fourth theme explored mothers' perspectives on autistic children's independent living, featuring subthemes such as poor communication abilities, financial management difficulties, social engagement, relationships with classmates, and aggressive behavior towards others. The fifth theme examined the challenges faced by mothers or primary caregivers of autistic children at home, including subthemes of dependency, burden and exhaustion, lack of awareness, insufficient health and education-related resources, centralization of resources, inadequate provisions for older adults and adolescents, cultural obstacles, and autism-related stigma. The final theme, as depicted in figure (1), focused on adaptation and mothers' recommendations for improved services, presenting subthemes such as increasing community awareness about autism-related disorders and ADHD, guiding families on care and support provision, emphasizing the importance of workshop materials, highlighting the significance of psychological care and burnout management, and addressing the shortage of human resources and professional development for caregiver

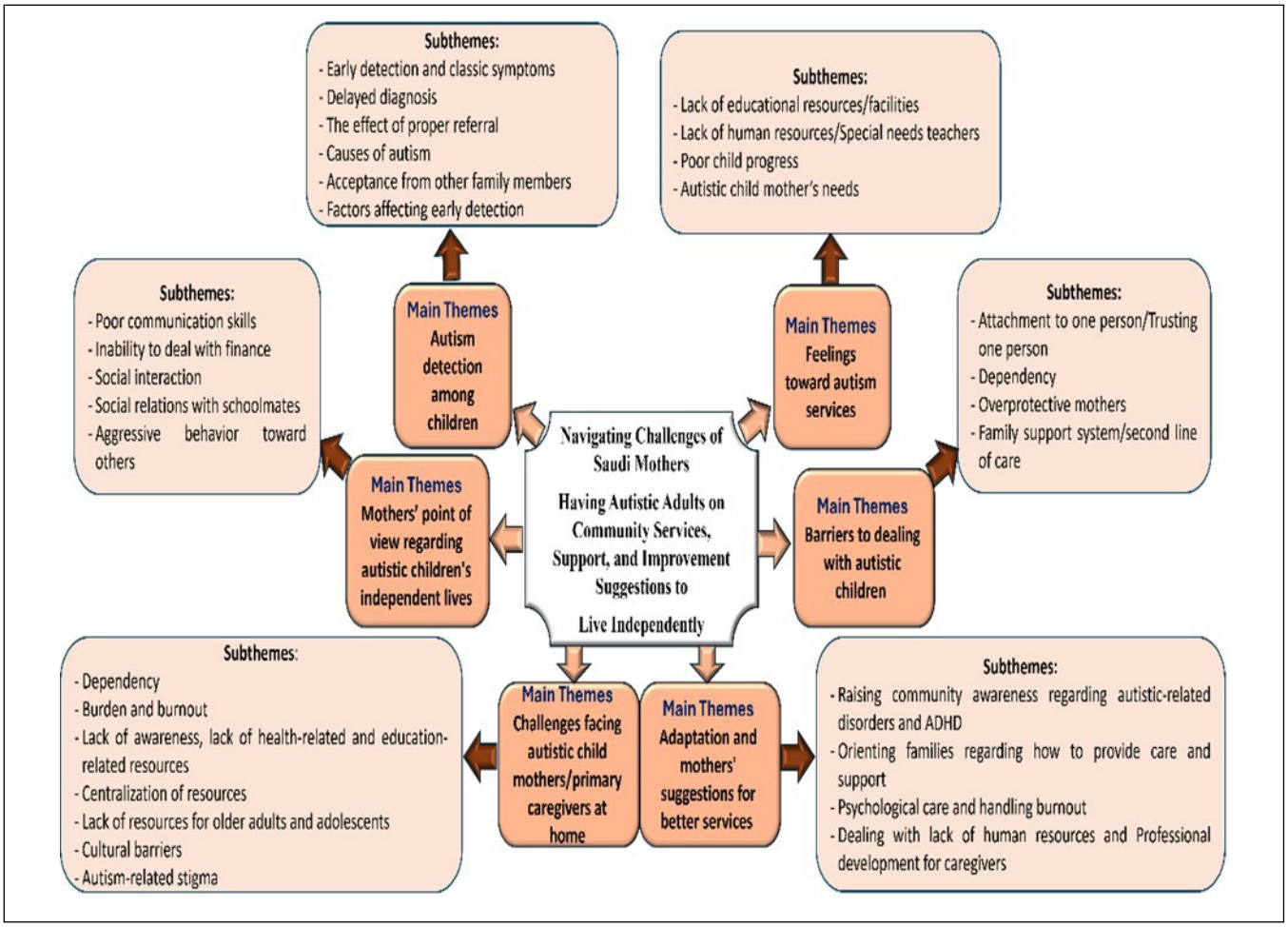

Fig. 1. Focus group discussion thematic analysis navigating challenges of saudi mothers having autistic adults
Picture taken by the authors

Theme 1: Autism detection among children

This theme includes subthemes such as early detection and classical symptoms, delayed diagnosis, the impact of proper referral, causes of autism, family acceptance, and factors influencing early detection.

A: Early detection and classical symptoms

A1: Age of discovery

Most mothers noticed abnormal symptoms in their children between the ages of 2 to 3 years, often recognizing developmental deviations compared to other children, relatives, or neighbors. Participants 1, 3, 7, and 15 stated, "I detect autism at age 2 to 3 years, actually I can't remember," and "Detected at 2.5 years."

A2: Early indicators

Some mothers identified early signs of autism in their children, including delayed speech, lack of responsiveness, non-verbal communication, and poor eye contact. Participants 2 and 3 mentioned, "The child stopped talking after 18 months even minor words" and "The child responds by shouting." Participants 1 and 3 noted, "When I am talking to him, he doesn't look at me and has poor eye-to-eye contact."

A3: Misdiagnosis

Some mothers reported that their children were misdiagnosed, initially being believed to have hearing problems or mental disturbances. For example, Participant 1 mentioned, "My relatives have told me that my child is crazy or psychologically disturbed; I didn't believe them at first, but now I'm starting to wonder if it's true." Others were misdiagnosed with ADHD, as noted by Participants 5 and 6. This highlights the challenges in accurately diagnosing autism.

A4: Repetitive and stereotyped behavior

Some mothers reported that their children are mostly isolated or withdrawn, and preferring to be alone. As mentioned by participants (8, 9, and 10), "My kids mostly sit at the same place in front of the TV, he mostly isolated, introverted didn't hear other words or neglect them,"

A5: Head banging

Some mothers reported that their child exhibited head-banging behavior. As stated by participants (1 and 3), "I noticed that he moved his head and flopped it backward," and "he pushed himself into the floor and hit his head."

A6: Risk perception

Some mothers reported that their children were unaware of dangers and threats, requiring constant supervision to prevent harm. As stated by participants (4 and 11), "My child can't differentiate between hazardous substances; they need continuous observation, they can hurt themselves."

A7: Impaired verbal communication

Some mothers reported that their children neglected them, did not use verbal communication, and failed to understand their words. As stated by participants (10 and 13), "He didn't understand me when I tried to speak to him."

A8: Agitation and Biting and hurting others

Some mothers reported that their children displayed aggressive behavior, moved quickly and frequently, and engaged in non-purposeful body movements, they bite and hurt their siblings. As stated by participants (2,4,11 and 13), "My son kept moving and they never stopped, do non-purposeful body movement, she responds by biting."

A9: attach to one clothes.

Some mothers reported that their children were closely attached to specific clothing and refused to wear anything else. As stated by participants (2 and 3), "I noticed that my kid is attached to certain clothing and refuses to wear anything else."

A10: Oversensitivity to sound

Some mothers reported their children are oversensitive to high-pitched sounds, becoming aggressive. As stated by participants (10 and 15), "I noticed that my child is oversensitive to sound and becomes aggressive in response to high-pitched sounds."

A11: Delayed gross motor and language development.

Some mothers observed a delay in their child's gross motor skills and language development, particularly when compared to an older sibling. As stated by Participants (1,3,17 and 18), "When I compare my autistic child with her oldest sister, I noticed that they didn't go on the same track.", "she uses very limited words and can't proceed in communication."

A12: Lack of orientation to place/settings

Some mothers noticed that their children would wander and feel lost if left alone. As stated by participants (1 and 3), "I can't leave my daughter alone anywhere, she can't tell others about their home or location."

A13: Hand flapping

Hand flapping was reported by some mothers, as stated by Participants 1 and 4, "My child continuously does hand flapping, especially with high loud sounds."

A14: Detached from reality.

Some mothers believe their child hears external sounds that detach them from reality. As stated by participants (10 and 16), "I observed that my child didn't concentrate, and he might hear other sounds that make him not aware."

B: Delayed diagnosis

Autism diagnosis was confirmed for some mothers when their children were 4–9 years old, initially misdiagnosed as mentally retarded before identifying autism. As stated by participants (1,3,5 and 17), "I have a problem with the delay of autism diagnosis, which leads to a lack of proper treatment."

C: Effect of proper referral

Some mothers reported significant benefits from proper referral and management. As stated by participants (1 and 13), "I become so excited after proper referral to the correct agency. My daughter behaves near to normal."

D: Causes of autism

D1: Lack of awareness of autism causes

Some mothers believe that high temperature might be a cause of autism. As stated by Participants 1, 7, and 13, "I remembered that my child got a high temperature at 6 months, then was diagnosed with autism at age 2 years. I believe that the high temperature was the cause. I didn't know why my kids get autism."

D2: Genetic predisposition and autism

Some mothers believed that familial tendencies and genetic factors might contribute to autism, while others disagreed. As stated by participants (3 and 9), "Consanguinity plays an important role from my point of view,", "No, I disagreed. There is no association between consanguinity and autism."

E: Acceptance from other family members

There is a discrepancy in family response and acceptance of autistic children. First-degree relatives, especially females, tend to be more cooperative and accepting than others. As stated by participants (2, 3, and 17), "I noticed that close family members, as sisters, are more accepting and helpful and caring than others or other relatives."

F: Factors affecting early detection

Mother's prior experience with other siblings affects early detection. As stated by participants (1, 2, 3, and 13), "From my experience, I noticed early that my autistic child is deviated from normal, compared my child with her sisters and sons."

Theme 2: Feeling toward autism services

The second theme presents the following subthemes: lack of educational resources/facilities, lack of human resources/Special needs teachers, poor child progress, and autistic child mother's needs.

A: Lack of Educational Resources/Facilities

Some mothers face challenges due to the lack of specialized educational resources for autistic children. As stated by participants (1 and 3), "The problem is the

lack of facilities to teach my autistic child in a specialized school."

B: Lack of Human Resources/Special Needs Teachers

Most mothers highlighted the need for special needs teachers, as regular teachers often lack the necessary experience. Participants 2, 4, 7, 9, and 14 "Having specialized support in classrooms to improve integration and ensure better care for autistic students".

C: Poor Child Progress

Some mothers are dissatisfied with their children's slow progress, believing it could improve with better-qualified care. Participants (10 and 13) mentioned, "The progress of my child is accepted, but it is very slow, he does not have a special needs teacher,"

D: Autistic Child Mother's Needs

Mothers highlighted two main sources of care: specialized centers with satisfactory services and general hospitals with unsatisfactory services. Participants 14 and 15 stated, "Health services are very limited" and "I go to hospitals for a speech therapist not available at schools."

Theme 3: Barriers to dealing with autistic children.

The third theme shows the following subthemes: attachment to one person/Trusting one person, dependency, overprotective mothers, and family support system/second line of care.

A: Attachment to One Person/Trusting One Person

Many mothers reported that their children are closely bonded to them and reject care from others. As stated by participants (1, 2, 3, 4, 5, and 17), "My child mainly refuses any care provided by others."

B: Dependency

Specialized centers and teachers keep children independent. As mentioned by participants (1 and 3), "Most of the time my child is dependent, which puts extra load on me. Dependency decreases if they receive care from specialized centers and teachers."

C: Overprotective Mothers

Some mothers exhibit overprotective behavior, fearing their children might hurt themselves. Participants 14 and 17 stated, "I am trying to encourage my child to have self-care activities and be independent," and "No, I have to protect my child, they may hurt themselves."

D: Family Support System/Second Line of Care

Most mothers agreed on the importance of preparing a second line of care. As mentioned by Participants 1, 2, 7, 9, 10, and 14, "The main concern is to prepare a second care provider," and "Family support is important for future life."

Theme 4: Mothers' point of view regarding autistic children independent life

The fourth theme presents the following subthemes: poor communication skills, inability to deal with finance, social interaction, social relations with schoolmates, and aggressive behavior toward others.

A: Poor Communication Skills

Many mothers believe that poor communication skills limit their autistic children's independence and affect their chances of marriage. Participants 1,2, and 15 stated, "I don't think my daughter can marry; she can't communicate well."

B: Inability to Deal with Finance

Some mothers worry that autistic individuals cannot handle finances, making marriage difficult. As stated by participants (5 and 7), "Financial skills needed for marriage. I can't believe my child can handle it, so it's difficult to get married."

C: Social Interaction

Poor social interaction skills were cited as a key factor in mothers' decisions about marriage. As mentioned by participants (1 and 3), "An autistic person with poor social interaction skills can't be married at all."

D: Social Relations with Schoolmates

Mothers noted that their children have limited social interactions with schoolmates. Participants (1, 2, 5, 9, and 11) shared, "I noticed that my child has a limited number of friends, and he lacks social interaction, so I can't accept the idea of his marriage."

E: Aggressive Behavior Toward Others

Aggressive behavior was a concern, making it difficult for autistic individuals to find marriage partners. As Participants 1 and 3 mentioned, "My child is aggressive, no family would accept this marriage," and "In our culture, autistic are considered mad and can't be married."

Theme 5: Challenges facing autistic child mothers/ primary caregivers at home.

The fifth theme portrays the following subthemes: dependency, burden and burnout, lack of awareness, lack of health-related and education-related resources, centralization of resources, lack of resources for older adults and adolescents, cultural barriers, and autism-related stigma.

Dependency

Most mothers felt overwhelmed expressing that they had no support and had to handle all aspects of care alone. Participants 7, 8, 9, 10, and 13 shared, "No one can help me, I am alone. My child is fully dependent and needs me all the time."

Burden and burnout

Many mothers felt powerless and emotionally drained, struggling to cope with the challenges of caregiving for their autistic children. Participants 1 and 3 stated, "I am human, and I can't tolerate it. I feel frustrated, I have no power."

Lack of awareness

Many mothers highlighted the lack of understanding about managing autism, which makes their situation difficult. As participants 7 and 13 stated, "If I don't know what autism is or how to manage it, I can't provide proper care. Lack of awareness prevents effective management."

Lack of health-related and education-related resources

Most mothers agreed that access to healthcare and educational facilities is crucial for managing autism. They stressed the need for specialized centers and schools to alleviate their burden. Participants 2, 4, 5, 6, 7, and 11 mentioned, "If we had adequate specialized hospitals and centers, we wouldn't feel unsupported."

Centralization of resources

The unequal distribution of resources, with many services concentrated in larger cities, posed a major challenge for mothers in remote areas, making it difficult to access essential care. Participants (1 and 3) highlighted this issue, noting that resources are unevenly spread, leaving smaller, rural areas underserved.

Lack of resources for older adults and adolescents

The shortage of services for older adolescents was a concern, leading to discontinuity in care. Participants (10, 11, 12, and 13) mentioned, "Most centers only offer services until the age of 10 or 12. There are no schools that provide integration, so we often must place our kids in general schools, which leads to setbacks."

Cultural barriers

Cultural factors, such as gender-specific services, were mentioned as a challenge affecting care. As participants (11 and 13) pointed out, "Services available for girls at schools are different from those for boys, especially when the care provider is of the opposite sex."

Autism-related stigma

The stigma around autism contributed to psychological challenges. They expressed feeling isolated and unsupported. As participants (11 and 13) explained, "When I knew autism diagnosis, I was shocked. I didn't know how to face the community, and I hid it to avoid their negative reactions and comments."

Theme 6: Adaptation and mothers' suggestions for better services

The last and sixth theme presents the following subthemes: raising community awareness regarding autistic-related disorders and ADHD, orienting families regarding how to provide care and support, and workshop materials are important, psychological care and handling burnout are important, and dealing with lack of human resources and Professional development for caregivers.

Raising community awareness regarding autistic-related disorders and adhd

Some mothers emphasized the need for increased community awareness about autism and ADHD. An informed community could offer better help and support. Participants (8 and 13) shared, "An aware community can provide help and support us. They can push toward better care."

Orienting families regarding how to provide care and support, workshop materials

Many mothers highlighted the importance of educating and training families to properly care for their autistic children. Participants (10, 11, 12, 13, and 14) stated, "Trained and skillful family members can provide better care."

Psychological care and handling burnout are important

Psychological stress and burnout were common issues for mothers. Most of them reported that access to psychological support could help alleviate frustration and reduce negative thoughts. As participants (8, 9, 10, 11, 12, and 14) stated, "If I found psychological support, it may protect me from frustration and decrease my negative thoughts."

Dealing with lack of human resources and professional development for caregivers

The shortage of trained and qualified staff in healthcare and educational facilities was a key issue for mothers, with many calling for increased government support to hire qualified professionals. As shared by Participant (1), "I have a question: why do we have a lack of trained and qualified teams? The government must support us and hire a qualified team."

DISCUSSION

This study explores how mothers detect autism in their children, focusing on early signs, challenges, and misdiagnoses. Mothers commonly notice symptoms such as developmental delays, lack of verbal communication, poor eye contact, and unusual social responses around 2–3 years of age, which align with existing research on early autism indicators [22,23]. Early detection enables timely interventions and access to support services that address developmental delays associated with autism spectrum disorder (ASD) [24]. However, diagnostic challenges arise due to symptom overlap with conditions such as hearing impairments, ADHD, and intellectual disabilities, often leading to misdiagnoses. This results in delays in receiving appropriate care and causes frustration for families [25,26].

The study highlights the challenges mothers face in detecting autism in their children, including delayed diagnoses, varied beliefs about autism, and the emo-

tional impact of caregiving. Misdiagnoses, such as ADHD or hearing impairments, can contribute to delays in obtaining an accurate diagnosis and appropriate interventions [25,26]. The psychological burden on mothers is significant, marked by worry, uncertainty, and frustration, particularly when dealing with societal stigma or diagnostic challenges. Adequate support is essential to help mothers navigate these difficulties and promote their child's development [27]. Timely, accurate diagnosis and early intervention are crucial for improving outcomes for children with autism [24].

Family dynamics, particularly support from female relatives, play a crucial role in helping mothers cope with autism. Prior experiences with siblings allow mothers to recognize early developmental signs [28]. Misconceptions about autism, stemming from genetic and environmental factors, further emphasize the need for increased community awareness [22].

The second theme provides insight into mothers' perspectives and experiences regarding available autism services and resources. The study highlights significant challenges mothers face in accessing and utilizing support services for their children with ASD, including limited specialized educational resources and a lack of trained special needs teachers, which impact academic progress [29,30]. Mothers expressed dissatisfaction with the care their children receive, particularly concerning behavioral issues, highlighting the need for tailored interventions to promote optimal development [31]. Furthermore, they emphasized the importance of integrated healthcare services, such as speech therapy and behavioral interventions, but many face obstacles in accessing coordinated care across different settings. Effective collaboration between healthcare providers, educators, and families is crucial for achieving positive outcomes [32].

In conclusion, improving the accessibility and quality of autism services—through specialized education, integrated healthcare support, and trained professionals—is essential. Collaboration among policymakers, educators, healthcare providers, and community stakeholders is necessary to provide holistic and sustained support for individuals with autism and their families.

The third theme examines the challenges mothers face in caring for children with autism, including attachment, dependency, overprotectiveness, and the need for support. Children with autism often form strong attachments to their mothers, making it difficult for them to accept care from others, thereby limiting access to external support services [33]. Dependency on mothers is another significant issue, as children who lack exposure to specialized centers and trained educators rely heavily on them. Structured interventions and educational programs are necessary to promote independence and reduce caregiving burdens [34].

Mothers adopt varying approaches to fostering independence, with some prioritizing autonomy while others emphasize safety, creating challenges in balancing these needs [35]. Additionally, strong support networks, including emotional support and respite care, are crucial for both the child and the family [36]. Addressing these challenges requires comprehensive interventions, such as tailored support services, caregiver training, and community involvement, to ensure effective care for children with autism and their families.

The fourth theme focuses on mothers' concerns about their autistic children's future independence, particularly in marriage and relationships. Many mothers worry about their children's limited communication skills, which hinder social interactions and romantic relationships [37]. They also express concerns about their children's financial literacy and decision-making abilities, questioning their capacity to handle marriage responsibilities [38]. These concerns highlight the need for targeted interventions aimed at improving communication, life skills, and social competence to foster greater independence.

Mothers emphasized the importance of social interactions in marriage, noting struggles with understanding social cues and forming meaningful relationships [39]. Limited social engagement often reflects their children's potential for future relationships, and mothers fear this could impact social competence and suitability for marriage [40]. Additionally, concerns about aggressive behavior and impulsivity were raised, as these traits challenge stable and harmonious relationships [40].

In conclusion, these findings underscore the multifaceted cognitive, social, and behavioral factors influencing mothers' perspectives on their autistic children's potential for independence and meaningful relationships. Addressing these concerns requires holistic support, including targeted interventions aimed at enhancing communication, emotional regulation, and social skills for individuals with ASD.

The fifth theme highlights the challenges mothers face in caring for children with autism, including emotional strain, isolation, and practical caregiving burdens. Many mothers feel overwhelmed by the sole responsibility of caregiving, leading to exhaustion and burnout. The lack of adequate support, such as respite care, exacerbates their struggles [37].

Mothers often experience gaps in their knowledge about autism and management strategies, limiting their access to effective care [38]. The shortage of healthcare and educational resources, particularly in rural areas, poses additional barriers to quality care [39]. Long-term

stability is further challenged by limited resources for older adolescents, discontinuity in care, and a lack of integrated services. Cultural norms and stigmatization also impact access to care, necessitating culturally sensitive approaches.

Addressing these challenges requires a holistic approach that includes culturally tailored support, equitable resource distribution, and collaboration across healthcare, education, and community sectors to improve caregiver well-being and ensure sustainable care for children with autism.

The sixth theme highlights the need for improvements in services for individuals with ASD and ADHD, as suggested by mothers. Key recommendations include raising community awareness to foster understanding and acceptance, providing educational workshops to equip families with essential caregiving skills, offering psychological support to manage caregiver stress, and addressing human resource challenges by enhancing recruitment and professional development opportunities in healthcare settings . Mothers' recommendations for improving care require a collective effort across healthcare, education, and community sectors. By focusing on awareness, family engagement, psychological support, and professional development, these suggestions aim to better support individuals with ASD and ADHD, along with their families.

CONCLUSIONS

To summarize, this study underscores the myriad challenges encountered by mothers caring for adults with autism. The principal concerns include obstacles to early identification, obtaining suitable support services, and promoting autonomy. Mothers stressed the importance of comprehensive assistance frameworks, encompassing early intervention programs, specialized resources, and skilled caregivers. Moreover, it is vital to address the mental health of caregivers through support services such as therapy and respite care. Bolstering family support networks and encouraging community acceptance can help reduce the burden on caregivers and enhance the quality of life of both individuals with autism and their families.

RECOMMENDATIONS

The findings suggest several key recommendations:

1. Enhance awareness and training for healthcare professionals to ensure early detection and intervention for autism and ADHD.
2. Build integrated support systems that offer access to specialized education, therapy, and healthcare services tailored to individuals with autism throughout their lives.
3. Provide psychological support, counseling, and respite care to caregivers, especially mothers, to reduce burnout and strengthen coping mechanisms.
4. Promote community awareness and acceptance of autism through workshops, support groups, and inclusive activities to reduce stigma.
5. Invest in professional development programs to enhance the skills of caregivers and healthcare providers in delivering effective, holistic care.

DATA AVAILABILITY STATEMENT

All data included in article/supp. material/referenced in the article. Further data will be available from the corresponding author upon reasonable request.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Peculiarities of future law enforcement officers' psychological readiness for professional stress in war conditions

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ABSTRACT

Aim: To investigate the peculiarities of future law enforcement officers' psychological readiness for professional activities under the influence of wartime stressors.
Materials and Methods: During 2023-2025, the research was conducted among cadets of the 3rd training years (2023-2024, Group A, n = 114) and (2024-2025, Group B, n = 112) aged 18-22 years who undertook their utilization tours in practical police units (for 3 months): Group A without prior professional and psychological training, Group B – after preliminary correctional and psychological work.
Results: It has been established that the specifics of the professional activities of law enforcement officers under martial law have a negative impact on the indicators of their psycho-emotional state and stress resilience. At the same time, targeted correctional and psychological work with cadets reduces the magnitude of negative changes in all diagnostic indicators: in Group A, the indicators of well-being, activity and mood significantly ($p \leq 0.05$-0.01) deteriorated by 0.6, 0.7 and 1.2 points, and in Group B – by 0.4, 0.4 and 0.5 points, respectively ($p > 0.05$); the indicators of psychological stress, stress resilience, predisposition to develop stress, endurance under stress in Group A deteriorated significantly ($p \leq 0.05$-0.01) by 6.2, 3.9, 4.9, 5.1 points, and in Group B – unreliably ($p > 0.05$) by 4.3, 2.6, 3.4 and 2.9 points, respectively.
Conclusions: It has been proven that a well-organized professional and psychological training contributes to improving the level of future law enforcement officers' psychological readiness for professional activities under the influence of wartime stress factors.

KEY WORDS: psychological readiness, professional stress, future law enforcement officers, professional activities, war

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INTRODUCTION

The introduction of martial law in the country has significantly increased social instability, significantly worsened the economic situation, and changed the political situation and the nature of the activities of all levels of government. Unfortunately, all citizens face difficult situations of physical survival and moral and psychological challenges related to the war. The society has moved to new realities of functioning, and all employees of state institutions continue to work in dangerous and stressful conditions [1, 2]. Law enforcement officers are no exception, being at the forefront of the fight against both internal and external threats, they are constantly faced with the problem of overcoming the effects of professional stress [3, 4]. Numerous studies [5-7] demonstrate that the problem of law enforcement officers' stress resilience is extremely acute due to the specifics of their professional activities: real danger, various factors of threats to life and health, risk, injury, aggressive communication environment, intensity of work, constant time pressure, increased personal responsibility for work results, etc. As rightly noted by scholars [8, 9], the professional activities of law enforcement officers often lead to an increase in negative emotions, anxiety, irritability, emotional burnout, loss of positive professional motivation, manifestation of various neurotic reactions and mental states, sleep disturbances, depression, various mental health disorders, etc. According to the observations of some researchers [10-12], in some cases, physical illnesses may develop or existing chronic diseases may be exacerbated. In general, the lack of proper psycho-emotional preparedness of police officers to overcome stress leads to poor performance of service tasks, miscalculations in professional activities, injuries and wounds, or even death.

It should be noted that the vast majority of stress studies, its impact on the personality of law enforcement officers, and the peculiarities of stress management were conducted in normal peacetime conditions [13-15]. As of today, the situation has become much more complicated due to the ongoing hostilities in the country, when a significant number of law enforcement officers are involved in performing uncharacteristic service tasks: ensuring access control at checkpoints, evacuating the population from dangerous regions, conducting stabilization measures in the de-occupied territories, etc. Hence, it can be argued that new functional responsibilities have been added, which means that new stressors and risks of professional activities have emerged that should be considered when training the current generation of law enforcement officers. Therefore, an in-depth study of the essence and peculiarities of future law enforcement officers' psychological readiness for professional activities in stressful conditions of war is of great theoretical and applied importance.

AIM

The aim is to investigate the peculiarities of future law enforcement officers' psychological readiness for professional activities under the influence of wartime stressors.

MATERIALS AND METHODS

PARTICIPANTS

To study the peculiarities of future law enforcement officers' psychological readiness for martial law stressful situations, we conducted diagnostic and correctional pedagogical work during the academic years 2023-2024 and 2024-2025 at Lviv State University of Internal Affairs (LSUIA, Lviv, Ukraine) among the 3rd training year cadets (males) of 2023-2024 (Group A, n = 114) and 2024-2025 (Group B, n = 112) aged 20-22 years, who underwent their utilization tours in practical units (3 months): Group A without prior professional psychological training, Group B – after preliminary correctional pedagogical work. The criteria for inclusion of cadets in the study groups were their specialty – Law Enforcement, period of study in the 3rd training year, participation in a utilization tour in a practical unit for 3 months, and written voluntary consent to participate in the research.

To achieve the research aim, a set of interrelated methods was used: bibliosemantic, psycho-diagnostic, and statistical. The bibliosemantic method was used to conduct an analytical review of scientific sources on the outlined range of issues (22 sources from PubMed, Scopus, Web of Science, Index Copernicus and other databases were analyzed).

The psycho-diagnostic method involved conducting research with cadets as future law enforcement officers. For this purpose, 5 methods were used: "Well-being-Activity-Mood" (WAM), PSM-25 (Lemyre-Tessier-Fillion) Psychological Stress Measure, Stress Resilience Self-Assessment Test (S. Cohen and G. Williamson), Assessment of Predisposition to Stress Development (T. A. Nemchin, J. Taylor), Endurance Under Stress (F. Gotvald, V. Hovald) [16-18]. The use of the Well-being-Activity-Mood method involved a quick assessment of such functional states of future law enforcement officers as well-being, activity, and mood. The respondents were asked to compare their current state with a list of signs on a specific scale. The scale comprises indices (3 2 1 0 1 2 3). It is located between thirty pairs of words (ten for each state) of opposite meanings, which reflect mobility, speed, and pace of functions (activity), strength, health, fatigue (well-being), as well as characteristics of the emotional state (mood). When processing the data, the respondents' scores were recoded as follows: index 3, which corresponds to poor well-being, low activity, and low mood, is taken as 1 point; the next index 2 is taken as 2 points; index 1 is taken as 3 points, and so on until index 3 on the opposite side of the scale, which is taken as 7 points. For each functional state, arithmetic averages were calculated and evaluated as follows: if the average score was from 1 to 3 points, the law enforcement officer's state was considered low; 4, 5 – average; 6, 7 – high. The PSM-25 Psychological Stress Measure is designed to measure the structure of stress experiences. It contains 25 statements, answering which the respondents chose the frequency of their manifestation and rated in points from 1 to 8, where 1 is never, 8 is always. After that, the sum of points for all statements was determined. If the sum was 99 or less, the stress level was considered low; 100-124 points – average; 125 and more – high. Stress was assessed as follows: if the sum of coincidences was 15 or less, there was no stress; 16-24 – moderate level of predisposition to stress; 25-39 – average; 40 and more – high. The Stress Resilience Self-Assessment Test contains 10 questions, answering which the cadet had to choose one of the proposed answers, which for questions 1, 2, 3, 7, 9, 10 were evaluated as follows: never – 0, almost never – 1, sometimes – 2, quite often – 3, often – 4; for questions 4, 5, 6, 8 – never – 4, almost never – 3, sometimes – 2, quite often – 1, often – 0. If the sum was 6.8 points or less, the level of stress resilience was considered excellent; 6.9-14.2 – good; 14.3-24.2 – satisfactory; 24.3-34.2 – poor; 34.3 and more – very poor. The method for determining

predisposition to stress development contains 50 statements and allows for assessing the cadets' predisposition to develop stress, anxiety level. It also allows for talking about their level of stress resilience. The respondents were offered a form with statements with "No" or "Yes" answers opposite them. It was necessary to put "+" if the proposed answer coincided with the respondent's opinion, or "–" if it did not. The Endurance Under Stress Method contains 33 statements with suggested answer options (often/strongly, rarely/sometimes, no/never). Each answer option was rated 0, 1, or 2 points. The data was processed by summing the points: 28 and more points – low stress resilience level; 13-27 – average; 12 and less – high. The choice of tools was based on the specifics of the professional activities of cadets – future law enforcement officers.

The above methods were used before and after the utilization tours of the 3rd training year cadets in practical police units (for 3 months).

ORGANIZATION OF THE RESEARCH

The research was conducted in three stages. The first stage provided the analytical review of the literature on the peculiarities of law enforcement officers' psychological readiness for crisis conditions of professional activities, and identification of diagnostic and methodological tools for conducting empirical research. The second stage included the diagnostic work with the help of the selected tools. For the experiment, electronic forms with the tasks of the methods were created, which contained brief instructions for completing the tasks. The respondents were not provided with keys to interpret the results. The third stage involved processing, systematization, generalization of indicators, and logical and semantic interpretation of the data. The organization of the research and collection of empirical material was carried out at LSUIA.

STATISTICAL ANALYSIS

The methods of mathematical statistics were used to process the data obtained. The reliability of the difference between the indicators was determined using the Student's t-test. The reliability of the difference was set at $p<0.05$. All statistical analyses were performed using SPSS software, version 10.0, adapted for medical and biological research.

The procedure for organizing the study and the topic of the article were previously agreed with the Committee on compliance with Academic Integrity and Ethics of the LSUIA. Also this study followed the regulations of the World Medical Association Declaration of Helsinki. Informed consent was received from all participants who took part in this study.

RESULTS

The cadets' utilization tour in practical police units lasted for 3 months. It included: performing service duties involving public safety and order, carrying out access control at checkpoints at the entrance to settlements and sectors of the state border, participation in search and prevention activities, etc. This process occurred in the real conditions of future professional activities and was intensified by crisis and extreme martial law situations. The initial study of the components of the psychophysical state of cadets by Well-being-Activity-Mood method led to the conclusion that all three states in the study group of the 3rd training year cadets of the academic year 2023-2024 (Group A, $n = 114$) significantly ($p \leq 0.05$-0.001) deteriorated during their stay in real conditions of professional activities (Table 1). Thus, according to the component Well-being, which was assessed by such characteristics as a sense of strength, working capacity, health, freshness, fatigue level, endurance, cheerfulness, etc., the cadets' performance after the utilization tour deteriorated by 0.6 points.

Such features characterize the Activity component as mobility, activity, speed, enthusiasm, excitement, attentiveness, etc. Thus, the value of deterioration in this component was 0.7 points. In the Mood component, which is characterized by happiness, cheerfulness, optimism, calmness, hope, and satisfaction, the indicators significantly deteriorated by 1.2 points. The deterioration of the indicators is due to the relative exhaustion of future law enforcement officers, which affects their well-being and the body's reaction to the negative factors of service activities under martial law.

A similar trend of results was found during the diagnosis of the 3rd training year cadets of the academic year 2023-2024 in terms of their psychological stress, stress resilience, and assessment of endurance under stress (Table 2).

During the research period, the stress level in the 3rd training year cadets of the academic year 2023-2024 significantly increased by 6.2 points ($p \leq 0.05$). It is stated that at the end of the research, the cadets who undertook their utilization tours in practical units showed an average level of psychological stress, which emphasizes the negative impact of stressors of professional activities under martial law on their mental health. Assessment of the stress resilience level shows that, as a result of the utilization tours, there was a statistically significant ($p \leq 0.01$) deterioration in the cadets' stress resilience level by 3.9 points. The study of the indicators

Table 1. Dynamics of the components of psychophysical state of the 3rd training year cadets of the academic year 2023-2024 by Well-being-Activity-Mood method before and after their utilization tours, in points

Components	Group A	Stages of the research		Δ	t; p
		Before the utilization tour	After the utilization tour		
Well-being	n=114	5.8±0.15	5.2±0.16	0.6	2.74; ≤0.05
Activity		6.1±0.17	5.4±0.18	0.7	2.83; ≤0.05
Mood		4.1±0.16	2.9±0.18	1.2	4.98; ≤0.001

Note: n – sample size; Δ – difference between indicators; t – Student's t-test value; p – p-value
Source: compiled by the authors of this study

Table 2. Dynamics of the indicators of psychological stress, stress resilience, predisposition to stress development, endurance under stress in the 3rd training year cadets of the academic year 2023-2024 before and after their utilization tours, in points

Diagnostic methods	Group A	Stages of the research		Δ	t; p
		Before the utilization tour	After the utilization tour		
PSM-25 Psychological Stress Measure	n=114	102.4±1.86	108.6±1.95	6.2	2.30; ≤0.05
Stress Resilience Self-Assessment Test		17.2±0.88	22.1±0.92	3.9	3.06; ≤0.01
Assessment of Predisposition to Stress Development Method		20.2±1.17	25.1±1.20	4.9	2.92; ≤0.05
Endurance Under Stress Method		16.2±1.11	21.3±1.15	5.1	3.19; ≤0.01

Note: n – sample size; Δ – difference between indicators; t – Student's t-test value; p – p-value
Source: compiled by the authors of this study

of predisposition to stress development shows that during the utilization tours period, the cadets had a significant ($p \leq 0.05$) deterioration in stress level by 4.9 points. The analysis of endurance under stress showed that during the utilization tours, the level of endurance under stress in the cadets also significantly ($p \leq 0.01$) deteriorated by 5.1 points.

To improve the situation and provide proper psychological support to the cadets of the next training years, before they were sent for their utilization tours, we developed the academic subject area referred to as "Professional and Psychological Training of Police Officers", which was introduced into the educational process and provided for the mastery of the theoretical and applied block named "Stress Resilience in Police Activities". This block is 40 hours long and includes classes and training sessions on the following modules: 1. Professional Stress: Concept, Signs, Types; 2. Psychological Determinants of Professional Stress in Police Activities; 3. Methods and Techniques of Stress Resilience Formation; 4. Development of Police Officers' Mental Self-Regulation Skills: Forms, Means, Techniques. The practical component was based mainly on the use of training technologies. To this end, trainings were implemented to increase the effectiveness of personnel training in mastering constructive strategies for overcoming professional stress: 1) communication training, which involves mastering the skills of establishing psychological contact and trusting relationships, and exerting psychological influence; 2) role-playing training, which includes the development of role-playing skills and the ability to improvise through role-playing exercises; 3) psychotechnical games, which involve performing certain roles and actions, as well as simulating complex and real-life law enforcement situations. At the same time, staff psychologists were involved in this process, focusing on the following techniques to reduce stress and increase the stress resilience in future law enforcement officers: anti-stress breathing (slowing down one's breathing and calming down); autogenic training (psychological relief by frequent repetition of special optimistic mobilizing formulas and words, which eventually leads to a reboot of information at all levels of the body); relaxation (releasing the body and mind from excessive stress by reducing the tone of the person's muscles, accompanied by an internal state of calm). In turn, systematic work was carried out to develop skills and techniques of mental self-regulation.

The next stage of our research was the diagnosis of the 3rd training year cadets in the academic year 2024-2025 (using the same methods) after the correctional and pedagogical work carried out in advance, which made it possible to improve the situation compared to the previous academic year (Table 3, Table 4).

Table 3. Dynamics of the components of psychophysical state of the 4th training year cadets of the academic year 2024-2025 by Well-being-Activity-Mood method before and after their utilization tours, in points

Components	Group B	Stages of the research		Δ	t; p
		Before the utilization tour	After the utilization tour		
Well-being	n=112	5.9±0.14	5.5±0.16	0.4	1.88; >0.05
Activity		6.0±0.17	5.6±0.18	0.4	1.62; >0.05
Mood		4.2±0.15	3.7±0.16	0.5	2.28; ≤0.05

Note: n – sample size; Δ – difference between indicators; t – Student's t-test value; p – p-value
Source: compiled by the authors of this study

Table 4. Dynamics of the indicators of psychological stress, stress resilience, predisposition to stress development, endurance under stress in the 4th training year cadets of the academic year 2024-2025 before and after their utilization tours, in points

Diagnostic methods	Group B	Stages of the research		Δ	t; p
		Before the utilization tour	After the utilization tour		
PSM-25 Psychological Stress Measure	n=112	100.2±2.03	104.5±2.11	4.3	1.45; >0.05
Stress Resilience Self-Assessment Test		17.1±0.93	19.7±0.97	2.6	1.93; >0.05
Assessment of Predisposition to Stress Development Method		19.9±1.21	23.3±1.25	3.4	1.95; >0.05
Endurance Under Stress Method		15.6±1.14	18.5±1.17	2.9	1.17; >0.05

Note: n – sample size; Δ – difference between indicators; t – Student's t-test value; p – p-value.
The results indicate that a well-organized professional psychological training improves future law enforcement officers' psychological readiness for professional activities under the influence of wartime stressors
Source: compiled by the authors of this study

As we can see, the specifics of law enforcement officers' service activities under martial law adjust their personal potential, even with prior professional psychological training. All components of the cadets' psychophysical state and stress resilience have deteriorated. However, well-organized correctional and pedagogical work with cadets reduces the degree of negative changes in all diagnostic indicators. In particular, according to the Well-being-Activity-Mood method, the value of deterioration of the components Well-being and Activity is 0.4 points and is unreliable ($p > 0.05$); in the component Mood, there was a significant deterioration by 0.5 points. Still, compared to Group A, these changes are less pronounced by 0.7 points. Even taking into account the general fatigue of the cadets, which affects their state and behavior, with favorable training, they are more psychologically prepared for future professional activities under martial law.

Regarding the dynamics of the indicators of psychological stress, stress resilience, predisposition to develop stress, and endurance under stress in Group B cadets, the changes in indicators are less pronounced compared to Group A. During utilization tours in practical units, the stress level in Group B cadets worsened by 4.3 points (compared to 6.2 points in Group A). Assessment of the stress resilience level showed a lesser deterioration in the stress resilience level in Group B cadets (by 2.6 points) compared to Group A (3.9 points). The study of the indicators of predisposition to stress development also showed less pronounced changes in Group B (by 3.4 points) than in Group A (by 4.9 points). The analysis of endurance under stress showed that during the utilization tours, the level of endurance under stress in Group B cadets deteriorated by 2.9 points. Still, these changes were less pronounced than in Group A (by 5.1 points). It is important to note that in Group B, all changes are not significant ($p > 0.05$), while in Group A, all the studied indicators deteriorated significantly ($p \leq 0.05$-0.01).

DISCUSSION

The specificity of law enforcement officers' service activities is the need to perform professional duties in conditions complicated by the influence of emotional and physical stress factors. In general, the law enforcement profession is characterized by extremity, stressfulness, risk, danger, non-standardization, diversity of service tasks, personal responsibility for decisions, a high level of workload on the individual, etc. This specificity can affect the quality of life and psychological state of law enforcement officers and their general psychophysical well-being. In this context, studying the possibilities of overcoming the stressful phenomena of service activities is particularly important.

B. Qi, Y. K. Wu, I. Okhrimenko, and their colleagues, in their scientific developments, pay attention to the peculiarities of determining the development of professional stress in law enforcement officers, noting many factors as stressors [3, 4, 9]. In some ways, a similar standpoint is taken by H. Yoo and W. D. Franke [10], pointing out that boredom, shift work, dangerous situations, etc., accompany the most typical stressors in law enforcement activities. The authors note that stress is also a factor of negative influence in the work of law enforcement officers, which affects the course and results of the performance of service duties. The data we obtained confirms these positions, because working under systematic stress first affects personal potential, leading to negative changes, and only then, as a consequence, the results of the professional activities of the specialist.

According to P. Galanis, D. Fragkou, and T. A. Katsoulas, timely identification of stress progression factors is the first step towards creating a system of preventive and corrective measures to overcome it by law enforcement officers. The academic subject area referred to as "Professional and Psychological Training of Police Officers" and related correctional and pedagogical measures developed by us aimed to improve the practice of combating stressful events among cadets at the stage of their professional formation. The results revealed positive dynamics and a better attitude of cadets to future professional activities, including at the level of the individual's regulatory focus. This confirms the standpoint of some researchers on this issue [21].

As noted by R. N. Carleton, S. Korol, J. E. Mason, et al. [22], the psychological readiness of a law enforcement officer's personality directly follows from their motivation to work, individual stress resilience, knowledge of mental health, and stigmatization. At the same time, the internal organization of the law enforcement officer in the performance of service tasks, combining all possible personal mechanisms, adds significant weight. Therefore, according to the results of our research, targeted correctional and preventive work with law enforcement officers at different stages of their professional development should be regularly conducted. Moreover, each stage should include diagnostics of law enforcement officers' psychological readiness for professional stress.

CONCLUSIONS

It has been found that professional stress is a peculiar form of reflection by a law enforcement officer of a difficult, extreme situation in their professional activities, which is manifested in their mental reactions. It has been revealed that cadets under the influence of stressful situations of professional activities, even with prior professional psychological training, have negative changes both at the personal (well-being, mood, indicators of the emotional and volitional sphere) and functional (activity, ability to perceive extreme situations adequately) levels. It has been established that the decline in the indicators is due to the relative exhaustion of cadets during their utilization tours in practical units, which affects their well-being and the body's reaction to the negative factors of service in martial law. At the same time, targeted correctional and psychological work with cadets reduces the magnitude of negative changes in all diagnostic indicators: in Group A, the indicators of well-being, activity and mood significantly ($p \leq 0.05$-0.01) deteriorated by 0.6, 0.7 and 1.2 points, and in Group B – by 0.4, 0.4 and 0.5 points, respectively ($p > 0.05$); the indicators of psychological stress, stress resilience, predisposition to develop stress, endurance under stress in Group A deteriorated significantly ($p \leq 0.05$-0.01) by 6.2, 3.9, 4.9, 5.1 points, and in Group B – unreliably ($p > 0.05$) by 4.3, 2.6, 3.4 and 2.9 points, respectively.

The developed academic subject area referred to as "Professional and Psychological Training of Police Officers" is aimed at improving the process of formation and increasing future law enforcement officers' psychological readiness for further professional activities in specific conditions. Its practical significance is manifested in the comprehensiveness of correctional and psychological measures aimed at ensuring the practice of counteracting stressful phenomena among cadets at the stage of their professional formation.

It has been proven that a well-organized professional psychological training contributes to improving the level of future law enforcement officers' psychological readiness for professional activities under the influence of wartime stress factors.

PROSPECTS FOR FURTHER RESEARCH

It is planned to investigate the peculiarities of future law enforcement officers' coping behavior because of martial law stressful situations.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Improving physical working capacity of high school students in the process of their functional training

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ABSTRACT

Aim: To investigate the effectiveness of functional training implementation for improving the physical working capacity of high school students in physical education.

Materials and Methods: The research, which was conducted in 2024-2025, involved 176 high school students aged 16, of whom the experimental (EG) and the control (CG) groups were formed. Functional training was introduced into the physical education classes of the EG, while the CG high school students studied according to the existing program. The following indices were used to assess high school students' physical working capacity: Rufier index, Kerdo vegetative index, circulatory efficiency coefficient, Stange and Genchi tests.

Results: During the research period the EG revealed a significant ($p \leq 0.05$-0.001) improvement in the Rufier index by 0.8 c. u. in boys and by 0.6 c. u. in girls, the Kerdo index – by 0.8 c. u. in boys and by 0.9 c. u. in girls, circulatory efficiency coefficient – by 175.8 c. u. in boys and 189.3 c. u. in girls, the Stange test – by 6.7 seconds in boys and 5.8 seconds in girls, the Genchi test – by 4.3 seconds in boys and 3.9 seconds in girls. At the end of the experiment, the EG high school students had all studied indicators significantly better than the CG's.

Conclusions: The results of the conducted experiment prove the effectiveness of functional training implementation in physical education of high school students to improve their physical working capacity.

KEY WORDS: physical working capacity, functional training, high school students, physical education, cardiovascular system, respiratory system, health

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INTRODUCTION

In today's living conditions in Ukraine, schooling harms children's health. At the same time, innovative educational institutions often accumulate the disadvantages of traditional schools, exacerbating this impact. The intensification of the educational process, permanent stress during martial law causes an increase in the load on the functional state of the high school students' bodies, resulting in changes characterized by a decrease in the functional reserve of the heart, deterioration of mental and physical working capacity, and a limitation of the body's adaptation and adjustment capabilities to motor activity. Excessive study loads, insufficient motor activity during the educational process, and violation of the day and sleep regime during air raids harm the bodies of high school students, whose formation is not yet complete [1-3].

In the context of the implementation of developmental learning technology, a significant number of high school students experience signs of fatigue, which is accompanied by a decrease in working capacity and an increase in morbidity [4, 5]. In recent years, education reforms have been accompanied by the emergence of innovative educational institutions (gymnasiums, lyceums), which are characterized by increased intellectual workload, increased mental stress, decreased motor activity, and intensified learning. At the same time, the volume of high school students' academic workload has increased to such an extent that the resulting limitations of muscle effort and increased neuropsychological stress cause various diseases, deterioration of physical condition, in particular physical working capacity [6, 7].

A high physical working capacity indicates good health; vice versa, a low level is a risk factor. Physical working capacity is associated with motor activity and lower morbidity, including cardiovascular diseases, which are among the leading causes of morbidity among children and youth [8-10]. Thus, the importance

of physical working capacity for the younger generation's health actualizes the search for and application of new, effective physical education and health-improving methods and technologies in school physical education.

AIM

The aim is to investigate the effectiveness of functional training implementation for improving the physical working capacity of high school students in physical education.

MATERIALS AND METHODS

PARTICIPANTS

The research involved 176 high school students aged 16 (89 girls and 87 boys), of whom the experimental (EG) and the control (CG) groups of the general secondary education institution Lyceum No. 17 "Kyrylivskyi" in Kyiv were formed. The groups of high school students for the study were formed randomly. The EG included 85 high school students (41 girls and 44 boys) from two tenth grades (A and B), and the CG included 91 high school students (48 girls and 43 boys) from the other two tenth grades (C and D). Functional training was introduced into the main part of physical education classes in the EG, while the CG high school students studied according to the existing program. The EG and the CG with girls and boys were homogeneous ($p > 0.05$), which is confirmed by the absence of a significant difference between the studied indicators at the beginning of the experiment. The experiment lasted for 9 months in the academic year 2024-2025 (September-May), was open, and the high school students were informed about its aim and tasks, which contributed to increased interest in the classes.

Research methods include the analysis and generalization of literary sources, medical and biological methods, and statistical methods. The analysis and generalization of literary sources were employed to substantiate the theoretical problem (20 sources from the scientometric databases MedLine, Scopus, and Web of Science were analyzed). The medical and biological methods allowed us to assess the high school students' physical working capacity indicators.

Rufier index (RI, c. u.) was used to assess physical working capacity by the functional state of the cardiovascular system of high school students. The method of its measurement is as follows: after five minutes of rest, in a sitting position, the subject's pulse was counted for 15 seconds. After that, the high school student performed 30 squats with arms extended forward for 45 seconds. At the end of the squats, the pulse was counted for the first 15 seconds of the first minute of recovery and for the last 15 seconds of the first minute of recovery. The assessment of the functional capabilities of the cardiovascular system was calculated by the formula: $RI = 4 \times (P1 + P2 + P3) / 10$, where: P1 is pulse for 15 seconds at rest; P2 is pulse for the first 15 seconds of the first minute of recovery; P3 is pulse for the last 15 seconds of the first minute of recovery. The level of functional heart reserve and adaptive capacities of an organism to motor loads in 16-year-old high school students was determined taking into account five gradations: less than 3 c. u. – high level; 4-6 c. u. – above average (good); 7-9 c. u. – average; 10-14 c. u. – below average (satisfactory); more than 15 c. u. – low.

Kerdo vegetative index (KI, c. u.) characterizes myocardial blood flow and was calculated by the formula: $KI = (1 – (DBP / HR)) \times 100$, where: DBP is diastolic blood pressure, mm Hg; HR is heart rate at rest, beats per minute. An increase in the KI indicates a weakening of the reserve functions of blood circulation regulation, which leads to a decrease in the body's aerobic capacity, and its positive value means an increase in sympathetic tone. A negative value of the KI indicates a predominance of parasympathetic influences in the studied groups. Its significant negative growth indicates an increase in the reserves of the circulatory regulation function and increases the body's aerobic capacity.

Circulatory efficiency coefficient (CEC, c. u.) is intended to assess the functioning of the cardiovascular system and was calculated by the formula: $CEC = (SBP – DBP) \times HR$, where SBP is systolic blood pressure, mm Hg; DBP is diastolic blood pressure, mm Hg; HR is resting heart rate, beats per minute. The normal value of the CEC indicator is 2600-3600 c. u., which corresponds to a healthy person. If the value exceeds this indicator, it may indicate a cardiovascular system malfunction. An increase in the CEC indicates an increase in energy consumption for the movement of blood through the body, a decrease in the CEC indicates an increase in the potential capabilities of the hemocirculatory system, a decrease in energy consumption for the movement of blood through the body.

The functional state of the respiratory system was determined by the Stange test (arbitrary breath holding on inhalation) and the Genchi test (breath holding on exhalation). The results of the tests were compared with the norms. For the Stange test, these norms are: more than 40 seconds – good; 35-39 seconds – satisfactory; less than 34 seconds – unsatisfactory; for the Genchi test, respectively: 50-60 seconds – excellent; 39-45 seconds – good; 20-34 seconds – satisfactory; 10-19 seconds – poor; less than 10 seconds – very poor.

Table 1. Average indicators of cardiovascular and respiratory system functioning in 16-year-old high school students (n = 176), X ± m

Boys (n = 87)	Girls (n = 89)
RI, c. u.	
9.2 ± 0.15	7.8 ± 0.13
KI, c. u.	
4.8 ± 0.16	7.7 ± 0.18
CEC, c. u.	
3442.0 ± 45.55	3158.1 ± 46.71
Stange test, sec	
45.5 ± 1.81	40.0 ± 1.69
Genchi test, sec	
23.2 ± 0.89	23.1 ± 0.75

Legend: X is the arithmetic mean; m is the standard error of the arithmetic mean
Source: compiled by the authors of this study

Table 2. Dynamics of indicators of the functional state of the cardiovascular system of high school students of the EG (n = 85) and the CG (n = 91) during the pedagogical experiment, X ± m

Functional indices	Groups	Stages of the experiment		The difference	Reliability of the difference (t, p)
		Before	After		
		Boys			
RI, c. u.	CG	9.1 ± 0.16	8.9 ± 0.15	-0.2	t = 0.91; p > 0.05
	EG	9.0 ± 0.15	8.2 ± 0.14**	-0.8	t = 3.90; p ≤ 0.001
		Girls			
RI, c. u.	CG	7.7 ± 0.13	7.6 ± 0.12	-0.1	t = 0.57; p > 0.05
	EG	7.8 ± 0.14	7.2 ± 0.13*	-0.6	t = 3.14; p ≤ 0.01
		Boys			
KI, c. u.	CG	4.9 ± 0.15	4.7 ± 0.15	-0.2	t = 0.94; p > 0.05
	EG	4.7 ± 0.16	3.9 ± 0.14**	-0.8	t = 3.76; p ≤ 0.001
		Girls			
KI, c. u.	CG	7.8 ± 0.19	7.5 ± 0.17	-0.3	t = 1.18; p > 0.05
	EG	7.7 ± 0.18	6.8 ± 0.17**	-0.9	t = 3.64; p ≤ 0.001
		Boys			
CEC, c. u.	CG	3446.6 ± 44.97	3398.1 ± 45.14	-48.5	t = 0.76; p > 0.05
	EG	3441.4 ± 45.11	3265.6 ± 44.24*	-175.8	t = 2.78; p ≤ 0.05
		Girls			
CEC, c. u.	CG	3158.2 ± 46.39	3102.3 ± 46.51	-55.9	t = 0.85; p > 0.05
	EG	3156.7 ± 46.82	2977.4 ± 45.73*	-189.3	t = 2.89; p ≤ 0.05

Legend: X – the arithmetic mean; m – the standard error of the arithmetic mean t – Student's t-test value, p – statistical significance indicator; *, ** – reliability of the difference between the EG and the CG at the end of the research at the level of p ≤ 0.05, p ≤ 0.01
Source: compiled by the authors of this study

STATISTICAL METHODS

At the beginning of the pedagogical experiment, the homogeneity of all indicators of the EG and the CG high school students was determined, i.e., the absence of a significant difference in the studied indicators (p > 0.05), and it was found that the distributions of the EG and the CG are normal, which allowed us to assess the reliability of the results using Student's t-test. The reliability of the difference was set at p ≤ 0.05. All statistical analyses were performed using SPSS software. The results were presented as X ± m, where X is the arithmetic mean and m is the standard error of the arithmetic mean.

ETHICAL STANDARDS

The process of research implementation is built following the requirements of scientific ethics. The Academic

Table 3. Dynamics of indicators of the functional state of the respiratory system of high school students of the EG (n = 85) and the CG (n = 91) during the pedagogical experiment, X ± m

Functional indices	Groups	Stages of the experiment		The difference	Reliability of the difference (t, p)
		Before	After		
		Boys			
Stange test, sec	CG	45.5 ± 1.84	46.2 ± 1.82	+ 0.7	t = 0.27; p > 0.05
	EG	45.4 ± 1.79	52.1 ± 1.83*	+ 6.7	t = 2.62; p ≤ 0.05
		Girls			
Stange test, sec	CG	39.9 ± 1.68	40.4 ± 1.69	+ 0.5	t = 0.21; p > 0.05
	EG	40.1 ± 1.70	45.9 ± 1.75*	+ 5.8	t = 2.38; p ≤ 0.05
		Boys			
Genchi test, sec	CG	23.2 ± 0.91	24.0 ± 0.93	+ 0.8	t = 0.61; p > 0.05
	EG	23.0 ± 0.88	27.3 ± 0.92*	+ 4.3	t = 3.38; p ≤ 0.01
		Girls			
Genchi test, sec	CG	22.9 ± 0.74	23.5 ± 0.77	+ 0.6	t = 0.56; p > 0.05
	EG	23.0 ± 0.76	26.9 ± 0.79**	+ 3.9	t = 3.56; p ≤ 0.01

Legend: X – the arithmetic mean; m – the standard error of the arithmetic mean t – Student's t-test value, p – statistical significance indicator; *, ** – reliability of the difference between the EG and the CG at the end of the research at the level of p ≤ 0.05, p ≤ 0.01
Source: compiled by the authors of this study

Ethics Commission of the Ukrainian State Dragomanov University approved the research. Also this research followed the regulations of the World Medical Association Declaration of Helsinki – ethical principles for medical research involving human subjects. The participants were informed about the aim and tasks of the research, and they voluntarily participated in it.

RESULTS

Physical working capacity was determined in the process of assessing the functional state of the cardiovascular system of the 10th-grade high school students by Rufier, Kerdo indices, and circulatory efficiency coefficient, as well as by indicators of the functional state of the respiratory system by Stange and Genchi tests before and after the pedagogical experiment. The average group data of the cardiovascular and respiratory systems functioning of 16-year-old boys and girls are presented in Table 1.

Comparison of the obtained data characterizing physical working capacity in blood circulation and respiration with age norms showed that they correspond to the average level.

During the pedagogical experiment, functional training was introduced into the physical education of the EG high school students. Functional training is one of the modern physical culture and health technologies characterized by high intensity of muscle work and involvement of all muscle groups. The peculiarity of functional exercises is the strengthening and development of deep stabilizing muscles that support the spine and joints from daily loads and injuries, emphasis on the core muscles through movements with body weight and external resistance: squats, dynamic lunges, lifts, presses, burpees, bends, jumps, isometric exercises to hold the body position and their combination with various movements, etc. Functional training combines elements of gymnastics, aerobics, cardio, and strength exercises. Functional training is characterized by the following features: organization of motor activity with musical accompaniment; a wide range of physical exercises and their combinations, which allow for the development of various motor skills; absence of direct load on the skeleton and joints; possibility of easy regulation of motor loads following the gender and age characteristics and level of fitness of high school students; high dynamism and emotionality of classes. Given that physical working capacity is characterized by the potential ability to perform static, dynamic, and mixed muscle work based on the functional capabilities of the cardiorespiratory system in different modes of energy supply, the priority task in the process of functional training was to develop different types of endurance and strength.

Physical education classes based on functional training were conducted according to a structure that includes three parts: preparatory, main, and final (recovery). The preparatory part solved the following tasks: organizing high school students and activating their attention; creating an appropriate psychological attitude and positive emotional state; preparing the

body for future motor activity. The classes began with an aerobic part, including a general developmental exercise warm-up. The duration of the preparatory part is 20 % of the training time. The structure of the main part of the lesson depended on the tasks set. If the task was to promote the development of general endurance, the aerobic long protocol was used, which involved 1-5 minutes of work and more, depending on the level of high school students' fitness. If the task was to promote the development of strength and anaerobic endurance, the aerobic short protocol was used, which provided 30-60 seconds of work. At the same time, strength exercises were used to develop the muscles of the abdominal press, trunk, shoulder girdle, muscles of the legs, and arms. The pace of the exercises was chosen as intensive (as many repetitions of the exercise as possible) or extensive (performing the exercise at an individual pace). At an intensive pace, a relatively complete rest was planned (90-120 seconds), at an extensive pace – a rigid rest between series of exercises was planned (until incomplete recovery 60 seconds). The duration of the main part is 70 % of the training time. After each series of strength exercises, exercises to stretch the working muscles were performed. The final part made up 10 % of the training time and involved the use of stretching exercises (elements of stretching, Pilates); restorative breathing exercises (elements of breathing exercises); relaxation exercises (elements of yoga).

Depending on the targeted focus of classes with high school students, the level of their motor and functional abilities, and other factors, the generalized structure of functional training had different variations. Special equipment was used in physical education classes: fitballs, rubber balls, jump ropes, expander-loops, weighting cuffs, dumbbells of different weights, which allowed for diversifying classes and more purposefully influencing the body of high school students to increase their physical working capacity. From this point of view, we considered functional training a highly effective system of health-improving classes aimed at improving physical conditions, health promotion, and harmonious physical development of high school students.

During the pedagogical experiment, the CG high school students studied according to the current physical education curriculum. To determine the effectiveness of functional training at the end of the school year, control measurements of the functional state of the cardiovascular and respiratory systems were conducted in the EG and the CG high school students. As a result of the introduction of functional training into the physical education of high school students, there is a statistically significant ($p \leq 0.05$-0.001) difference between all studied indicators before and after the experiment, both in boys and girls of the EG. The difference between indicators before and after the experiment in the CG was not significant ($p > 0.05$) (Table 2).

The analysis of the RI shows that during the experiment the indicators of the EG high school students significantly ($p \leq 0.01$) improved by 0.8 c. u. in boys and by 0.6 c. u. in girls, in contrast to the CG, where the difference between the initial and final data of the experiment was 0.2 and 0.1 c. u. in boys and girls, respectively ($p > 0.05$). The comparative analysis of the RI in the EG and the CG at the end of the research shows that functional training has a more pronounced positive effect on improving the functioning of the cardiovascular system in 16-year-old high school students compared to the current school curriculum: the indicators of the RI in the EG at the end of the experiment were significantly better than in the CG by 0.7 c. u. in boys ($p \leq 0.01$) and by 0.4 c.u. in girls ($p \leq 0.05$). Analysis of the KI also testifies to the positive influence of functional training classes on the functional state of the cardiovascular system of high school students of the EG: more expressed changes in the indicators of the KI were revealed in the EG than in the CG during the research period. Thus, in the EG boys the value of the KI significantly decreased by 0.8 c. u., and in girls – by 0.9 c. u. ($p \leq 0.001$); in the CG, there was also an improvement in the KI, but the changes were not significant ($p > 0.05$). At the end of the research, the EG indicators were significantly better than in the CG by 0.8 and 0.7 c.u. in boys and girls, respectively ($p \leq 0.01$). The obtained results testify to the strengthening of reserves of the function of blood circulation regulation in the EG high school students, which leads to the growth of aerobic capacities of their organism. The analysis of the CEC indicators confirms our previous conclusions about the effectiveness of functional training on the functioning of the cardiovascular system of the EG high school students. During the research period, the EG boys and girls, in contrast to the CG, had a significant ($p \leq 0.05$) decrease of the CEC values by 175.8 and 189.3 c. u. respectively, which indicates an increase of potential capabilities of hemocirculatory system, decrease of energy expenditures for blood movement through the body. At the end of the research, the CEC indicators in the EG were also significantly better than in the CG, by 132.5 and 124.9 c. u. in boys and girls, respectively ($p \leq 0.05$).

Positive dynamics in both groups' breath samples of high school students during the experiment were also established, but changes were reliable only in the EG (Table 3).

The analysis of the indicators of the Stange and Genchi tests in high school students at the end of the research showed that both the EG boys and girls had

significantly ($p \leq 0.05$-0.01) better indicators than the CG, by 5.9 seconds and 5.5 seconds in the Stange test and by 3.3 seconds and 3.4 seconds in the Genchi test in boys and girls, respectively. This indicates the effectiveness of functional training on improving the functioning of the respiratory system in 16-year-old high school students. Thus, due to the introduction of functional training in the process of physical education of 16-year-old high school students, there is a significant improvement in the activity of their cardiovascular and respiratory systems. In addition, according to the results of attending classes, the developed program improved the level of motivation of high school students to systematic physical exercises.

DISCUSSION

The effectiveness of the educational process in physical education depends on many factors, in particular, on the choice of sports by high school students, the qualifications of the physical education teacher, climatic and geographical conditions, the condition of the equipment, the availability of appropriate equipment, during classes in the gymnasium, swimming pool, playground or outdoor sports ground, stadium, natural environment, and others [11, 12]. At the same time, functional training is considered to be a very promising health-improving technology that is accessible and quite popular among young people, expands opportunities for improving physical fitness, functional capabilities of the body, motivation for motor activity, improving physique, muscle relief, psycho-emotional state, manifestation of high school students' individuality, and diversification of the process of physical education [13, 14].

Functional training consists of aerobics, cardio training and strength training with musical accompaniment, includes a wide range of physical exercises taking into account interests and needs of high school students and their level of fitness, does not require special qualification from physical education teacher, special conditions for classes, sophisticated equipment and inventory, allows to vary motor loads and methods of organization of those engaged (frontal, game, circle) and to engage any number of high school students [15, 16].

Motor exercises of functional aerobics training include general developmental exercises in sitting and lying position (exercises for feet, exercises for legs in lying position and in kneeling position, exercises for abdominal muscles in lying position on the back, exercises for back muscles in lying position on the stomach and in kneeling position); in a standing position (exercises for arms and shoulder girdle in different directions, exercises for torso and neck, exercises for legs); stretching exercises, basic aerobics steps, types of running in place, jumps, static exercises for holding static positions in a supine position, lying on bent arms, the same supports in combination with accompanying movements [17, 18].

Scientists [19, 20], according to the results of their research, note that when choosing physical exercises for functional training classes, it is necessary to consider the age, gender, and level of physical fitness of those who are engaged. At the same time, the exercises are performed at an intensive and extensive pace and provide for relatively complete and rigid rest options, i.e. until incomplete recovery, which, through the targeted development of strength and various types of endurance, allows for an impact on aerobic working capacity, increasing the physical working capacity of the high school students' bodies. Our research confirms the conclusions of many scientists that functional training has potential for improving the morphological and functional status of the body, increasing the speed of metabolic processes, which contributes to weight loss by burning fat. In addition, the pedagogical effect of using functional training in the process of physical education of 16-year-old high school students is observed since this age is a sensitive period for the development of strength and endurance. Other scientists share a similar opinion [13, 16].

Our results also complement the results of other scientists in terms of the fact that the variability of the content of functional training classes due to a wide range of motor loads and a variety of equipment arouses a keen interest in both boys and girls. The impact on the psycho-emotional state of high school students is achieved through musical accompaniment. In addition, in our opinion, for the first time we have identified the strategic importance of including functional training in rationally organized motor activity of high school students is that it has an impact on the psycho-emotional and physical state of the body, namely, reducing permanent stress of high school students during martial law, improving the functional reserve of the heart, physical working capacity, adaptation and adjustment capabilities of the body to motor loads.

CONCLUSIONS

As a result of the implementation of functional training in the EG high school students, there were recorded reliable positive changes in indicators of the functional state of the cardiovascular and respiratory systems. During the research period in the EG there was a sig-

nificant ($p \leq 0.05$-0.001) improvement of the indicators of the RI by 0.8 c. u. in boys and by 0.6 c. u. in girls, the KI – by 0.8 c. u. in boys and by 0.9 c. u. in girls, the CEC – by 175.8 c. u. in boys and 189.3 c. u. in girls, the Stange test – by 6.7 seconds in boys and 5.8seconds in girls, the Genchi test – by 4.3 seconds in boys and 3.9 seconds in girls. As for the dynamics of physical working capacity of the CG boys and girls according to all studied indicators of the functional state of the cardiovascular and respiratory systems, it is positive, but does not have statistical significance ($p > 0.05$).

At the end of the experiment, all studied indicators in the EG high school students were significantly ($p \leq 0.05$-0.001) better than in the CG. Thus, the indicators of the RI in the EG are better than in the CG by 0.7 and 0.4 c. u. in boys and girls, respectively; the indicators of the KI – by 0.8 and 0.7 c. u. in boys and girls, respectively; the indicators of the CEC – by 132.5 and 124.9 c. u. in boys and girls, respectively; the indicators of the Stange and the Genchi tests by 5.9 and 5.5 seconds and by 3.3 seconds and 3.4 seconds in boys and girls, respectively. This indicates that functional training has a more pronounced positive effect on improving the functioning of the cardiovascular and respiratory systems in 16-year-old high school students compared to the current school curriculum. The results also indicate an increase in the reserves of the circulatory regulation function in the EG high school students, which leads to an increase in the aerobic capacity of their bodies and health improvement.

The results of the conducted pedagogical experiment allow us to assert the effectiveness of functional training for increasing the physical working capacity of 16-year-old high school students in physical education classes.

PROSPECTS FOR FURTHER RESEARCH

Further research will be directed to the determination of the influence of functional training on high school students' somatic and mental health.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Improvement of the functional and psycho-emotional state of female students in the process of their swimming training sessions

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ABSTRACT

Aim: To investigate the impact of swimming training sessions on the functional and psycho-emotional state of female students in the process of their studying under martial law.

Materials and Methods: The research, conducted in 2024-2025, involved 85 female students aged 17-18 in the first year of study. The experimental (EG, n = 42) and the control (CG, n = 43) groups were formed. The EG female students attended a swimming sports club; the CG female students were engaged in a traditional physical education program. Methods: analysis and generalization of literary sources; Harvard step test; methodology for assessing adaptive potential; body mass index; stress level test; methods of mathematical statistics.

Results: It has been found that during the research period, the EG female students improved the adaptive potential of the cardiovascular system (by 0.09 c. u.), increased their Harvard step test indicators of the speed of recovery processes in the body after physical exertion (by 4.3 c. u.), and reduced the level of stress (by 3.0 points), while in the CG female students no changes in the studied indicators were recorded. At the end of the research, most of the studied indicators of the EG female students were significantly ($p \leq 0.05$) better than in the CG.

Conclusions: After orienteering training sessions, the EG high schoolers showed a significant improvement in physical health indicators, which confirms the enhanced health-improving effect of this type of motor activity in the natural environment.

KEY WORDS: female students, motor activity, swimming, functional state, psycho-emotional state, stress, health, martial law

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INTRODUCTION

The difficult realities of modern life in Ukraine under martial law lead to the accumulation of negative emotions and feelings, increasing the psycho-emotional pressure on students' personalities. The intensification and application of various forms of organizing the educational process at universities, the emergence of a lack of motor activity during study, worsens the functional state of students, significantly reducing the physiological resources of the body. The first year of studying at higher educational institutions is difficult, causing a change in the usual household and motor regime, excessive stress on the cognitive functions and mental sphere of students, and therefore causes the manifestation of academic stress, which can negatively affect their physical and mental health [1, 2].

The biological aspect of students' learning activities in the conditions of martial law stressors involves the economical use of the body's functional reserves to preserve health, which ensures the full functioning of the body's major systems and maintaining optimal performance in the face of increased energy consumption during study, independent work, and examination sessions. The proper level of performance of educational activities in the conditions of increased stressfulness of the educational environment is associated with the adaptive capabilities of the students' body [3, 4]. The power of regulatory systems and mobilization of functional reserves determines the adaptive potential of the body. The role of the cardiovascular system in adapting the human body to the negative effects of the stressful environment

has been proven, and the informativeness of heart rate variability indicators in diagnosing the adaptive capabilities of the students' body in learning has been confirmed [5]. Scientists [6] consider the level of functioning of the circulatory system as a leading indicator of the balance between the body and the environment. The heart's functional reserve impacts the body's resistance to physical and psycho-emotional stress. Since functional reserves include the range of activation of the capabilities of physiological systems, and their depletion leads to a failure of the adaptive mechanism, the level of vegetative changes in the parameters of the cardiovascular system, taking into account morphological data, can be used to assess the adaptive potential of the body [7]. Scientists [8] point to the importance of the functional capabilities of the cardiovascular system in the adaptation process and resistance to stressors.

Therefore, the implementation of health-improving tasks in the process of physical education in the system of higher education of Ukraine should be approached from the standpoint of the theory of adaptation, since the adaptive capabilities of the body determine the degree of individual health of students, which has deteriorated greatly in recent years, especially during the war [9-12]. It is known that the most effective and rational means of improving the adaptive capacity of the human body is aerobic motor activity, which affects all physiological systems of the body, especially the cardiovascular system. At the same time, it is important to assess the effectiveness of the exercise in reducing stress levels. This is of strategic importance and actualizes the use of such types of motor activity that can simultaneously maintain and improve students' functional and psycho-emotional state.

AIM

The aim is to investigate the impact of swimming training sessions on the functional and psycho-emotional state of female students in the process of their studying under martial law.

MATERIALS AND METHODS

The research, conducted in 2024-2025, involved 85 female students aged 17-18 years of the 1st academic year at the Ukrainian State Dragomanov University (USDU, Kyiv, Ukraine), specialty: 015 Vocational Education and 035 Philology. To test the effectiveness of physical exercises on maintaining and improving female students' functional and psycho-emotional state, we formed the experimental (EG) and the control (CG) groups solely at their own will. The experimental group included 42 female students, the control group – 43 female students, all of whom had no significant health problems. The EG girls attended the swimming training sessions twice a week for 2 academic hours; all involved female students knew how to swim. The girls of the CG were engaged in the traditional physical education program in the same amount. At the same time, the level of their weekly motor activity in extracurricular time was not studied.

Research methods: analysis and generalization of literary sources; Harvard step test; R. M. Bayevsky's methodology; body mass index; stress level test; methods of mathematical statistics. The Harvard step test was used to study the physical performance of the cardiovascular system by measuring the speed of recovery processes in the body after aerobic exercise. The step test is based on climbing a 50-centimeter-high bench with a frequency of 30 cycles per minute (120 steps) for 5 minutes. The formula determined the Harvard step test index (HSTI): HSTI = 100 x t / 5.5 x n, where t is the time of ascent in seconds; n is the heart rate for the first 30 seconds of the second minute of recovery. The level of physical performance was assessed as low if the HSTI was less than 55 c. u., below average – 55-64 c. u., average – 65-79 c. u., above average – 80-89 c. u., high – 90 c. u. and more. The methodology of R. M. Bayevsky was used to assess the adaptive potential of the cardiovascular system, based on the consideration of prognostically significant morphological parameters. The length (L, cm) and body mass (m, kg), heart rate (bpm), systolic (SBP, mm Hg) and diastolic blood pressure (DBP, mm Hg), and age (years) of the studied female students were determined. The formula calculated the value of adaptive potential (AP): AP = 0.011 x HR + 0.014 x SBP + 0.008 x DBP + 0.014 x age + 0.009 x m + 0.009 x L – 0.27. The state of functional adaptability of female students' body was evaluated according to a certain gradation: sufficient functional capabilities of the body with satisfactory adaptation to environmental conditions (1.50-2.59 c. u.), functional tension of the body with increased activation of adaptation mechanisms (2.60-3.09 c. u.), decrease in functional capabilities of the body with unsatisfactory adaptation of functional systems to environmental conditions (3.1-3.6 c. u.), sharp decrease in functional capabilities of the body on the verge of failure of adaptation mechanisms (3.6 and more c. u.). To assess the risk of cardiovascular disease, the body mass index (BMI) was used, which was calculated by the formula: BMI = m / L^2 [kg/m^2]. Norms of BMI: if BMI < 18.5, then body

Table 1. Characteristics of the indicators of the functional and psycho-emotional state of the EG and the CG female students at the beginning of the pedagogical experiment (M ± m)

Indicators under study	EG (n = 42)	Level under the norm	CG (n = 43)	Level under the norm	The difference	t / p
HSTI, c. u.	67.5 ± 1.61	average level	66.8 ± 1.55	average level	1.1	0.49 / > 0.05
AP, c. u.	2.12 ± 0.08	satisfactory adaptation	2.14 ± 0.09	satisfactory adaptation	0.02	0.17 / > 0.05
BMI, kg/m^2	21.6 ± 0.37	normal body mass	21.7 ± 0.41	normal body mass	0.1	0.18 / > 0.05
SL, points	13.5 ± 1.14	severe stress	14.1 ± 1.21	severe stress	0.6	0.36 / > 0.05

Legend: M – arithmetic mean, m – error of the arithmetic mean, t – Student's t-test value, p – statistical significance indicator
Source: compiled by the authors of this study

Table 2. Characteristics of the indicators of the functional and psycho-emotional state of the EG and the CG female students after the pedagogical experiment (M ± m)

Indicators under study	EG (n = 42)	Level under the norm	CG (n = 43)	Level under the norm	The difference	t / p
HSTI, c. u.	71.8 ± 1.65	average level	66.9 ± 1.57	average level	4.9	2.15 / ≤ 0.05
AP, c. u.	2.03 ± 0.07	satisfactory adaptation	2.13 ± 0.08	satisfactory adaptation	0.1	0.94 / > 0.05
BMI, kg/m^2	21.2 ± 0.31	normal body mass	21.9 ± 0.45	normal body mass	0.7	1.28 / > 0.05
SL, points	10.5 ± 1.16	moderate stress	13.9 ± 1.18	severe stress	3.4	2.05 / ≤ 0.05

Legend: M – arithmetic mean, m – error of the arithmetic mean, t – Student's t-test value, p – statistical significance indicator
Source: compiled by the authors of this study

mass is insufficient, BMI is in the range from 18.5 to 24.9 – body mass is normal; BMI is in the range from 25.0 to 29.9 – body mass is overweight, which is a risk of cardiovascular disease; BMI > 30 is a sign of obesity. To determine the stress level (SL), we used the methodology of Yu. V. Shcherbatykh, which is a questionnaire that allows you to explore various signs of stress – intellectual, behavioral, emotional and physiological and determine the overall level of stress. A female student could receive from 0 to 66 points based on the answers to the questions. The data obtained as a result of the survey indicate absence of stress at this point in life (0-5 points); the fact that the female student is experiencing moderate stress, which can be compensated for in the process of rational use of time, healthy rest and finding a rational way out of a problem situation (6-12 points); rather severe stress that could not be compensated for, and the resulting severe psycho-emotional stress of the body, which arose in response to it and determines the need for special methods of overcoming stress (13-24 points); a state of severe stress, for the successful overcoming of which psychological assistance is desirable (25-40 points). The latter level (over 40 points) indicates that the body is already having difficulty resisting stress, or that the body is moving to the third, most dangerous stage of stress – depletion of adaptive energy reserves.

The statistical processing of the results was performed using the methods of variation statistics. Before the experiment, both groups of girls were tested for normality of distribution using the Kolmogorov-Smirnov test in IBM SPSS Statistics 23.0. The samples were found to be subject to the normal distribution law, which allows for statistical calculations using Student's t-test. The digital data of the studied indicators were presented in the form (M ± m), where M is the arithmetic mean and m is the error of the arithmetic mean. The reliability of the difference between the indicators of students of the studied groups was determined using Student's t-test. The level of statistical significance of the research results was chosen as 5 %, that is, the reliability of the difference between the studied indicators is p ≤ 0.05. Girls' EG and CG groups were homogeneous (p > 0.05), which was confirmed by the absence of a significant difference between the studied indicators of the functional and psycho-emotional state at the beginning of the experiment.

The research implementation process is built following the requirements of scientific ethics. The USDU Academic Ethics Commission approved the research. The pedagogical experiment lasted 9 months of the

2024/2025 academic year (September-May), was open, female students were informed about its aim and tasks, and they voluntarily participated in it.

RESULTS

The results of the study of the functional and psycho-emotional state level of the EG and the CG female students in terms of their HSTI, AP, and BMI, and SL at the beginning of the experiment are presented in Table 1.

It has been established that at the beginning of the experiment, there was no significant difference between the EG and the CG female students in terms of indicators of the body's functional state ($p > 0.05$). The average group data of the studied indicators in the girls of both groups indicate satisfactory adaptation of the cardiovascular system, an average level of physical performance, and normal body mass under the defined norms. It has been found that the 1st year female students are characterized by severe stress and the resulting pronounced psycho-emotional stress of the body, which arises in response to it and determines the need for special methods of overcoming stress, particularly organized motor activity.

To maintain and improve the functional and psycho-emotional state of the EG girls, swimming training sessions were offered as a fairly popular type of motor activity. Swimming training sessions were held in the USDU indoor pool, 25 meters long, containing 6 lanes. Swimming is a cyclic type of aerobic motor activity. Since the volume and intensity of muscle activity in the process of swimming can vary widely (from a stationary position in the water to performing exercises at maximum speed, at which the HR can increase to 160-180 beats per minute), it can be used for female students with different levels of physical health and fitness. Musical accompaniment contributes to a high emotional level of training sessions, a huge arsenal of tools and methods for performing exercises in water provides opportunities for exercising both individual muscles and various muscle groups.

The swimming training session consisted of three parts: preparatory (warm-up on land – 10-15 minutes), main (aqua fitness exercises 15-20 minutes + distance swimming 35-40 minutes), and final (5-15 minutes), each of which has its purpose. The preparatory part was aimed at preparing the body for the main load. It included general developmental exercises to warm up the working muscles and joints on land (exercises for the muscles of the neck, shoulder girdle, torso, legs, exercises for mobility of the shoulder, hip, and ankle joints, etc.). The main part of aqua fitness exercises planning included mainly aqua aerobics and aqua power exercises. It involved the performance of cyclic and acyclic aerobic and strength exercises with and without additional equipment or weights to develop speed, strength of coordination muscles. Different starting positions, intensity of performance, use of additional weight, etc., provide the variability of pedagogical influence. Distance swimming included swimming exercises using sports, mixed and original methods in different training modes, with full coordination of movements and coherence with breathing, and by elements (swimming with a board on hands or feet, swimming with blades, swimming in flippers, and swimming under water). The goal of distance swimming was to increase aerobic, speed, and strength endurance, as well as coordination and strength endurance. The swimming intensity for female students was planned to be moderate (at a heart rate of 130-170 beats per minute), with the distance segments of 50-400 m. Swimming at a moderate pace was planned to be of a greater volume and vice versa. With the growth of training in the process of systematic training sessions, they tried to increase the total distance. The final part contained exercises that promote the recovery of the body after physical exertion: breathing exercises, relaxation exercises, stretching, hydromassage, sliding, and lying on the water.

At the end of the experiment, a follow-up assessment of the functional and psycho-emotional state indicators was conducted among the EG and the CG female students, and their homogeneity was examined (Table 2).

A significant improvement in physical performance (by 4.3 c. u., $p \leq 0.05$), adaptive potential (by 0.09 c. u., $p > 0.05$), reduction of stress level (by 3.0 points, $p \leq 0.05$) and body mass index (by 0.4 kg/m^2, $p > 0.05$) was found in female students who were engaged in swimming during the academic year. There were no significant changes in any studied indicators in the CG female students ($p > 0.05$).

It has been found that after the experiment, the EG female students have significantly better indicators of physical performance (by 4.9 c. u.) and lower indicators of stress level (by 3.4 points) than the CG female students ($p \leq 0.05$). At the same time, the differences between the indicators of adaptive potential of the cardiovascular system and body mass index in the EG and the CG female students were not significant ($p > 0.05$). It should be noted that swimming training sessions contribute to a significant reduction in stress levels, in particular, the differences in stress levels in the EG and the CG female students were significant: the stress level of the girls who were involved in swimming training sessions decreased to a moderate level, and in

the girls who were involved in the traditional physical education program remained at the level of severe stress. Thus, the results of our research showed that swimming training sessions have a high health effect, contribute to the maintenance and improvement of the functional and psycho-emotional state of female students during their studies at higher educational institutions under martial law.

DISCUSSION

The academic stress of the 1st year students and the challenges of martial law significantly impact physical and mental health, accelerating the consumption of energy resources, depleting the body's functional reserves. The stock of functional reserves of the body measures its adaptive capabilities, which ensure the adaptation of physiological systems to changes in the usual motor regime, increased neuropsychic stress, overload of the cognitive and volitional spheres in the educational environment [2, 13].

The cardiovascular system, with its regulatory apparatus, is considered the most sensitive indicator of an individual's adaptive capabilities to physical and psycho-emotional stress. Adaptive capacities and physical performance are interrelated and characterize the body's ability to quickly and efficiently restore functional resources and compensate for energy expenditure [5, 14, 15]. It is generally recognized that the level of physical performance is one of the most important criteria for assessing somatic health, characterizing the state of the cardiovascular system as the basis of life support [16, 17]. Scientists [18] have proven that the level of cardiovascular system functioning depends on stress and body weight. Stress, especially prolonged stress, can lead to increased blood pressure, changes in heart rate, and an increased risk of developing cardiovascular disease, and being overweight has an increased impact on the functioning of the heart, depleting it more quickly. Therefore, to assess the adaptive capabilities of students' bodies to academic stress, we chose indicators that characterize physical performance, the speed of recovery processes, stress levels, and body mass as a marker of cardiovascular disease risk.

Among the various types of motor activity that positively affect the cardiovascular system's functioning, aerobic exercise has the highest effect – it helps to strengthen the heart muscle, increase the volume of stroke output, reduce resting heart rate, and improve blood circulation. Swimming refers to aerobic exercise of relatively low intensity, performed for a long time with the same heart rate and respiration rate [19]. The effectiveness of swimming training sessions in improving the health of people of different ages and genders has been studied by many scientists [20-22]. The results of our research confirmed these conclusions and expanded them based on studies of the health-improving effect of swimming training sessions for the 1st year female students during the war in Ukraine.

In the course of the pedagogical experiment before distance swimming aimed at the development of general and special types of endurance – aerobic, speed and strength, and coordination, we additionally introduced elements of aqua fitness to develop speed and strength of muscles, coordination of movements, and mobility in joints. At the same time, the training sessions provided musical accompaniment. The effectiveness of the proposed content of the training sessions was confirmed by a significant increase in the physical performance of the cardiovascular system, a decrease in the level of stress of the EG female students, and a significant improvement in their adaptive potential and a decrease in body mass.

CONCLUSIONS

It has been found that during the research period, the EG female students improved the adaptive potential of the cardiovascular system (by 0.09 c. u.), increased the Harvard step test indicators by the speed of recovery processes in the body after physical exertion (by 4.3 c. u.), and decreased the level of stress (by 3.0 points) and body mass index (by 0.4 kg/m^2), while the CG female students did not show any changes in the studied indicators.

At the end of the experiment, the EG female students showed significantly better indicators of physical performance (by 4.9 c. u.) and lower stress levels (by 3.4 points) than the CG female students ($p \leq 0.05$). At the same time, the differences between the indicators of the adaptive potential of the cardiovascular system and body mass index in the EG and the CG female students were not significant ($p > 0.05$). Herewith, the stress level in the EG female students decreased to a moderate level, and the CG remained at the severe stress level.

The research results indicate that systematic swimming training sessions as a cyclic and aerobic type of motor activity have a high health-improving effect, contributing to the improvement of the functional and psycho-emotional state of female students during their studies under martial law.

PROSPECTS FOR FURTHER RESEARCH

Prospects for further research will be aimed at studying the impact of non-traditional types of motor activity on maintaining and improving the functional and psycho-emotional state of students under martial law.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Assessment of students' body response to physical exertions based on quantitative criteria of resistance

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ABSTRACT

Aim: To investigate the biomechanical indicators of the statokinesiogram to assess coordination-related stability (balance) criteria in students before and after physical exertion.

Materials and Methods: The research, which was conducted in 2024-2025, involved 30 male students of the 1st-2nd academic years of the main medical group. Methods: analysis and generalization of literary sources, method of computerized stabilography (statokinesiometry), methods of mathematical statistics. The complicated Romberg stance assessed students' balance.

Results: The biomechanical indicators of the statokinesiogram were investigated to assess the criteria of students' stability before and after physical exertion during physical education training sessions. Students demonstrate stable statokinesiogram indicators with a significantly unchanged ellipse area of the COM oscillations before and after exertion (S_{EIIS} – 3606 and 4004 mm^2; $\alpha > 5$ %). The leading role of proprioceptive, amplitude-frequency characteristics of the body's COM oscillations in balance control has been proven.

Conclusions: It has been established that maintaining balance by a student is a dynamic phenomenon that requires continuous body movement, which is the result of the interaction of vestibular and visual analyzers, joint and muscle proprioception, central and peripheral nervous systems. The cause of body mass center fluctuations is respiratory movements, blood circulation, as well as the functional state of the central nervous system and receptor apparatus. The effectiveness of the stabilography method for assessing the coordination criteria of stability (balance) of students before and after physical exertion has been proven. The results obtained indicate that physical exercises have a positive effect on improving the indicators of students' stability (balance).

KEY WORDS: exertion, health, biomechanical analysis of statokinesiogram, physical education, stability factors, students

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INTRODUCTION

The motor activity of students at higher education institutions (HEIs) in many cases requires students' ability to hold certain working postures quite economically and with high working effect, to modify them, maintaining the balance of the body in space under different conditions of professional activities. Biomechanically rational movements and postures often determine the final result of a particular human activity and are therefore the subject of detailed research by specialists [1-3]. In the last century, the Hungarian doctor Romberg introduced the observation of the vertical position of the body into clinical practice and developed a methodology for assessing the degree of body sway and limb tremor [4]. He proved that the assessment of the vertical body position due to quantitative biomechanical criteria of stability is an important indicator of the functional state of students' bodies and their health [5].

In physical education training sessions, various static positions and postures are often used. Such static positions include various stances, hangs, and holds in gymnastic exercises, starting positions in athletics, swimming, and other sports, postures of weightlifters, shooters, etc. The role of these positions and postures

as elements of sports technique can be quite different if we consider their three main phases – initial, intermediate, and final. Depending on which of these phases the static posture under study belongs to, its role in the effective solution of a motor task can be specifically assessed. The significant role of static positions and postures in sports is also evidenced by the fact that in competitions, the judicial rules regulate the fixation of static postures [7, 8].

The process of preserving the position and posture of the body is a complex process of regulation control and intermuscular coordination. From the biomechanical point of view, the human body in biostatistics can be represented as a multi-link mechanical system consisting of a number of links that do not deform. These links are connected through hinges, in which joint moments act to ensure the rigidity of the static position of the entire moving system [9]. The stabilography method is now widely used to assess the conditions of human body balance [10]. Recently, this method, in addition to studying the biomechanical foundations of stability, has also been used to study the functional state of the human body, tolerance to physical exertion of various kinds, and to assess the coordination capabilities of students in terms of their professional selection. For all the complexity of the electronic equipment used in the stabilography method, the student is not burdened with attaching sensors to the body's biological links during the measurements: they only need to stand on the stabilography platform and perform the corresponding control test. The stabilography method makes it possible to study the biomechanical characteristics of human movements, and also allows: to quantify the stability of the human body and body systems; to monitor the progress of training various types of balance in health training and sports; to test the state of students before tests; to determine adaptation to training loads; to carry out professional selection of the most capable in terms of the main quantitative indicators of stabilography [11].

Modern researches testify that the oscillation frequency of the body's Center of Mass (COM) is a key factor in the development of intermuscular coordination and the vestibular analyzer, and lies within the limits: in an ordinary person – 4-6 Hz, in athletes – 10-12 Hz, separate sports – 15-18 Hz, acrobats-quilibrists – 20-25 Hz. This means that the higher the frequency of oscillations of COM during balance exercises, the more times per unit of time the human body returns to a position of stable balance. Therefore, the probability of falling decreases and the quality of the exercise is high. Thus, the stabilography method makes it possible to quantify the stability of the human body (balance); to control the progress of training different types of balance in health training and sports; to test the condition of athletes; to study tolerance to training exertions; to carry out rehabilitation after injuries.

AIM

The aim is to investigate the biomechanical indicators of the statokinesiogram to assess coordination-related stability (balance) criteria in students before and after physical exertion.

MATERIALS AND METHODS

PARTICIPANTS

The research, which was conducted in 2024-2025, involved 30 male students of the 1st-2nd academic years of the main medical group (without health conditions) with an average level of physical development. The students studied at the Ukrainian State Dragomanov University (Kyiv, Ukraine) in the following specialties: 053 – Psychology and 014 – Secondary Education. The main criterion for including students in the study group was the absence of contraindications to physical education training sessions and informative consent to voluntary participation in the research. The students were engaged in physical education training sessions 2 times a week for 2 hours according to the current physical education program at the HEI. The physical fitness of these students did not exceed the standards of the physical education program at the HEI. There were no significant differences between health and physical fitness indicators in the studied students ($p > 0.05$).

THE SUBJECT OF THE RESEARCH

Oscillations in the body's COM, where the leading human sensory systems: vestibular, proprioceptive, and visual, integrate their contributions unequally.

RESEARCH METHODS

Analysis and generalization of literary sources (18 sources from scientometric databases MedLine, Scopus, Web of Science were analyzed), method of computerized stabilography (statokinesiometry), methods of mathematical statistics.

The method of computerized stabilography of the hardware and software complex "Force Plate with Biofeedback – Stabilan 01-2", which allows for objective registration of oscillations of the COM, as the movement of the pressure center, recorded by the sensors of the stabilization platform on which the person is located (Fig. 1) [12].

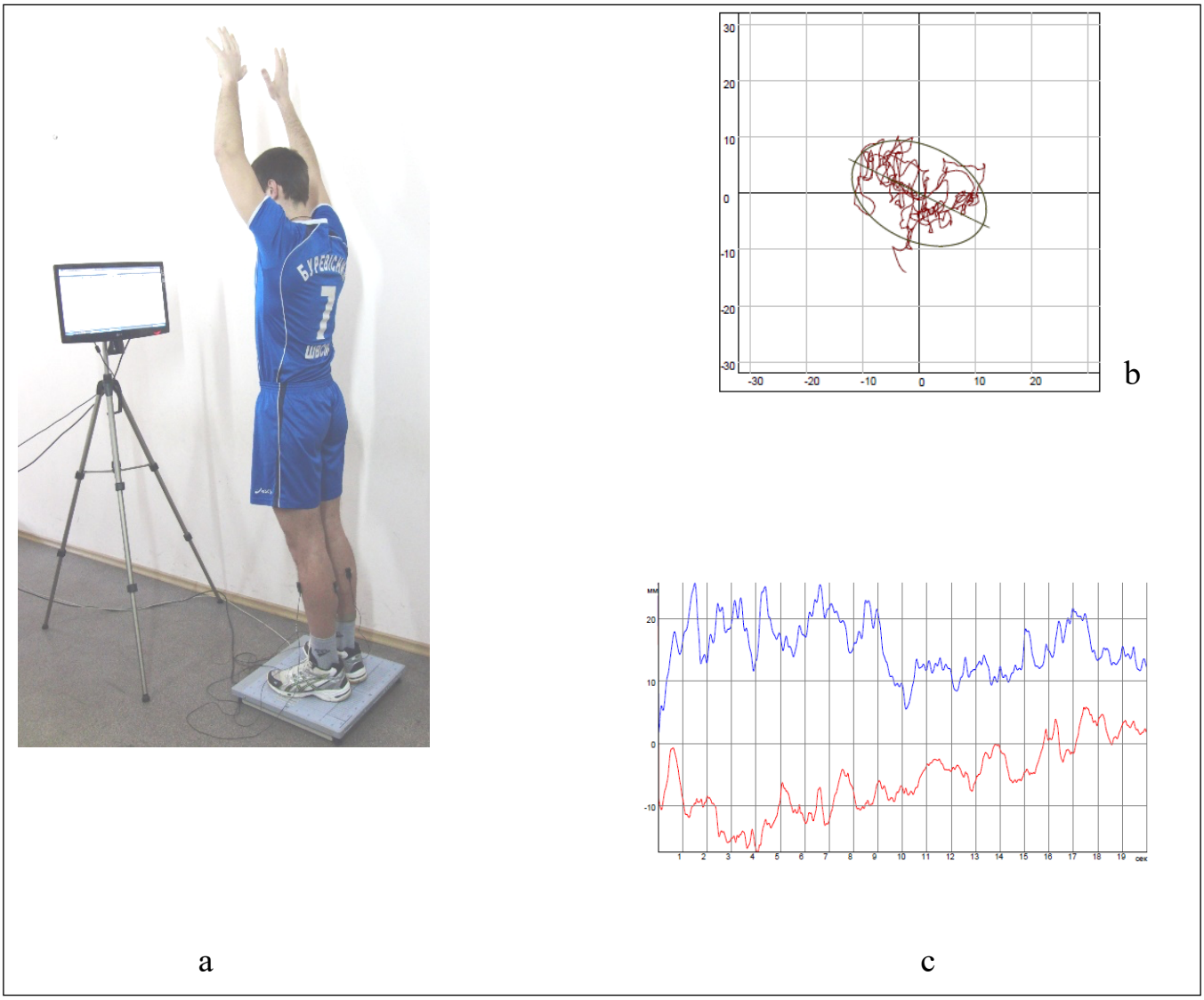

Fig. 1. Complicated Romberg stance for 20 sec (basic toe stand, feet shoulder-width apart, arms up, eyes closed) on the stabilization platform of the hardware and software complex "Force Plate with Biofeedback – Stabilan (01-2)" (a) with real-time registration on a personal computer: hodograph of stabilogram – projection of the oscillations of the COM on a horizontal plane (b); time, amplitude and frequency of oscillations of the COM in the directions: back and forth, right and left (c)
Picture taken by the authors

The hardware and software complex "Statokinesiometer – Stabilan (01-2)" was used for its intended purpose: to study the function of balance and statokinetic stability of a person by computer stabilography (statokinesiometry). It is known that during the arbitrary maintenance of an upright posture, the so-called "mobile balance" is constantly carried out. Its essence lies in the continuous redistribution of muscle tone in the main groups of antigravity muscles, aimed at stabilizing the position of the human body in space and, in particular, such resulting parameters as the center of mass and the center of gravity. The advantages of computerized stabilography include:

• comfort of the examination, which is carried out on a special stabilization platform in clothes and shoes in an upright position or sitting, i.e., in comfortable conditions that do not require special preparation of the patient or attachment of sensors to them;

• short examination time, consisting of the time of information acquisition (usually within 20-60 seconds) and the time of viewing the obtained data and analyzing the processing results, which in case of mass examinations does not exceed 1-2 minutes; informative study, which allows to assess both the general condition of a person and the state of several physiological systems involved in the process of maintaining an upright posture;

• high sensitivity to the impact on a person, which allows for to objectively assess their reaction to physical and mental influences, to taking medications, and even odors;

• multifunctionality, which allows using stabilography as a diagnostic tool for a wide range of diseases and pre-diseases, as a means of monitoring and objective assessment of impacts on a person, as well as a means of rehabilitation of disorders of human statokinetic function, training of coordination.

METHODS OF MATHEMATICAL STATISTICS

average values (X, σ, V, m), the sampling method (calculation of the Student's t test of consistency), correlation analysis (calculation of paired and multiple correlation coefficients: $_{x/y,}$ R_{tt} – Brave-Pearson) and multiple regression analysis (P. L. Chebyshev polynomials):

$\hat{Y} = a_0 + a_1X_1 + a_2X_2 + \ldots + a_nX_n$; $\hat{Y} = b_1X_1^2 + b_2X_2^2 + \ldots + b_nX_n^2$,

where: $\hat{Y}$ – partial criterion (the resultant feature is S_{EllS}, mm^2 – the area of the ellipse of COM oscillations); X_n – arithmetic averages of biomechanical variables of stability criteria (factor features); a_0 – an intercept term; a_n – linear regression coefficients; and b_n – quadratic regression coefficients. When the initial data approximating the response values are sufficiently large, a transition to higher-order regression models is made:

$\hat{Y} = a_0 + a_1X + a_1X^2 + \ldots + a_{n-1}X^{n-1} + a_nX^n$.

This transition is carried out until the final variance is significantly reduced. In this case, the determination of whether the final variance decreases significantly was checked by statistical criteria of difference (in this case, Pearson's $\chi 2$ test was used).

ETHICAL STANDARDS

The process of research implementation is built following the requirements of scientific ethics. The Academic Ethics Commission of the Ukrainian State Dragomanov University approved the research. Also this research followed the regulations of the World Medical Association Declaration of Helsinki – ethical principles for medical research involving human subjects. The participants were informed about the aim and tasks of the research, and they voluntarily participated in it.

RESULTS

As a result of the research, the database of the subjects included the processing of 65 biomechanical indicators to assess the coordination criteria of stability (balance) of four main groups of factors: Group I – values of traditional parameters of the amplitude-frequency characteristics of COM oscillations – 21 indicators (Nos. 1-21); Group II – integral indicators of COM oscillations – 19 indicators (Nos. 22-41), Group III – parameters of vector analysis – 19 indicators (Nos. 42-61), Group IV – indicators of bioelectrical activity of the anterior and posterior surfaces of skeletal muscles of the left and right tibia – 4 indicators (Nos. 62-65). Biomechanical indicators of coordination criteria of stability are presented below:

I. Parameters of the amplitude-frequency characteristics of COM oscillations:

1. *MO(x), mm* – displacement of COM oscillations along the frontal axis (FA).
2. *MO(y), mm* – displacement of COM oscillations along the sagittal axis (SA).
3. *Q(x), mm* – scatter of COM oscillations along the FA.
4. *Q(y), mm* – scatter of COM oscillations along the SA.
5. *R, mm* – average scatter of COM oscillations.
6. *V, mm/sec* – average velocity of the COM pressure center movement.
7. *SV, sq.mm/sec* – rate of change in the area of the statokinesiogram.
8. *Angle, deg* – average direction of COM oscillations.
9. S_{EllS}, mm^2 – area of the ellipse of the COM oscillations.
10. *EllE* – compression ratio.
11. *IV* – index of velocity.
12. *MA* – motion assessment.
13. *KAss0(x), %* – coefficient of asymmetry relative to zero along the FA.
14. *KAss0(y), %* – coefficient of asymmetry relative to zero along the SA.
15. *KAssM(x), %* – coefficient of asymmetry relative to the COM displacement along the FA.
16. *KAssM(y), %* – coefficient of asymmetry relative to the COM displacement along the SA.
17. *KAssO'(x), %* – coefficient of asymmetry relative to the mode along the FA.
18. *KAssO'(y), %* – coefficient of asymmetry relative to the mode along the SA.
19. *KAssE(x), %* – coefficient of asymmetry relative to the median along the FA.
20. *KAssE(y), %* – coefficient of asymmetry relative to the median along the SA.
21. *Curv, rad/mm* – coefficient of curvature of the COM displacement.

II. Integral indicators of COM oscillations.

22. *LX, mm* – length of COM displacement trajectory along the FA.
23. *LY, mm* – length of COM displacement trajectory along the SA.
24. *LFS, 1/mm* – length of the COM displacement depending on its ellipse area.
25. *QEF, %* – quality of the equilibrium function.
26. *NAV, sq.mm./sec* – normalized area of the vectorgram.
27. *CACDM, %* – coefficient of abrupt change in the direction of motion.
28. *ALV, mm/sec* – average linear velocity.
29. *ALVV, mm/sec* – amplitude of linear velocity variation.
30. *PLVV, sec* – period of linear velocity variation.

Table 1. Quantitative data of mathematical and statistical processing of biomechanical indicators of the statokinesiograms in the performance of the complicated Romberg posture (before exertion – the upper indicator, after exertion – the lower indicator (n = 30)

No	Biomechanical indicators of the statokinesiogram	X	σ	V	m	χ2 – Pearson criterion ($\chi 2_{gr.}$ = 0.34)	t – Student criterion ($t_{gr.}$ = 2.01)
	MO(x), mm	8.1 8.4	1.07 1.24	13.44 14.1	0.34 0.39	0.33	0.96
	MO(y), mm	6.6 8.84	0.9 1.3	13.21 14.3	0.29 0.44	0.24	**4.64**
	Q(x), mm	11.0 9.77	1.51 1.43	13.91 14.77	0.51 0.5	0.04	**2.09**
	Q(y), mm	19.84 19.93	2.84 2.94	14.01 14.22	0.92 0.94	-0.29	0.08
	R, mm	19.32 19.22	3.32 2.75	16.53 13.45	0.86 0.79	0.17	0.38
	V, mm/sec	92.84 68.34	12.64 9.85	14.2 14.43	3.87 3.14	0.33	**5.32**
	SV, mm²/sec	572 321	83.21 45.12	15.11 14.47	26.8 14.8	0.41	**8.31**
	Angle, deg	4.41 9.94	0.58 1.47	13.26 15.17	0.19 0.48	0.18	**10.97**
	S_{Ells}, mm²	3642 4012	577 568	15.12 14.13	179 187	-0.44	1.87
	EllE	1.61 1.71	0.24 0.19	14.42 11.79	0.67 0.14	**0.43**	1.63
	IV	58.12 44.01	7.66 4.44	13.53 10.74	2.39 1.42	0.34	**5.74**
	MA	90.67 88.21	13.21 12.76	14.28 14.74	4.11 4.74	0.09	0.54
	KAss0(x), %	49.76 45.89	7.43 5.21	14.23 11.11	2.23 1.58	1.23	1.49
	KAss0(y), %	24.32 43.86	3.23 7.32	14.22 15.12	1.14 2.43	-0.43	**9.38**
	KAssM(x), %	15.11 15.22	2.33 2.09	14.58 15.43	0.87 0.84	-0.28	0.43
	KAssM(y), %	13.34 14.54	1.78 2.16	14.16 15.22	0.63 0.72	0.06	1.70
	KAssO(x), %	25.56 27.08	3.58 3.87	14.09 14.23	1.21 1.18	0.32	0.94
	KAssO(y), %	50.99 72.78	6.87 8.14	13.1 11.1	2.33 2.64	-0.07	**6.43**
	KAssE(x), %	4.26 7.76	0.56 1.09	13.93 14.01	0.23 0.43	0.34	**8.94**
	KAssE(y), %	63.32 75.58	9.84 10.83	15.54 14.11	3.09 3.38	0.16	**2.67**
	Curv, rad/mm	0.36 0.49	0.04 0.07	10.93 14.60	0.01 0.02	-0.28	**5.21**
	LX, mm	698.83 546.76	90.31 75.79	12.92 13.86	28.6 24	0.06	**4.08**
	LY, mm	1448.5 1280.3	205.9 138.15	14.21 10.79	65.1 43.7	-0.02	**2.15**
	LFS, 1/mm	0.55 0.65	0.08 0.09	14.48 13.57	0.03 0.04	0.09	**2.76**
	QEF, %	1.38 2.76	0.20 0.41	14.38 14.97	0.06 0.13	-0.05	**9.54**

Table 1. Cont.

NAV, sq.mm./sec	11.09 11.85	1.48 1.11	13.31 9.38	0.47 0.35	0.04	1.30
CACDM, %	11.05 13.53	1.22 1.96	11.09 14.46	0.39 0.62	0.06	**3.40**
ALV, mm/sec	72.29 68.59	8.57 4.00	11.85 5.84	2.71 1.27	**0.56**	1.24
ALVV, mm/sec	50.04 50.86	4.85 6.44	9.69 12.66	1.53 2.04	0.13	0.32
PLVV, sec	0.52 0.52	0.02 0.02	4.23 4.45	0.01 0.02	**0.42**	0.27
AAV, deg/sec	21.35 22.84	2.58 2.31	12.09 10.12	0.82 0.73	0.05	1.36
AAVV, deg/sec	26.10 25.53	3.28 3.11	12.56 12.17	1.04 0.98	-0.01	0.40
PAVV, sec	0.50 0.46	0.03 0.03	6.24 5.90	0.01 0.02	-0.13	**2.77**
CAAV, %	7.96 9.71	1.13 1.41	14.24 14.57	0.36 0.45	-0.36	**3.05**
ADD, rev.	5.81 5.67	0.81 0.77	13.87 13.62	0.25 0.24	-0.36	0.39
ALV_f, mm/sec	29.12 27.39	3.17 2.36	10.88 8.63	1.00 0.75	0.20	1.38
ALV_s, mm/sec	58.04 57.75	7.16 7.64	12.33 13.23	2.26 2.42	-0.14	0.09
CALV_f, %	1.91 2.04	0.28 0.30	14.66 14.49	0.09 0.08	0.08	1.04
CALV_s, %	1.09 1.16	0.15 0.17	13.88 14.76	0.05 0.06	0.31	1.03
PV, sq.mm./sec	153.58 150.76	22.94 22.42	4.94 14.87	7.25 7.09	0.12	0.28
LV/AV, mm/deg	3.45 3.33	0.44 0.48	12.69 14.53	0.14 0.15	-0.28	0.60
F1(F), Hz	0.25 0.21	0.04 0.03	4.21 14.80	0.01 0.03	-0.08	**2.89**
A1(F), mm	2.43 3.74	0.30 0.57	12.37 15.26	0.10 0.18	-0.17	**6.43**
F2(F), Hz	0.42 0.37	0.06 0.05	14.87 12.94	0.02 0.03	-0.34	1.79
A2(F), mm	2.248 3.261	0.204 0.47	9.094 14.56	0.06.15	0.15	**6.18**
F3(F), Hz	0.49 0.49	0.06 0.07	12.22 14.97	0.02 0.02	-0.43	0.16
A3(F), mm	2.176 2.24	0.257 0.24	11.8 10.72	0.08 0.09	0.14	0.57
60%Pw(F), Hz	0.97 0.91	0.13 0.13	13.28 14.91	0.04 0.04	-0.02	1.16
Pw1(F), %	14.47 16.17	2.08 1.84	14.38 11.38	0.66 0.58	0.11	1.94
Pw2(F), %	69.00 67.50	4.86 4.75	7.04 7.04	1.54 1.50	0.26	0.70
Pw3(F), %	18.13 17.50	2.67 2.42	14.75 13.81	0.85 0.76	0.16	0.56

Table 1. Cont.

F1(S), Hz	0.21 0.18	0.03 0.02	14.53 12.17	0.01 0.01	**0.52**	**2.44**
A1(S), mm	6.474 6.99	0.945 1.04	14.59 14.90	0.299 0.33	-0.13	1.15
F2(S), Hz	0.28 0.22	0.04 0.03	14.39 14.17	0.01 0.01	0.29	3.95
A2(S), mm	4.75 4.88	0.68 0.73	14.40 14.92	0.22 0.23	-0.07	0.41
F3(S), Hz	0.44 0.43	0.05 0.06	12.25 14.70	0.02 0.02	-0.12	0.24
A3(S), mm	3.75 4.02	0.44 0.45	11.60 11.16	0.14 0.14	-0.19	1.35
60%Pw(S), Hz	1.18 1.12	0.09 0.12	8.06 10.61	0.03 0.04	0.26	1.28
Pw1(S), %	13.30 15.00	0.65 2.02	4.90 13.45	0.21 0.64	-0.37	**2.54**
Pw2(S), %	64.77 61.20	6.44 2.72	9.95 4.45	2.04 0.86	0.23	1.61
Pw3(S), %	23.20 23.00	3.24 2.27	13.97 9.89	1.03 0.72	-0.16	0.16
Ampl, mV-1	0.55 0.80	0.07 0.09	12.89 11.05	0.02 0.03	-0.26	**6.88**
Ampl, mV-2	0.58 0.76	0.07 0.10	12.55 12.88	0.02 0.03	-0.54	**4.65**
Ampl, mV-3	0.59 0.93	0.08 0.11	13.84 12.26	0.03 0.04	0.04	**7.62**
Ampl, mV-4	0.30 0.65	0.04 0.09	14.34 14.62	0.01 0.03	-0.04	**10.68**
Number of significant differences					**4 (α < 1 %)**	**27 (α < 5 %)**

Legend: X – arithmetic mean, σ – standard deviation, V – coefficient of variation, and m – representativeness error
Source: compiled by the authors of this study

31. *AAV, deg/sec* – average angular velocity.
32. *AAVV, deg/s* – amplitude of angular velocity variation.
33. *PAVV, sec* – period of angular velocity variation.
34. *CAAV, %* – coefficient of asymmetry of angular velocity.
35. *AAD, rev*. – accumulated angle of displacement.
36. *ALV_f, mm/sec* – average linear velocity along the FA.
37. *ALV_s, mm/sec* – average linear velocity along the SA.
38. *CALV_f,%* – coefficient of asymmetry of linear velocity along the FA.
39. *CALV_s, %* –– coefficient of asymmetry of linear velocity along the SA.
40. *PV, sq.mm./sec* – power of the vectorgram.
41. *LV/AV, mm/deg* – ratio of linear to angular velocities.

III. Vector indicators of COM oscillations.

42. *F1(S), Hz* – frequency of the first amplitude peak on the SA spectrum.
43. *A1(S), mm* – amplitude of the first amplitude peak on the SA spectrum.
44. *F2(S), Hz* – frequency of the second amplitude peak on the SA spectrum.
45. *A2(S), mm* – amplitude of the second amplitude peak on the SA spectrum.
46. *F3(S), Hz* – frequency of the third amplitude peak on the SA spectrum.
47. *A3(S), mm* – amplitude of the third amplitude peak on the SA spectrum.
48. *F2(F), Hz* – frequency of the second peak on the FA spectrum.
49. *F1(F), Hz* – frequency of the first peak on the FA spectrum.
50. *A1(F), mm* – amplitude of the first peak on the FA spectrum.
51. *A2(F), mm* – amplitude of the second peak on the FA spectrum.
52. *F3(F), Hz* – frequency of the third peak on the FA spectrum.
53. *A3(F), mm* – amplitude of the third peak on the FA spectrum.
54. *60%Pw(F), Hz* – 60 % power level of the spectrum along the FA.
55. *Pw1(F), %* – spectral power of the first zone of the stabilogram along the FA.

56. *Pw2(F), %* – spectral power of the second zone of the stabilogram along the FA.
57. *Pw3(F), %* – spectral power of the third zone of the stabilogram along the FA.
58. *60%Pw(S), Hz* – 60 % power level of the spectrum along the SA.
59. *Pw1(S), %* – spectral power of the first zone of the stabilogram along the SA.
60. *Pw2(S), %* – spectral power of the second zone of the stabilogram along the SA.
61. *Pw3(S), %* – spectral power of the third zone of the stabilogram along the SA.

IV. Indicators of bioelectrical activity of the anterior and posterior surfaces of skeletal muscles of the left and right tibiae (average amplitude for 20 seconds)

1. *Ampl, mV-1* **–** electromyogram (EMG) of the anterior surface muscles of the left tibia.
2. *Ampl, mV-2* – EMG of the anterior surface muscles of the right tibia.
3. *Ampl, mV-3* – EMG of the posterior surface muscles of the left tibia.
4. *Ampl, mV-4* – EMG of the posterior surface muscles of the right tibia.

The results of mathematical and statistical processing of all biomechanical indicators of the statokinesiogram in the performance of the complicated Romberg posture for 20 seconds (the main stand on toes, feet on the width of shoulders, arms up) before and after exertion at physical training sessions are presented in Table 1.

The results obtained once again show that students demonstrate stable statokinesiogram indicators with a significantly unchanged ellipse area of the COM oscillations before and after exertion (S_{EllS} – 3606 and 4004 mm^2; $\alpha > 5$ %). The total number of significant differences was 27 (43 % $\alpha < 5$ %). Moreover: in Group I there were 11 (53 %): 2, 3, 6, 7, 8, 11,14, 18, 19, 20, 21; in Group II there were 7 (38 %): 22, 23, 24, 25, 27, 33, 34); in Group III there were 5 (27 %): 42, 43, 45, 52, 59; in Group IV there were 4 (99.9 %): 62, 63, 64, 65. It means that the regulation of posture in students is more effective at the expense of the economy of changes of indicators of the body's COM statokinesiogram in Groups I, II, and III, and also a 99 % increase of all indicators in Group IV.

The analysis of correlations shows 57 % of reliable correlation relationships before and 43 % after exertion, that is, the process of stability control from the phase of irradiation passed into the phases of concentration and stabilization. More correlation relationships decreased in Group I (18 from 21 – 88 %) and Group II of indicators (16 from 19 – 84 %).

The further regression analysis was carried out as follows: the main factor of quality of maintenance of balance in a given posture – S_{EllS} – area of ellipse of the COM oscillations – was taken as a partial criterion (resultant feature $\hat{Y}$); biomechanical indicators of statokinesiograms having reliable correlation relationships with S_{EllS}, 13 indicators before exertion (these are nos. 1–12, 13, 14, 16. 17, 20, 31, 36, 38, 44, 52, 54, 60 of the Table) and 9 after exertion (these are nos. 1–2, 4, 7, 12, 13, 14, 21, 35, 44 of the Table) were taken as factors features.

The results of the regression analysis indicate that the indicators make the greatest contribution to the resultant feature $\hat{Y}$ (S_{EllS}) of the stability margin assessment: 12. MA – motion assessment; 13. KAss0(x), % – coefficient of asymmetry relative to zero along the frontal axis; 16. KAssM(y), % – coefficient of asymmetry relative to the COM displacement along the sagittal axis.

The indicators of the stability margin assessment allowed us to evaluate the possibility of body deviation forward, backward, right, and left. According to the asymmetry of the resulting zone, one can speculate about hidden disorders of posture regulation and their predominance in any direction.

DISCUSSION

Scientists [13, 14] note that biolinks are a kind of lever and pendulum. Bones that are connected in a movable way form the basis of biokinematic pairs and biochains. The forces applied to them (muscle traction and others) act on the links of biokinematic chains like levers. This makes it possible to transmit the effect of the force through the links at a distance, as well as to change the effect of the applied forces. Bone levers, which are movably connected in joints, can maintain their position and change it under the influence of applied forces. All forces applied to a bone link as a lever can be divided into groups: 1) forces that lie in the plane of the joint axis (they cannot affect the movement around this axis); 2) forces that have components that lie in the plane perpendicular to the axis of the lever (these forces can affect the movement around this axis in two directly opposite directions), i.e. moving (directed behind the movement) and inhibitory (directed opposite to the movement).

The optimal functioning of the vestibular sensory system is of practical importance for achieving the planned sports results in various sports, but, most of all, in those where the athlete is required to demonstrate a high level of sensorimotor coordination. Development and improvement of sensorimotor coordination as a basis of technical fitness are achieved

through vestibular training (orientation, coordination, body posture, balance, motor interaction) with strict regulation and control of the exercises performed. The lack of adequate training of the vestibular analyzer causes a violation of sensorimotor coordination, which, in turn, leads to technical errors in the movements of athletes [15, 16].

The laws of classical physics are applied in the human musculoskeletal system, namely, they allow us to consider in more detail the possibilities of the motor function of the human body: restoration of lost movements through the construction of special motor programs in physical education and sports rehabilitation and health training of a person, taking into account the characteristics of each individual; development of motor skills, including strength, as the main criterion for the ability to work with the human body's supporting-motor apparatus in conditions of constant, overcoming mechanical work. An example can be simulators with a special design, where overcoming work is always performed in rotational movements, such as a biceps machine with an eccentric [17].

Our research shows that when controlling balance, the human body does not always obey the laws of mechanics: in Fig. 1 b, the hodograph of the stabilogram – the projection of the COM oscillations on the horizontal plane goes beyond the support area, but the balance is maintained, which is confirmed by the research of many experts [2, 5, 9, 17, 18].

CONCLUSIONS

1. The reason for oscillations of the center of gravity is respiratory movements, blood circulation, as well as the functional state of the central nervous system and the receptor apparatus controlling the motor muscular system, which causes the opposite effects of various somatic and nervous disorders, intoxication and fatigue on the student's balance system. Considering the above, as well as the simplicity of registration of stabilographic indicators, the possibility of obtaining them without distracting the student from the activity performed and the high sensitivity of this method, it is possible to use stabilography as a convenient method for assessing the dynamics of the functional state of students in the conditions of physical exertion, functional disorders of the central nervous system and musculoskeletal system.
2. The leading role of proprioceptive, amplitude-frequency characteristics of the body's COM oscillations in balance control has been proven. The results indicate that the greatest contribution to the resultant feature $\hat{Y}$ *(*S_{EIIS} *ellipse area of the COM oscillations)* is made by the indicators of stability margin assessment: 12. *MA* – motion assessment; 13. *KAss0(x), %* – coefficient of asymmetry relative to zero along the frontal axis; 16. *KAssM(y), %* – coefficient of asymmetry relative to the COM displacement along the sagittal axis.
3. The student's keeping of balance is a dynamic phenomenon requiring continuous body movement. It is the result of the interaction of vestibular and visual analyzers, joint and muscle proprioception, central and peripheral nervous systems.
4. Students demonstrate stable indicators of statokinesiogram with a significantly unchanged area of the ellipse of the COM oscillations before and after exertion (S_{EIIS} – 3606 and 4004 mm^2; $\alpha > 5$ %). The total number of significant differences was 27 (43 % $\alpha < 5$ %). Moreover: in Group I there were 11 of them (53 %): 2, 3, 6, 7, 8, 11,14, 18, 19, 20, 21; in Group II there were 7 (38 %): 22, 23, 24, 25, 27, 33, 34); in Group III there were 5 (27 %): 42, 43, 45, 52, 59; in Group IV there were 4 (99.9 %): 62, 63, 64, 65. These indicators characterize the increase in muscle tone and improvement of body posture. The obtained results indicate that physical exercises have a positive effect on improving students' stability (balance).
5. The analysis of correlations shows 57 % of reliable correlation relationships before and 43 % after exertion, that is, the process of stability management from the phase of irradiation passed into the phases of concentration and stabilization. More correlation relationships decreased in the first (18 out of 21 – 88 %) and second groups of indicators (16 out of 19 – 84 %). Thus, it has been proven that the stabilographic method provides an important positive qualitative and quantitative assessment of the body's response to physical exertion.

PROSPECTS FOR FURTHER RESEARCH

Prospects for further research are seen in the study of biomechanical indicators of stability (balance) of students (male and female) in the process of practicing various sports.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Effect of *Ocimum basilicum* herbs extract on pro-inflammatory cytokines in ethanol-induced liver damage in rats

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ABSTRACT

Aim: The aim of this study is to evaluate the hepatoprotective and immunomodulatory effects of *Ocimum basilicum* extract on pro-inflammatory cytokines, specifically TNF-α, IL-6, and IL-1β, in a rat model of ethanol-induced liver damage.

Materials and Methods: A total of 120 male rats were divided into four groups: a control group, an ethanol-induced liver damage group, a low-dose basil treatment group, and a high-dose basil treatment group. Pro-inflammatory cytokines (TNF-α, IL-6, IL-1β) were measured using ELISA.

Results: The ethanol exposure group showed significantly elevated TNF-α (548.8 ± 83.78 pg/mL), IL-6 (410.3 ± 167.7 pg/mL), and IL-1β (373.1 ± 127.7 pg/mL) compared to the control group. Basil supplementation, particularly at high doses (100 mg/kg), effectively reduced these cytokines, with TNF-α (316.4 ± 57.37 pg/mL) and IL-6 (133.9 ± 86.76 pg/mL) levels approaching control values. IL-1β was also significantly reduced (152.3 ± 79.37 pg/mL) but remained slightly elevated.

Conclusions: This study showed that *Ocimum basilicum* extract has potent hepato protective and anti-inflammatory properties, making it a promising natural therapeutic agent for alcohol-induced liver damage.

KEY WORDS: liver, TNF-α, *Ocimum basilicum*, cytokines, rats, bioactive compounds

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INTRODUCTION

Basil (*Ocimum spp.*) is known as a fragrant herb belonging to the Lamiaceae family; it is widely familiar for its role in medicinal and therapeutic uses [1]. Basil is currently grown all over the world for its fragrant leaves and extracts that are high in phytochemicals. Basil have numerous health benefits, and often known as holy basil because its species widely used in traditional medical systems, especially Ayurveda [2].

Basil is herbs considering as reservoir of bioactive compounds such as ursolic acid, eugenol, apigenin, rosmarinic acid and caryophyllene which have been known to be responsible for the diverse pharmacological and medicinal activities. Basil has been well for possessing strong anti-oxidant, anti-inflammatory, hepato-protective, anti-microbial and immunological activities [3]. All these activities of basil make it a subject of significant interest in modern pharmacological and medical research. Due to its rich phytochemical composition and extensive therapeutics, basil continues to be an area of intense focus of research within the field of herbal medicine science, pharmacology, and integrative-health.

Basil herb is relevant to the health of the liver function since it inhibits inflammation, prevents oxidative stress and detoxifying hepatocytes from negative effect of toxins, infections and medications [4]. It is confirmation of its efficacy as an adjunctive traditional therapeutic agent for liver damage and inflammatory disorders of a systemic nature via its potential to modulate inflammatory mediators, e.g., TNF-α (tumor necrosis factor alpha), IL-6 (interleukin-6), and IL-1β (interleukin-1 beta) [5].

Apart from this, Basil herb is a useful plant that improves the immune system of the body since it has the potential to increase the immune system. It keeps the immune system balanced, reduces the chances of over-inflammation and its role in recovery from infections and inflammatory conditions by controlling immunological response [6]. There are several reasons for damage to the liver such as alcohol intake, toxins, infection and autoimmune disorders. Perhaps most common is alcohol induced liver damage that consists

of inflammation, oxidative stress and dysfunctional liver function [7]. Due to its significant function of detoxification, the liver is highly susceptible to damage due to the accumulation of inflammatory mediators and toxic substances .

The immune-response has a main role in liver injury. Tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), and interleukin-1 beta (IL-1β) are examples of pro-inflammatory cytokines that are raised and contribute to chronic-inflammation, which damages tissue and accelerates the development of cirrhosis, fibrosis or liver failure [8-10].

AIM

The aim of this study is to evaluate the hepatoprotective and immunomodulatory effects of *Ocimum basilicum* extract on pro-inflammatory cytokines, specifically TNF-α, IL-6, and IL-1β, in a rat model of ethanol-induced liver damage.

MATERIALS AND METHODS

PREPARATION OF BASIL EXTRACTION

Fresh basil leaves are typically used which are supply form local farm in Samawah city, Leaves are rinsed thoroughly with distilled water to remove impurities. Then they are drying in a shaded, well-ventilated area at room temperature then grinded into a fine powder using a blender [11].

For the extraction of bioactive compounds from basil, 200 g of powdered basil was placed in a flask with 300 mL of ethanol (70%) was added. The mixture was heated in 70°C with stirring continuously for 4 hours to facilitate the extraction of phytochemicals from the basil powder. After the extraction, the mixture was filtered to separate the solid plant material from the liquid extract using standard filter paper.

The product was concentrated using a rotary evaporator vacuum under reduced pressure at a temperature of 40–50°C to remove the ethanol-solvent. It was washed with "diethyl ether" and the final extract was stored in dark containers in a cool, dry place, and refrigeration [12].

ANIMAL GROUPS

A total of 120 male rats, weighing approximately 250 g, were randomly divided into four groups, with 30 rats per group. These groups were as follows:

Group 1 Healthy, Untreated Control (UC): This group remained untreated and served as the baseline for comparison.

Group 2 Ethanol Treatment (EtOH): Rats in this group were given 10-20% ethanol in their drinking-water to induce liver damage and inflammation.

Group 3 Low Basil Dose + Ethanol (LB): Rats were treated with a low dose of basil-extract (50 mg/kg body weight/day) along with 10-20% ethanol in their drinking water.

Group 4 High Basil Dose + Ethanol (HB): Rats received a high dose of basil extract 100 mg/kg body weight/day) along with 10-20% ethanol in their drinking-water.

The rats received the treatment over the course of four weeks, during which period their behavior, body weight, and any indications of distress were observed. After the treatment period ended, the rats were euthanized, and blood was collected for immunological tests.

EVALUATION OF CYTOKINES

The pro-inflammatory cytokines (Tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), and interleukin-1 beta (IL-1β)) levels were measured to study the immunomodulatory activity of basil extract in "ethanol-induced liver injury". The blood was collected from every research group by heart puncture under anaesthesia at the end of the experiment. The serum was isolated by centrifugation at 3,000 rpm for 10 minutes and stored at -80°C until analysis [13]. Enzyme-linked immunosorbent assay (ELISA) kits were used to measure the levels of TNF-α, IL-6, and IL-1β. To guarantee the accuracy of the data, each experiment was repeated three times. Cytokine levels were used as markers of systemic inflammation, and they were measured in pg/mL.

STATISTICAL ANALYSIS

Data of cytokines were analyzed by one-way ANOVA and then post hoc comparisons were made by "Tukey's test". Data were presented as mean ± standard error (SE), and significance was considered at $p < 0.05$. These studies indicated immunomodulatory and hepatoprotective activity of basil extraction in "ethanol-induced liver damage" in rats [14].

RESULTS AND DISCUSSION

The serum TNF-α levels varied significantly among the experimental groups, as confirmed by one-way ANOVA analysis ($F = 8.053$, $P < 0.05$), indicating a significant effect of ethanol-induced liver damage and basil supplementation (Table 1). The inflammatory cytokines IL-6 and IL-1β followed a similar trend to TNF-α. One-way ANOVA analysis revealed a highly significant effect of ethanol and basil supplementation on IL-6 ($F = 55.82$, $P < 0.05$) and IL-1β ($F = 54.64$, $P < 0.05$), with both showing

Table 1. Statistical analysis of groups results according to ANOVA test

ANOVA summary	TNF-α	IL-6	IL-1β
F	8.053	55.82	54.64
P value	< 0.05	< 0.05	< 0.05
P value summary	***	***	***
Statistically significant? (P < 0.05)	Yes	Yes	Yes
R square	0.1724	0.5908	0.5856

Note: *Tumor necrosis factor-alpha (TNF-α), Interleukin-6 (IL-6) and Interleukin-1 beta (IL-1β), **P < 0.01, *P < 0.001, ***P < 0.0001
Source: compiled by the authors of this study

Table 2. Statistical analysis of groups, p value ≤ 0.05

Groups	N	Mean ± SD pg/mL	95% CI of diff.	Statistically significant? (P < 0.05)
Tumor necrosis factor-alpha (TNF-α)				
UC	30	288.4 ± 44.01		
EtOH	30	548.8 ± 83.78	-393.0 to -127.7	Yes (****)
LB+EtOH	30	449.3 ± 92.80	-293.5 to -28.23	Yes (*)
HB+EtOH	30	316.4 ± 57.37	-160.6 to 104.7	No
Interleukin-6 (IL-6)				
UC	30	70.53 ± 23.39		
EtOH	30	410.3 ± 167.7	-422.8 to -256.8	Yes (****)
LB+EtOH	30	366.8 ± 157.1	-379.3 to -213.2	Yes (****)
HB+EtOH	30	133.9 ± 86.76	-146.4 to 19.63	No
Interleukin-1 beta (IL-1β)				
UC	30	73.67 ± 26.21		
EtOH	30	373.1 ± 127.7	-364.1 to -234.8	Yes (****)
LB+EtOH	30	254.0 ± 116.7	-245.0 to -115.6	Yes (****)
HB+EtOH	30	152.3 ± 79.37	-143.3 to -13.95	Yes (*)

Note: US: Untreated group, EtOH: Ethanol treated group, LB+EtOH: Group treated with ethanol and low dose of extract, HB+EtOH: group treated with ethanol and high dose of extract, GraphPad prism results showed: P< 0.05, **P < 0.01, *P < 0.001, ****P < 0.0001.
Source: compiled by the authors of this study

strong statistical significance ($P < 0.05$, $R^2 = 0.5908$ and 0.5856, respectively) as showed in Table 1.

Tumor necrosis factor-alpha (TNF-α) is a key inflammatory cytokine involved in liver injury and immune response regulation [15]. In this study, ethanol exposure significantly elevated TNF-α levels, confirming its role in inducing hepatic inflammation. However, basil supplementation effectively mitigated this effect, with the high-dose basil (HB+EtOH) group showing TNF-α levels statistically similar to the control group, indicating strong protective activity.

The ethanol-only (EtOH) group exhibited a significant increase in TNF-α levels (548.8 ± 83.78 pg/mL, P < 0.0001) compared to the control (288.4 ± 44.01 pg/mL). This increase is well-documented in alcohol-induced liver damage, where ethanol metabolism generates oxidative stress, gut-derived endotoxins, and activation of Kupffer cells, all of which stimulate TNF-α production [17, 18]. Elevated TNF-α is a hallmark of alcohol-induced liver injury and a key driver of inflammation and hepatocyte apoptosis [19]. The low-dose basil (LB+EtOH, 50 mg/kg) group showed a significant reduction in TNF-α levels (449.3 ± 92.80 pg/mL, P < 0.05) compared to the ethanol-only group. This suggests that basil at this dose exerts anti-inflammatory effects, likely through its antioxidant and NF-κB inhibitory properties as illustrated in Table 2 and Fig. 1.

The high-dose basil (HB+EtOH, 100 mg/kg) group exhibited a greater reduction in TNF-α (316.4 ± 57.37 pg/mL). Importantly, this reduction was not statistically different from the control group (P > 0.05), indicating that basil at this dose was highly effective in counteracting ethanol-induced inflammation, restoring TNF-α levels to near-normal values. Unlike in the LB+EtOH group, where TNF-α levels were still significantly elevated compared to controls, the HB+EtOH group's TNF-α levels were statistically indistinguishable from the control group. This finding is highly favorable, as it suggests that high-dose basil extract was so effective in reducing inflammation that TNF-α levels remained

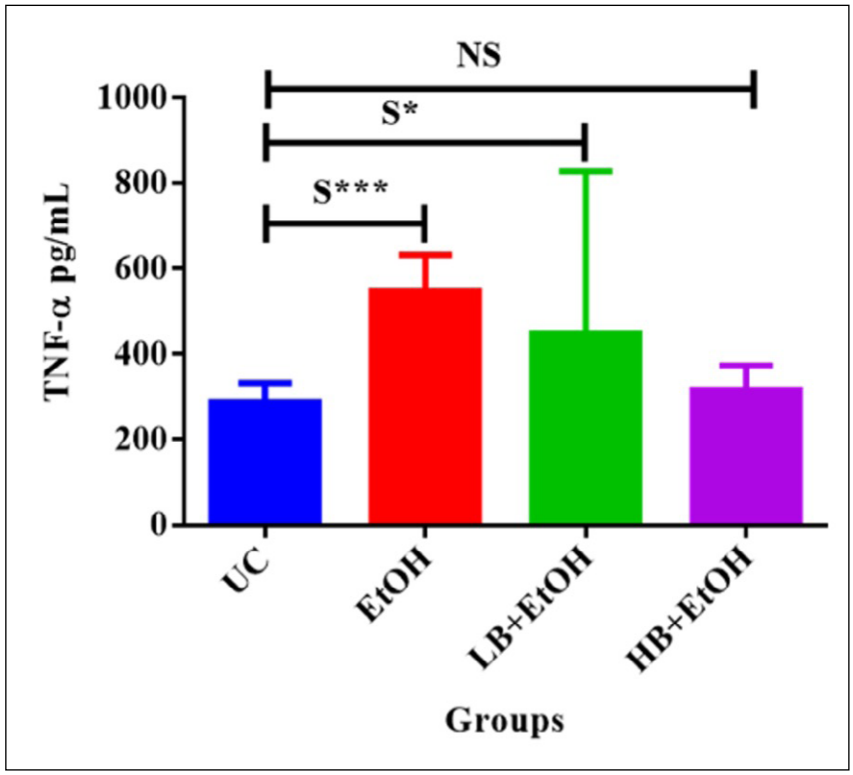

Fig. 1. Levels of TNF-**α** in the groups, P valie < 0.05; *P < 0.001; ***P < 0.0001
Picture taken by the authors

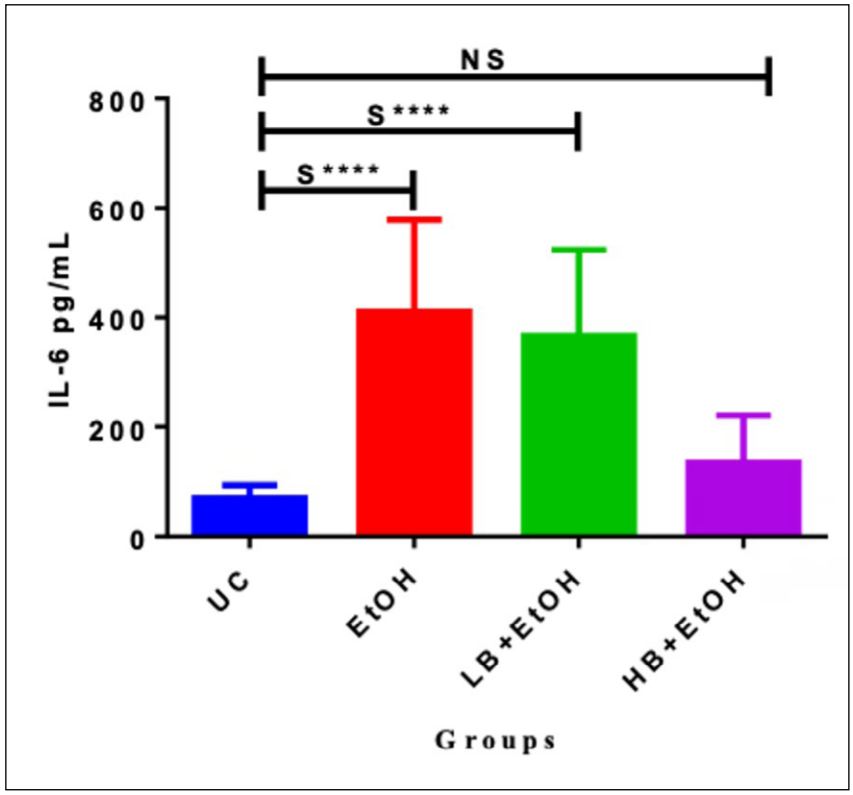

Fig. 2. Levels of IL-6 in the groups, P value < 0.05, ****P < 0.0001
Picture taken by the authors

stable, despite ethanol exposure. This indicates a strong protective effect, preventing TNF-α elevation and maintaining a normal inflammatory balance.

Hence, the absence of statistical significance between the HB+EtOH and control groups is not a defect but rather a confirmation of the high potency of basil against ethanol-induced inflammation. This supports the hypothesis that high-dose basil extract possesses strong hepatoprotective properties, with potential mechanisms involving antioxidant actions, suppression of pro-inflammatory signals, and regulation of immune activity [20].

Interleukin-6 (IL-6) is a pro-inflammatory cytokine responsible for immune modulation and liver inflammation

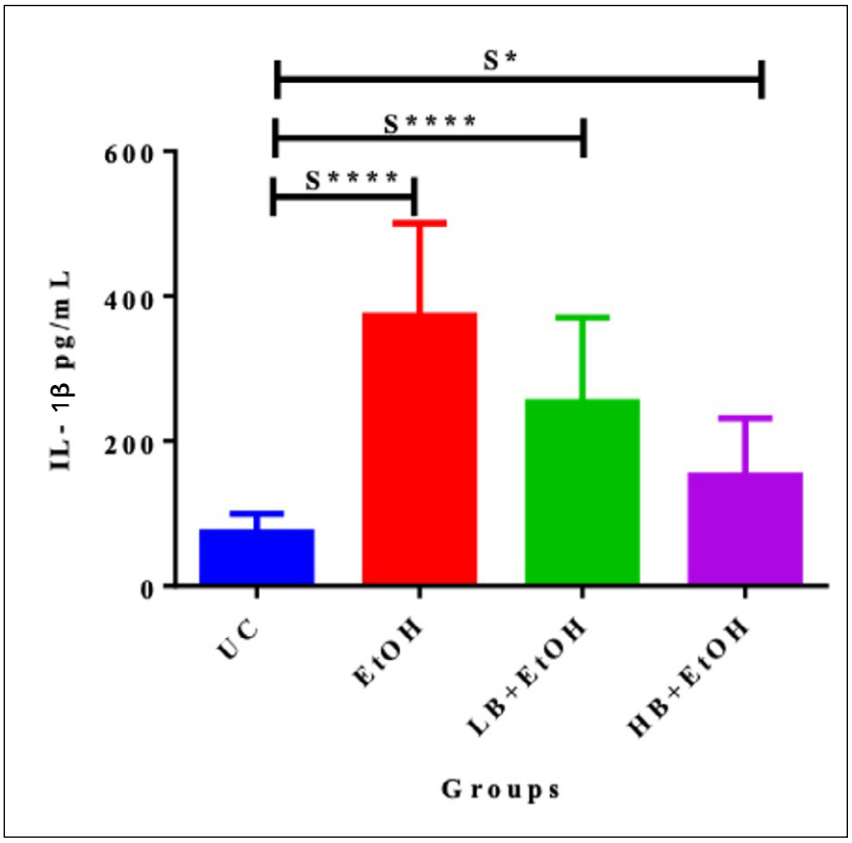

Fig. 3. Levels of IL-1**β** in the groups, *P < 0.001, ****P < 0.0001
Picture taken by the authors

[21]. The results of this current study show that ethanol exposure had a substantial elevation of IL-6 levels, while high-dose basil supplementation (HB+EtOH) returned the levels of IL-6 to nearly normal levels, as demonstrated by the lack of statistical difference between this group and the control. The ethanol-only (EtOH) group exhibited a dramatic increase in IL-6 levels (410.3 ± 167.7 pg/mL, P < 0.0001) compared to the control group (70.53 ± 23.39 pg/mL) as illustrated in Table 2 and Fig. 2.

This sharp elevated confirms the pro-inflammatory effect of chronic ethanol consumption, which stimulates hepatic immune cells (Kupffer cells) and causes oxidative stress, leading to IL-6 overexpression [22]. Elevated IL-6 has been correlated with hepatocellular damage, fibrosis, and the progression of alcohol-related liver disease. The low-dose basil (LB+EtOH) group showed a moderate decrease in IL-6 levels (366.8 ± 157.1 pg/mL, P < 0.0001) compared to the ethanol-only group. However, with this reduction, IL-6 remained significantly higher than that of the control group, showing that this dose provided only a partial protection against ethanol-induced inflammation. The HB+EtOH group exhibited a substantial reduction in IL-6 (133.9 ± 86.76 pg/mL), and most importantly, there was no statistical difference between this group and the control (P > 0.05).

This result suggests that high-dose basil supplementation fully counteracted the ethanol-induced IL-6 elevation, effectively restoring IL-6 levels to normal. The absence of a statistical difference between the HB+EtOH and control groups suggests that high-dose basil completely neutralized the IL-6 increase caused by ethanol. This is a highly favorable outcome, as it implies that basil at this dose was effective enough to prevent inflammatory changes rather than just reducing them [23].

Unlike the LB+EtOH group, where IL-6 remained significantly elevated, the HB+EtOH group's normalization of IL-6 suggests a strong anti-inflammatory response, possibly due to Inhibition of NF-κB activation, reducing IL-6 gene expression, antioxidant properties of basil polyphenols, scavenging reactive oxygen species (ROS) that drive inflammation, and Modulation of gut microbiota, reducing endotoxin-mediated cytokine release [24]. Since IL-6 is a key driver of liver inflammation and fibrosis, the ability of high-dose basil to completely prevent IL-6 elevation suggests a strong therapeutic potential for managing alcohol-induced liver injury [25]. These results indicate that basil supplementation at an optimized dose may help prevent progression to more severe liver conditions such as fibrosis or cirrhosis.

Interleukin-1 beta (IL-1β) is a key pro-inflammatory cytokine involved in liver inflammation and immune responses [26]. The results of this study confirm that ethanol exposure significantly elevated IL-1β levels, while basil supplementation, particularly at a high dose, effectively reduced IL-1β, though it remained

slightly elevated compared to the control group. The ethanol-only (EtOH) group exhibited a substantial increase in IL-1β levels (373.1 ± 127.7 pg/mL, $P < 0.0001$) compared to the control group (73.67 ± 26.21 pg/mL) as illustrated in Table 2 and Fig. 3.

This sharp rise highlights the role of ethanol in triggering liver inflammation through oxidative stress, gut-derived endotoxins, and activation of immune cells (Kupffer cells). IL-1β is a critical mediator in the pathogenesis of alcoholic liver disease (ALD), promoting hepatocyte apoptosis, fibrosis, and further inflammatory cytokine release. The low-dose basil (LB+EtOH, 50 mg/kg) group exhibited a marked reduction in IL-1β (254.0 ± 116.7 pg/mL, $P < 0.0001$) compared to the ethanol-only group. However, IL-1β levels remained significantly higher than the control group, indicating partial protection against ethanol-induced inflammation. he high-dose basil (HB+EtOH, 100 mg/kg) group further reduced IL-1β (152.3 ± 79.37 pg/mL, $P < 0.05$), bringing levels much closer to the control. While there was still a statistically significant difference from the control group ($P < 0.05$), the reduction was substantial, indicating strong hepatoprotective effects. Unlike TNF-α and IL-6, which were fully restored to normal with high-dose basil, IL-1β remained slightly elevated, though significantly reduced compared to ethanol exposure alone. This suggests that basil effectively mitigates ethanol-induced IL-1β elevation but does not completely normalize it. Possible reasons for this include: Different regulatory mechanisms: IL-1β production is tightly controlled by inflammasome activation, which may not be fully inhibited by basil at the given dose [27]. Residual oxidative stress and immune activation, while basil reduces inflammation, some residual ethanol-induced damage may still contribute to IL-1β production [28] [29]. Delayed response, IL-1β is one of the earliest cytokines activated in response to liver injury [30]. A longer duration of basil treatment may be needed for full normalization. Since IL-1β is a major contributor to liver fibrosis and hepatocyte apoptosis [31], the ability of high-dose basil to significantly lower IL-1β suggests potential therapeutic benefits in preventing the progression of alcohol-induced liver disease (ALD), steatohepatitis, and fibrosis. While IL-1β was not fully normalized, its substantial reduction implies that basil supplementation could still mitigate long-term liver damage and inflammatory progression.

CONCLUSIONS

The conclusion of this study demonstrate that *Ocimum basilicum* extract, particularly at high doses, effectively mitigates ethanol-induced liver inflammation by reducing pro-inflammatory cytokine levels. The high-dose basil group showed TNF-α and IL-6 levels statistically similar to the control group, suggesting a strong hepato-protective effect. Although IL-1β levels were not fully normalized, they were significantly reduced compared to the ethanol-only group. These findings highlight the potential of basil as a natural therapeutic agent for preventing liver damage and inflammatory diseases associated with chronic ethanol exposure.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Peculiarities of aggressive behavior manifestation and mental self-regulation in police officers during the war

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ABSTRACT

Aim: To compare the peculiarities of aggressive behavior and mental self-regulation in police officers with different experiences of service activities in the conditions of war.

Materials and Methods: The research was conducted during 2023-2024 among police officers (n = 68) and the 3rd training year police cadets (n = 72). Research methods: analysis and generalization of literary sources, psycho-diagnostic methods, methods of mathematical statistics.

Results: Differences in the manifestations of aggression between police officers and cadets were found. In particular, the cadets demonstrated significantly ($p < 0.001$) higher values on the scales of "Suspicion" (4.2 points) and "Hostility index" (7.4 points), which indicates a more pronounced tendency to interpret the social environment as potentially threatening. At the same time, police officers showed significantly ($p < 0.001$) higher indicators on the scales of "Physical aggression" (8.2 points) and "Aggression index" (22.6 points), which indicates a readiness to physically respond to a threat. It was found that police officers have a significantly lower level of general mental self-regulation (24.0 points) and flexibility (6.3 points) compared to cadets (32.7 and 7.0 points, respectively), which may indicate the rigidity of behavioral strategies due to adaptation to professional activities under martial law.

Conclusions: The results obtained indicate the need to develop mechanisms of self-regulation in police officers as a critical component of the system of psychological support for the professional activities of police officers, prevention of their aggressive behavior, especially in the context of performing service duties in situations of increased threat and uncertainty characteristic of wartime.

KEY WORDS: self-regulation, aggression, police activities, locus of control

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INTRODUCTION

The mental health of police officers is a critical resource for ensuring the effective performance of professional functions to ensure law and order and the safety of citizens, especially in times of war. Police service activities involve constant readiness to act in emergency situations, is accompanied by a high level of psycho-emotional stress, chronic stress and the need to make decisions in a state of uncertainty and time pressure.

Prolonged exposure to high-risk conditions leads to negative consequences, primarily in the mental sphere [1]. In stressful situations, the body's blood composition also changes. Hormones secreted by the endocrine glands cause anxiety, alertness, and aggression [2]. The issue of studying and maintaining stable psycho-emotional states is relevant, as their imbalance reduces professional efficiency and creates risks for both the employee and the environment.

Mental self-regulation is a key mechanism for controlling emotions and aggression in difficult conditions. Self-regulation is understood as the ability to consciously adjust emotional state and behavior using mental techniques and attitudes. According to research, the development of self-regulation skills in stressful (extreme) situations is one of the most effective ways to increase police officers' psychological resilience [3]. Highly developed self-regulation skills play a leading role in a person's ability to control their own mental activity, emotional states and behavior in professional activities [4]. During martial law, when the intensity of psycho-emotional stress increases significantly, the importance of self-regulation enhances meaningfully. Previous research confirms the effectiveness of targeted training of emotional regulation skills, physical and psychophysiological training as a means of reducing stress reactivity among law enforcement officers [5]. This involves the use of various psychological and physiological techniques (breathing exercises, relaxation, conscious regulation of emotions, etc.) to reduce muscle tension and emotional arousal that accompany

dangerous activities. Preventing the accumulation of aggressive impulses through self-regulation helps to reduce the risks of escalation of conflicts in service activities and excessive aggression. The results of the research can be used in the system of psychological support for police officers to develop trainings and programs of psychological support for police officers aimed at increasing their stress resilience and developing self-regulation skills to prevent excessive aggression.

AIM

The aim is to compare the peculiarities of aggressive behavior and mental self-regulation in police officers with different experiences of service activities in the conditions of war.

MATERIALS AND METHODS

PARTICIPANTS

The empirical basis of the work is the results of an experimental research conducted in 2023-2024 with the participation of the 3rd training year police cadets studying in the specialty referred to as "Law Enforcement" at the National Academy of Internal Affairs (NAIA, Kyiv, Ukraine) who underwent practical training (n = 72) and patrol police officers who took advanced training courses at the NAIA (n = 68). The study groups were formed taking into account the duration of practical experience: from 6 months (police cadets) to 3 years (police officers). This time interval reflects the early stage of professional adaptation and entry into police activities.

To achieve the research aim, a set of interrelated methods was used: analysis and generalization of literary sources on the selected topic, psycho-diagnostic methods, methods of mathematical statistics. Analysis and generalization of literature sources was used to conduct an analytical review of scientific sources on the outlined range of issues (19 sources from MedLine, Scopus, Web of Science, and Index Copernicus were analyzed).

Psycho-diagnostic methods involved conducting research work with police officers. For this purpose, valid methods were used: Buss-Durkee Aggression Inventory, Proclivity for Legitimized Aggression Questionnaire (PLAQ), J. Rotter's Internal-External Locus of Control Scale, V. Morosanova's Style of Self-Regulation of Behavior Questionnaire [6-8].

The Buss-Durkee Aggression Inventory allows assessing the overall level of police aggression, as well as identifying the predominant forms of aggressive behavior: physical, verbal aggression, hostility, suspicion, and sense of guilt. The respondents were asked to answer 75 questions by choosing one of the following options: "yes"; "probably yes"; "probably no"; "no". After receiving the respondents' answers, the sum of points for each scale was calculated according to the "key".

The Proclivity for Legitimized Aggression Questionnaire (PLAQ) is used to study aggression that is socially approved, i.e., legitimized. The use of this questionnaire makes it possible to identify legitimized manifestations of aggression and separate them from spontaneous and uncontrolled aggression. The method includes an integral indicator that can be used to draw a conclusion about a person's general tendency to legitimized aggression. The respondents were asked to answer 44 questions by choosing one of the proposed options. The conclusion about the severity of a particular trait was made as follows: up to 30 % of the total number of points – no or slight severity of the trait, above 60 % of the total number of points – a clearly expressed trait, a tendency to aggression.

The Internal-External Locus of Control Scale (J. Rotter) was used to determine the locus of control (internality/externality). This method allows us to determine the extent to which police officers are focused on their own responsibility for the consequences of their actions. The respondents were asked to evaluate 29 statements and choose one of two statements. When processing the results, the scores were summed up, taking into account the key for interpreting the research methodology. The total and maximum score for internality and externality was 23 points.

The Style of Self-Regulation of Behavior Questionnaire (by V. Morosanova) is used to determine the level of formation of an individual system of conscious mental self-regulation, which covers such key components as goal setting (planning), action programming, behavioral flexibility, independence, and evaluation of results. The method helps to determine the ability of police officers to manage their own psycho-emotional state and behavior under stress. The respondents were offered a number of statements (46 statement questions) about behavioral peculiarities. They had to choose one of four possible answers: "Correct", "Probably true", "Probably false", "Incorrect". The scores were summarized according to the key provided for interpreting the research methodology.

ORGANIZATION OF THE RESEARCH

The research was conducted in three consecutive stages. The first stage provided for the analytical review of modern scientific sources on the issues of self-regulation, aggression, and the peculiarities of

Table 1. The results of the study of aggression of police officers (n = 68) and cadets (n = 72) according to the Buss-Durkee Inventory (Mean ± m), points

Type of aggressive behavior	Police officers (n = 68)		Police cadets (n = 72)		Significance of the difference	
	Level of manifestation	Mean ± m	Level of manifestation	Mean ± m	t	p
Verbal aggression	high	6.3±0.28	high	7.0±0.26	1.83	>0.05
Physical aggression	high	8.2±0.24	average	4.8±0.25	9.81	<0.001
Indirect aggression	average	4.4±0.18	average	4.3±0.17	0.40	>0.05
Suspicion	low	2.8±0.13	average	4.2±0.11	8.22	<0.001
Sense of guilt	average	3.9±0.17	average	3.8±0.16	0.43	>0.05
Irritation	average	4.2±0.15	average	4.1±0.17	0.44	>0.05
Resentment	average	4.7±0.16	average	4.5±0.15	0.91	>0.05
Negativism	low	2.0±0.13	low	2.3±0.14	1.57	>0.05
Hostility index	within norms	6.1±0.17	within norms	7.4±0.18	5.25	<0.001
Aggressiveness index	within norms	22.6±0.31	lower norm	15.5±0.26	17.55	<0.001

Note: M is the arithmetic mean; m is the standard error of the arithmetic mean; t is a Student's t-test value; p is the statistical significance indicator
Source: compiled by the authors of this study

police professional activities in wartime. Based on this, psycho-diagnostic methods were selected that meet the research objectives. The second stage involved diagnostic work organization with police employees – police officers and police cadets. Forms were created that contained brief instructions for each method. The testing was conducted on an individual basis in compliance with the principle of voluntariness and confidentiality. The respondents were not provided with keys for independent interpretation of the results. The third stage involved quantitative and qualitative processing of the results. Mathematical and statistical analysis, comparison of data by subgroups (police cadets and police officers), and interpretation of indicators were conducted. The organization of the research and processing of the results was carried out at the Department of Legal Psychology of the NAIA.

STATISTICAL ANALYSIS

The statistical method was used to process the experimental data obtained. For the statistical comparison of the groups of subjects, the Student's t-test for independent samples was used. The criterion allows us to determine the difference in the mean values of the samples on the respective questionnaire scales. The reliability of the difference was set at the level of $p < 0.05$. All statistical analyses were performed using SPSS version 10.0 software adapted for medical and biological research.

The research was carried out in accordance with the requirements of the Regulations on academic integrity at the National Academy of Internal Affairs. This document was approved by the Academic Council of the National Academy of Internal Affairs (protocol No. 5 of 27.03.2018) and put into effect by order of the rector of the Academy (Order No. 422 of 30.03.2018). Prior consent to participate in the study was obtained from all respondents.

RESULTS

In the course of the research, we were able to obtain relevant results and outline certain trends in the behavior of police officers with different service experiences. In particular, the results of the assessment of aggressive behavior of police officers and cadets are presented in Table 1.

According to the results of the Buss-Durkee Aggression Inventory, the average indicators of police cadets and police officers differ significantly ($p > 0.05$) and correspond to the average level of expression of such forms of aggression as "Sense of guilt", "Irritation" and "Resentment". This level of aggression is considered to be within the normal range: its absence can limit personal development and professional effectiveness, while excessive aggression complicates social interaction and causes conflict.

The "Verbal aggression" scale revealed a high and significantly similar ($p > 0.05$) level of this type of aggression in police officers (6.3 points) and cadets (7.0 points), which manifests itself in verbal reactions such as a raised tone, remarks or instructions. At the same time, police officers have a high level on the "Physical aggression" scale (8.2 points). This value is significantly ($p < 0.001$) higher than that of cadets (4.8 points) by 3.4 points. This form of aggression can be used when performing the goals and tasks assigned to a police officer, in

Table 2. The results of the study of legitimized aggression in police officers (n = 68) and cadets (n = 72) using the PLAQ methodology (Mean ± m), points

Scale	Police officers (n = 68)		Police cadets (n = 72)		Significance of the difference	
	Level of manifestation	Mean ± m	Level of manifestation	Mean ± m	t	p
Integral scale of legitimized aggression	average	70.7±2.16	average	77.8±2.29	2.26	<0.05

Note: M is the arithmetic mean; m is the standard error of the arithmetic mean; t is a Student's t-test value; p is the statistical significance indicator
Source: compiled by the authors of this study

Table 3. The results of assessing internal-external locus of control in police officers (n = 68) and cadets (n = 72) by J. Rotter's method (Mean ± m), points

Scale	Police officers (n = 68)		Police cadets (n = 72)		Significance of the difference	
	Quantity, %	Mean ± m	Quantity, %	Mean ± m	t	p
Internality	78	13.9±0.51	80	14.1±0.57	0.26	>0.05
Externality	22	9.1±0.22	20	8.9±0.24	0.61	>0.05

Note: M is the arithmetic mean; m is the standard error of the arithmetic mean; t is a Student's t-test value; p is the statistical significance indicator
Source: compiled by the authors of this study

particular, the use of physical force for preventive purposes, the use of coercive measures or the protection of public order. Both groups of subjects demonstrated a low and significantly similar ($p > 0.05$) level on the "Negativism" scale, which is manifested in the absence of a tendency to protest or demonstratively deny the established norms.

When summarizing the results, it was taken into account that irritation, physical, indirect and verbal aggression form the aggression index, while resentment and suspicion form the hostility index. The norm of aggression is considered to be the value of its index equal to 21 ± 4 points. The hostility index should be within 7 ± 3 points. The average values of the hostility index of police cadets (7.4 points) and police officers (6.1 points) are within the normal range, although police cadets have a significantly higher level of this indicator ($p < 0.001$) compared to officers. This may be due to age-related peculiarities, in particular, a tendency to maximalism and categorical judgments typical of the youth period, as well as the process of forming a socio-professional identity. The aggression index of police officers (22.6 points) is also within the normal range, while in cadets (15.5 points) this index is significantly ($p < 0.001$) lower compared to officers and to the normative value. The higher level of aggression among officers is due to the influence of professional stressors accumulating during their service.

Thus, the presence of statistically significant differences in the scales of "Suspicion", "Hostility index", "Physical aggression", "Aggression index" indicates that police cadets demonstrate higher levels of suspicion and hostility compared to officers, which is due to age-related characteristics and the presence of rigid social attitudes in the process of their professional development. Instead, police officers show a higher tendency to physical aggression, which reflects the process of professional adaptation to the conditions of service, where the use of force is seen as a tool for responding to threatening situations.

The results of the research were further confirmed by the Proclivity for Legitimized Aggression Questionnaire (PLAQ), which aims to identify the respondents' attitudes toward socially approved (legitimized aggression), as well as to determine the forms of aggressive behavior that they consider acceptable in specific circumstances. The PLAQ methodology revealed the following results, which are presented in Table 2.

According to the results, there is a tendency for the respondents to justify aggressive behavior, to give it the status of acceptable or justified under certain circumstances. Both groups – police officers (70.7 points) and cadets (77.8 points) – showed an average level of inclination to display legitimized aggression, but there was a statistically significant ($p < 0.05$) difference between them (7.1 points), which indicates a higher level of acceptability of aggressive actions among police cadets. Such an attitude may be due to psychological mechanisms of self-defense, in particular, the desire to justify their own actions in the eyes of others.

One of the key aspects in the study of aggressive behavior is to determine the level of personal responsibility for aggressive actions and to analyze the belief system that underlies the approval or denial of such manifestations. J. Rotter's Internal-External Locus of Control Scale methodology allows assessing the indi-

Table 4. The results of the study of self-regulation of police officers (n = 68) and cadets (n = 72) by the Style of Self-Regulation of Behavior Questionnaire (Mean ± m), points

Scale	Police officers (n = 68)		Police cadets (n = 72)		Significance of the difference	
	Level of manifestation	Mean ± m	Level of manifestation	Mean ± m	t	p
Planning	high	7.0±0.21	average	6.2±0.23	2.57	<0.05
Modeling	average	6.3±0.25	high	7.1±0.25	2.26	<0.05
Programming	average	6.1±0.20	average	6.4±0.19	1.09	>0.05
Evaluation of results	average	6.2±0.22	average	6.0±0.21	0.69	>0.05
Flexibility	average	6.3±0.19	average	7.0±0.20	2.54	<0.05
Independence	average	5.6±0.20	low	5.2±0.21	1.38	>0.05
General level of self-regulation	average	24.0±0.75	high	32.7±0.79	7.99	<0.001

Note: M is the arithmetic mean; m is the standard error of the arithmetic mean; t is a Student's t-test value; p is the statistical significance indicator
Source: compiled by the authors of this study

vidual's readiness to take responsibility for their own actions. According to the J. Rotter's Internal-External Locus of Control Scale methodology, the following results were found, which are presented in Table 3.

The directionality of the locus of control should be judged by the relative excess of the results of one dimension over the other. As you can see, the majority of the respondents, both cadets (80.0 %) and officers (78.0 %), have an internal locus of control. No significant difference was found between the indicators ($p > 0.05$). This indicates that beliefs about success or failure depend on their qualifications, level of abilities and are the result of purposeful activity.

The formed system of self-regulation is a determining factor in the professional success of police officers, as it allows them to control their own behavior and use aggression only to the extent necessary and sufficient to fulfill their professional goals and tasks. To study the level of self-regulation of police officers, the Style of Self-Regulation of Behavior Questionnaire by V. Morosanova was used. It aims to study the general level of self-regulation, as well as its components: planning, modeling, programming, evaluation of results, flexibility, and independence. The results are presented in Table 4.

The average values on the questionnaire scales indicate that there are no significant ($p > 0.05$) differences between police officers and cadets in terms of such indicators as programming, evaluation of results, and independence. Most of them are at the average level, which indicates the ability of both groups to consciously formulate goals, adapt to changes and effectively achieve results.

At the same time, there are significant differences in the "Planning" scale: police officers have a high level (7.0 points), while cadets (6.2 points) have an average level. This indicates a more developed ability to consciously plan professional activities among more experienced professionals, including the formation of realistic, detailed and sustainable plans. On the other hand, the cadets scored higher on the "Modeling" scale (7.1 points) compared to officers (6.3 points), which indicates a more active use of imaginative modeling of future actions. This feature may be related to educational motivation and involvement in training forms of education.

The overall level of self-regulation was significantly ($p < 0.001$) higher among cadets (32.7 points) than among officers (24.0 points), which indicates a more developed ability to consciously regulate one's own behavior, plan, control and correct actions among younger respondents. The lower level of self-regulation among police officers may be the result of psycho-emotional exhaustion that accompanies their professional activities. Police officers are also characterized by a significantly lower level of flexibility ($p < 0.05$) compared to cadets, which is manifested in uncompromising, clear and consistent performance of duties, relying on established algorithms of action. This potentially reduces adaptability in non-standard or stressful situations requiring a variable approach.

Summarizing the results of the research, it should be noted that there are significant differences in the manifestation of aggressive behavior between police officers and police cadets. Higher indicators on the "Suspicion" and "Hostility index" scales among cadets indicate a tendency to perceive the social environment as threatening, which may be due to lack of professional experience and high sensitivity to external stimuli. Police officers, on the other hand, demonstrate higher levels of physical aggression and general aggression index, which is likely a consequence of prolonged professional adaptation to

extreme conditions of service, where physical response to a threat becomes functional. At the same time, officers show a lower level of mental self-regulation, in particular in terms of flexibility indicators, which shows the formation of rigid, automated response models that may not be effective in situations of uncertainty. In view of this, the results of the research necessitate the systematic development of police officers' self-regulation skills as a critical resource for maintaining emotional stability, ensuring professional efficiency and preventing destructive behaviors in armed conflict.

DISCUSSION

The armed conflict in Ukraine has significantly complicated the conditions of police officers' professional activities, leading to an increase in psychological stress, the risk of emotional exhaustion and the likelihood of destructive behavioral reactions. A number of studies have shown that chronic professional stress correlates with increased anxiety, emotional instability, and reduced self-control, which creates prerequisites for aggression [4, 8, 9]. In particular, Staller, Müller, and Yan Wang found that mental exhaustion significantly reduces the ability to self-regulate, increasing the risk of impulsive use of force [11, 12]. The findings of our research are consistent with these conclusions: police officers demonstrate a higher tendency to physical aggression and lower indicators of mental self-regulation compared to cadets, which may indicate manifestations of psycho-emotional exhaustion in the process of professional adaptation.

At the same time, in times of war, psychological challenges are typical not only for practicing officers, but also for cadets undergoing professional training. Thus, according to the study, academic stressors in wartime have a negative impact on the mental health of cadets, contributing to increased anxiety, emotional stress and reduced stress resilience [13-15]. These results are partially consistent with our findings: cadets demonstrate higher levels of hostility and suspicion, which may be a consequence of increased susceptibility to potential threats in an unstable environment.

The development of self-regulation skills is central to modern approaches to increasing stress resilience and psychological stability, especially in conditions of increased professional stress. Positive results are demonstrated by neurofeedback training, resilience development programs, physical activity, and targeted psychoprophylactic interventions [5, 16-19]. The data of our empirical research confirm the expediency of integrating such approaches into the system of psychological support for law enforcement activities under martial law as a means of minimizing the risk of excessive aggression and increasing professional efficiency.

CONCLUSIONS

Differences in the manifestations of aggression between police officers and cadets were found. In particular, the cadets demonstrated significantly ($p < 0.001$) higher values on the "Suspicion" (4.2 points) and "Hostility index" (7.4 points) scales, which indicates a more pronounced tendency to interpret the social environment as potentially threatening. This tendency to distrust and emotional tension may be due to youthful age, instability of worldview standpoints, and rigidity of social attitudes in the process of their professional development. At the same time, police officers showed significantly ($p < 0.001$) higher indicators on the "Physical aggression" (8.2 points) and "Aggression index" (22.6 points) scales, which indicates a readiness to physically respond to a threat. This fact can be viewed as a consequence of professional adaptation, in which physical response is perceived as an acceptable and functional tool for performing service tasks. In this context, aggressive behavior acquires the characteristics of a normative, legitimized strategy of action, especially in times of war.

It was found that police officers have a significantly lower level ($p < 0.05$-0.001) of general mental self-regulation (24.0 points) and flexibility (6.3 points) compared to cadets (32.7 and 7.0 points, respectively), which may indicate the rigidity of behavioral strategies due to adaptation to professional activities under martial law. This result reflects the influence of an educational environment focused on the development of personal potential, increased intrinsic motivation for professional growth, and the absence of a cumulative effect of professional stress. Instead, the lower level of self-regulation among officers, as well as statistically significant differences in the "Flexibility" scale, indicate the dominance of automated, rigid behavioral patterns that are formed during the period of professional adaptation.

The findings emphasize the importance of developing self-regulation skills as a key tool for preventing aggressive behavior among police officers, especially in wartime. In this regard, it is advisable to introduce targeted programs for the development of mental self-regulation into the system of psychological support for the professional activities of police officers, which will help to increase professional reliability and maintain ethical responsibility in difficult conditions of performing service duties.

PROSPECTS FOR FURTHER RESEARCH

To study gender peculiarities of self-regulation and aggression manifestation among police officers in view of stressful situations of martial law.

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The topic and content of the article correspond to the provisions of the priority areas of research of the National Academy of Internal Affairs within the research work for 2020-2025 under "Psychological, pedagogical and sociological support of law enforcement" (State registration number 0113U008196).

CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Improving the health of people with diseases of the musculoskeletal system through physical therapy

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ABSTRACT

Aim: To investigate the effectiveness of physical therapy in improving the health of patients with diseases of the musculoskeletal system.

Materials and Methods: The research, conducted in 2022-2024, involved 105 patients with musculoskeletal disorders. Research methods were bibliosemantic, medical and sociological, and statistical.

Results: It has been found that only 24.8 % of the patients engage in physical activity daily to maintain the health of the musculoskeletal system, 24.8 % rarely, and 14.3 % do not engage at all. It has been found that among the physical therapy means used by the patients to maintain the health of their musculoskeletal system are exercise machines – 32.4 %, therapeutic physical education – 26.7 %, therapeutic massage – 16.2 %, and yoga – 8.6 %. The patients rarely use manual therapy (7.6 %) and Kinesio taping (5.7 %). Factors limiting access to physical therapy means for the patients in their region include a lack of reliable information about the availability and affordability of physical therapy means – 48.6 %, financial difficulties – 30.4 %, and remoteness of healthcare facilities – 8.6 %. 96.2 % of the patients indicated they needed advice and information on physical therapy to strengthen their musculoskeletal system.

Conclusions: Effective ways to increase the use of physical therapy for patients with diseases of the musculoskeletal system include intensifying the information campaign on therapeutic exercise and other physical therapy means in the media, expanding the network of rehabilitation facilities, and reducing the cost of rehabilitation services.

KEY WORDS: health, diseases of the musculoskeletal system, musculoskeletal disorders, physical therapy, patients

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INTRODUCTION

The results of the World Health Organization's Global Burden of Disease study (2019) show that disorders of the musculoskeletal system are the second leading cause of disability worldwide [1]. In Ukraine, diseases of the musculoskeletal system increase primary disability by about 0.5 % annually compared to previous years [2, 3]. These diseases lead to a deterioration in health and a decrease in the ability to work, which has significant economic consequences for the state.

The incidence and prevalence of diseases of the musculoskeletal system or supporting motor apparatus among people of different age groups vary significantly. Ukraine is one of the countries with a relatively high level of population aging. While among children, the prevalence of musculoskeletal diseases exceeds the incidence rate by 2.24-2.36 times, with age (in the older age group), it increases by 4.7 times [4].

According to specialists [5], the most common diseases of the musculoskeletal system (disorders of the supporting motor apparatus) that require physical therapy include arthritis, osteochondrosis, scoliosis, hip dysplasia, injuries of joints, muscles, tendons, and patellar dislocation.

One of the main areas of improving the health of patients with diseases of the musculoskeletal system is physical therapy, which involves a set of measures aimed at reducing the level of disability among the population [6]. According to scientists [7], physical therapy seeks to restore disabled people's health and ability to work; it is carried out in the context of integrative activities of healthcare workers and public health pro-

fessionals. Diagnostics and examination of the health status of patients with diseases of the musculoskeletal system involves an examination, collection of medical history, and the use of special tests and measurements. Based on the collected data, possible developments are predicted. Modelled forecasts are used to develop a physical therapy plan for patients. The physical therapy program includes cooperation with the patient and family members, a list of medications, and physical therapy means [8]. Upon completion of the physical therapy course, the effectiveness of rehabilitation achievements is determined, and recommendations are made for a further individualized trajectory for the patient's physical rehabilitation. Patients receive instructions and advice on how to improve their health, physical activity and self-care methods. If necessary, appropriate adjustments are made to the physical therapy plan [9]. At the same time, the study of the patients' opinions and attitudes regarding the effectiveness of physical therapy in the recovery of musculoskeletal disorders is appropriate and relevant.

AIM

The aim is to investigate the effectiveness of physical therapy in improving the health of patients with diseases of the musculoskeletal system.

MATERIALS AND METHODS

The research was conducted in 2022-2024 at Zhytomyr Ivan Franko State University and Poltava State Medical University. The research involved 105 patients with musculoskeletal disorders (71 women (67.6 %) and 34 men (32.4 %)). The vast majority of the patients were 18-24 (55.2 %) and 25-44 (26.7 %).

Research methods: bibliosemantic, medical and sociological (survey), statistical. The research was conducted in four consecutive stages. The first stage involved substantiation of the relevance of the chosen topic, determination of the aim, analysis of the literature on physical therapy, its means and effectiveness of their use for patients with musculoskeletal disorders, and selection of appropriate research methods. The second stage provided for the development of the means of conducting a medical and sociological study, the determination of the contingent of respondents, and the development and approval of a questionnaire (18 questions) by the bioethics committee. Questionnaire was assessed by the experts in this field (2 professors and 5 associate professors) and was approved by the Academic Council of Zhytomyr Medical Institute of Zhytomyr Regional Council (Protocol No. 5 dated 03.10.2022). The third stage involved a survey among patients of healthcare facilities (n = 105). The survey aimed to study the effectiveness of physical therapy in improving the health of patients with musculoskeletal disorders. Due to the military operations in Ukraine, the survey was conducted remotely using the GOOGLE-FORMS tool. The patient respondents had the opportunity to use the survey materials at the link: https://docs.google.com/forms/d/1rnI_-vvwveUXW-WjYjVOsFevlyz-AK-nARiNP3qifJAc/edit?usp=drive_web. The questionnaire was anonymous without any references to the authors of the article in the answers. The results were used for scientific purposes only. The survey results were statistically processed on a personal computer using MS Excel. The fourth stage of the research allowed the general conclusions of the work to be formulated. Consent to voluntary participation in the survey was obtained from all the respondents involved in the study. This research followed the regulations of the World Medical Association Declaration of Helsinki – ethical principles for medical research involving human subjects.

RESULTS

The results of the survey of patients with musculoskeletal system diseases on the availability of knowledge about the importance of physical therapy for maintaining the health of the musculoskeletal system show that 60.7 % of the respondents have a high level of knowledge about the importance of physical therapy for preserving the health of the musculoskeletal system; 19.6 % have an average level of expertise; 19.7 % have an insufficient level of knowledge.

It has been found that only 24.8 % of the respondents engage in physical activity daily to maintain musculoskeletal health, 35.3 % – several times a week, 24.8 % – rarely, and 15.1 % of the respondents do not engage in physical activity at all or extremely infrequently. At the same time, 55.2 % of the respondents use physical therapy means to maintain or improve their health, 35.3 % – rarely, and 9.5 % – do not use it. It has been found that when choosing a type of physical activity, 60.9 % of the respondents take into account the state of their musculoskeletal system; 30.4 % do not take it into account.

Among the physical therapy means used by the patients to maintain the health of their musculoskeletal system, the following were identified: exercise machines – 32.4 %, therapeutic physical education (TPE) – 26.7 %, therapeutic massage – 16.2 %, and yoga – 8.6 %. Rarely, the patients use manual therapy (7.6 %), Kinesio taping (5.7 %), and other means (2.8 %) (Fig. 1). The most effective means of physical therapy used by the

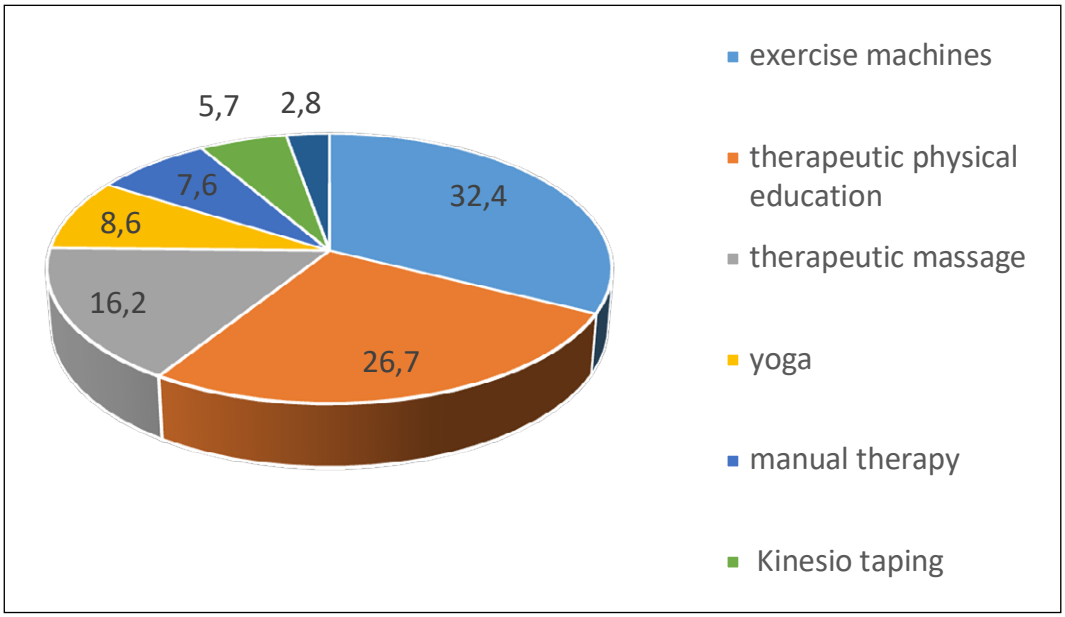

Fig. 1. Physical therapy means used by the patients to maintain the health of their musculoskeletal system
Picture taken by the authors

patients to maintain their health include exercise machines training (30.4 %), TPE training sessions (21.9 %), and therapeutic massage (23.8 %).

The factors that limit the accessibility of physical therapy means for the patients in their region include lack of reliable information about the availability and affordability of physical therapy means – 48.6 %, finances – 30.4 %, and remoteness of healthcare facilities – 8.6 %. At the same time, 44.6 % of the respondents believe that accessibility of physical therapy means for the general population can be increased by providing information about these services; 23.8 % of the respondents believe that expansion of the network of healthcare facilities can help; 23.8 % point to the practicality of reducing the cost of services. Moreover, 96.2 % of the patients said they needed advice and information on physical therapy to strengthen their musculoskeletal system. It was also found that 53.3 % of the respondents use apps or online resources to get the necessary advice on maintaining the health of their musculoskeletal system, with the majority (73.3 %) of the respondents using YouTube.

It has been found that more than half (53.3 %) of the patients use additional means to maintain the health of their musculoskeletal system, including orthopedic pillows or mattresses – 21.9 %, and orthopedic insoles in shoes – 7.6 %. Unfortunately, 47.6 % of the patients do not use any additional means to maintain the health of their musculoskeletal system. The reasons that prevent patients from using physical therapy include lack of time (62.9 %), apathy and indifference to their health improvement (16.1 %). The most effective measures to increase public interest in musculoskeletal health and physical therapy, according to patients, are information campaigns on television, social media and the Internet (57.1 %), organization of thematic events (21.9 %), involvement of celebrities who have overcome their musculoskeletal problems (8.6 %). According to the surveyed patients, the factors that would encourage people to participate more actively in physical therapy programs are providing subsidies and discounts for gym memberships (32.3 %), involving family and friends in active participation in physical therapy programs (24.7 %), meeting people who are actively engaged in physical therapy (19.1 %), and the need to organize health groups (14.3 %).

Answering the question, "What recommendations for strengthening the musculoskeletal system would you give to other people, especially those who face the same problems?" the respondents' answers were as follows: 44.8 % of the respondents said that regular physical activity is an important way to strengthen the musculoskeletal system; 14.3 % consider it important to visit rehabilitation specialists; 16.1 % called self-belief an important condition for strengthening the musculoskeletal system.

Thus, according to the survey of patients with musculoskeletal problems, most have access to physical therapy in their region. More than half of the respondents said that the most effective measures to increase public interest in musculoskeletal health and physical therapy are information campaigns on television, social media, etc. Almost half of the respondents believe that regular physical activity and visits to rehabilitation specialists are important ways to strengthen the musculoskeletal system.

DISCUSSION

According to the International Statistical Classification of Diseases, Tenth Revision (ICD-10), Class XIII, it is a musculoskeletal system disease with more than 120 nosologies. Most of them are degenerative and dystrophic diseases, as well as arthropathies and dorsopathies of inflammatory origin [10]. This explains the age-related differences in the structure of this class's incidence and prevalence of diseases. While degenerative and dystrophic diseases are more typical for adults, inflammatory atrophies (mainly rheumatoid) are more common in adolescents and young men. In general, the degenerative and dystrophic diseases group accounts for more than 60 % of the total number of diseases of the musculoskeletal system, and inflammatory arthropathies – about 8 % [11]. The proportion of diseases of the musculoskeletal system in the overall structure of morbidity depending on age is as follows: 0-14 years old – 1.84 ± 0.13 %, 15-17 years old – 4.84 ± 0.76 %, among women aged 18-55 years and men aged 18-60 years – 5.60 ± 0.26 %, women over 55 years and men over 60 years – 7.56 ± 0.26 % [12].

The proportion of musculoskeletal system diseases in the structure of total morbidity also depended on the age of patients, with a peak increase in young people, which was revealed during a detailed study of the health of young men by conscription commissions. The proportion of morbidity of the musculoskeletal system was as follows: 0-14 years old – 3.41 ± 0.18 %, 15-17 years old – 8.23 ± 0.58 %, women aged 18-55 years and men aged 18-60 years – 5.59 ± 0.31 %, women over 55 years and men over 60 years – 6.21 ± 0.22 % [13].

According to experts [14], the actual incidence of musculoskeletal system diseases is much higher due to the category of patients who, after diagnosis and treatment, self-medicated and next visited a doctor several years later when they were already disabled. The average long-term growth rate of musculoskeletal diseases was 0.10 % from 2002 to 2018 and 1.30 % from 2019 to 2022 [15].

In 2002-2018, the incidence of osteochondrosis was 101.72 ± 32.77 per 100 thousand people, and in 2019-2022, respectively, 105.12 ± 5.63. The average prevalence of osteochondrosis in 2002-2018 was 331.55 ± 27.79 per 100 thousand people and 361.24 ± 20.80 in 2019-2022 [16].

According to scientists [17], diseases of the musculoskeletal system, even in the early stages, negatively affect motor functions, which affects not only the ability to work but also the quality of life of such patients. Ineffective treatment and rehabilitation lead to temporary loss of working capacity and disability. Improving the results of treatment, including physical therapy means, and improving the quality of life of this group of patients is possible through outpatient support [18].

The treatment of diseases of the musculoskeletal system requires an integrated approach, from diagnosis to rehabilitation. Despite the variety of treatment methods, these diseases often lead to a high level of disability, which reflects both the state of health and the quality of medical and preventive services [19].

Scientists [20] note that physical therapy for patients with musculoskeletal disorders is carried out using active and passive means. Active means of physical therapy include TPE (modern name – kinesiotherapy), including therapeutic swimming, dosed walking, mechanical, hydro, and occupational therapy, home walking skills training, games, tourism, and outdoor recreation. The group of passive physical therapy means includes therapeutic massage, Kinesio taping, manual therapy, etc. [21].

When conducting physical therapy, experts [22] advise taking into account the following aspects: the type of injury, i.e. any abnormality or loss of anatomical or physiological structures and functions in the body, which may be the result of injury, disease or other factors; the nature of the impairment that occurs as a result of the injury and is defined as the loss or restriction of the ability to carry out daily activities within the limits considered normal for human society. Impairment of life-sustaining activities may include such aspects as motor limitations, pain, inability to perform self-care, etc. Taking these aspects into account allows us to assess the severity of the musculoskeletal disorder and develop individualized rehabilitation programs for patients.

CONCLUSIONS

It has been found that diseases of the musculoskeletal system are an important social problem that significantly affects patients' ability to work and their quality of life. Ineffective treatment and a lack of physical therapy lead to temporary loss of working capacity and disability, which is accompanied by significant economic losses for the state and patients.

It has been found that only 24.8 % of the patients engage in physical activity daily to maintain musculoskeletal health, 35.3 % – several times a week, 24.8 % – rarely, and 15.1% do not engage in physical activity at all or extremely infrequently. At the same time, 55.2 % of the respondents use physical therapy to maintain or improve their health, 35.3% – rarely, and 9.5% do not use it at al.

It has been found that among the physical therapy means used by the patients to maintain the health of

their musculoskeletal system are exercise machines – 32.4 %, therapeutic physical education (TPE) – 26.7 %, therapeutic massage – 16.2 %, and yoga – 8.6 %. Rarely do patients use manual therapy (7.6 %), Kinesio taping (5.7 %), and other means (2.8 %). The factors that limit the availability of physical therapy means for the patients in their region include a lack of reliable information about the availability and affordability of physical therapy means – 48.6 %, financial difficulties – 30.4 %, and remoteness of medical facilities – 8.6 %. Moreover, 96.2 % of the patients said they needed advice and information on physical therapy to strengthen their musculoskeletal system.

The patients consider information campaigns (57.1 %), organization of thematic events (21.9 %), and involvement of celebrities who have overcome their musculoskeletal problems (8.6 %) to be the most effective measures to increase public interest in musculoskeletal health and physical therapy. At the same time, 44.8 % of the patients are convinced that regular physical activity is an important way to strengthen the musculoskeletal system; 14.3 % consider it important to visit rehabilitation specialists; 16.1 % called self-belief an important condition for strengthening the musculoskeletal system.

Given the above, effective ways to increase physical therapy means for patients with musculoskeletal diseases are intensifying the information campaign on therapeutic exercise and other physical therapy means in the media, expanding rehabilitation facilities, and reducing the cost of rehabilitation services.

PROSPECTS FOR FURTHER RESEARCH

It is planned to develop a physical therapy program for patients depending on their musculoskeletal disorders based on the use of motor activity equipment and test its effectiveness in practice.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

The role of health monitoring technologies in optimising athletes' self-regulation

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ABSTRACT

Aim: To analyse current approaches to monitoring sports performance and health of athletes by developing an intelligent system that combines wearable devices, cloud computing and deep learning methods.

Materials and Methods: The paper analyses related literature in sports medicine, informatics and artificial intelligence. The work is based on studying the effectiveness of devices such as Fitbit Charge 5, Garmin Venu 2, Samsung Galaxy Watch 4, and Oura Ring Gen 3.

Results: Showed that such systems provide high accuracy in predicting athletes' health status. The presented models allow real-time tracking of physiological parameters, analysing the data and generating health reports for prompt adjustment of the training process. These devices enable systematic monitoring of various indicators, such as heart rate, stress level, sleep quality and overall physical activity. Reading these indicators allows athletes to receive objective information about their condition. This, in turn, contributes to more effective training planning, recovery and injury prevention.

Conclusions: Integrating wearables, cloud computing, and deep learning methods presented on the latest devices is a promising approach to sports health monitoring. The analysed devices can improve athletes' performance, prevent injuries and optimise training programmes.

KEY WORDS: wearable devices, mobile applications, analytics, self-regulation, sports performance, psychological well-being

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INTRODUCTION

In today's world, where technological advancements are covering all areas of life, sport is no exception. Technology has become an integral part of everyday practice, enabling athletes, coaches and even amateurs to improve their performance and maintain their health. Smartwatches, fitness trackers, and sleep and physical activity monitoring apps are just a few examples of how technology is being integrated into sports. Their role goes far beyond convenience, as they have an impact on optimising training, developing athletes' self-regulation and increasing the efficiency of goal achievement [1].

The relevance of the topic lies in the fact that the role of technology in sports is becoming increasingly important, especially in the context of professional and amateur training. The growing popularity of fitness apps and health monitoring platforms such as Strava, Fitbit, and Garmin Connect indicates a change in approaches to maintaining physical activity.

Such tools allow athletes to track key parameters, including heart rate, sleep duration and quality, number of steps, calories burned, and other metrics that determine the overall health of the body.

Considerable attention is paid to personalised approaches, where data obtained through technology is analysed and used to create individual training programmes [1, 2]. In this context, the importance of innovative solutions becomes obvious: they help athletes develop self-regulation skills, which is key to achieving long-term results and maintaining health.

Despite the fact that this topic has been studied, there are still research gaps. Despite the wide range of research on the use of technology in sports, many questions remain open. Most studies focus on the physical aspects of performance, while the psychological impact of monitoring technologies is often overlooked. The impact of such tools on athletes' motivation, emotional state, and cognitive processes has not been sufficiently studied. In addition, it is important to assess the long-term effect of such technologies, in particular, their ability to promote the development of self-regulation in different groups of athletes, from beginners to professionals.

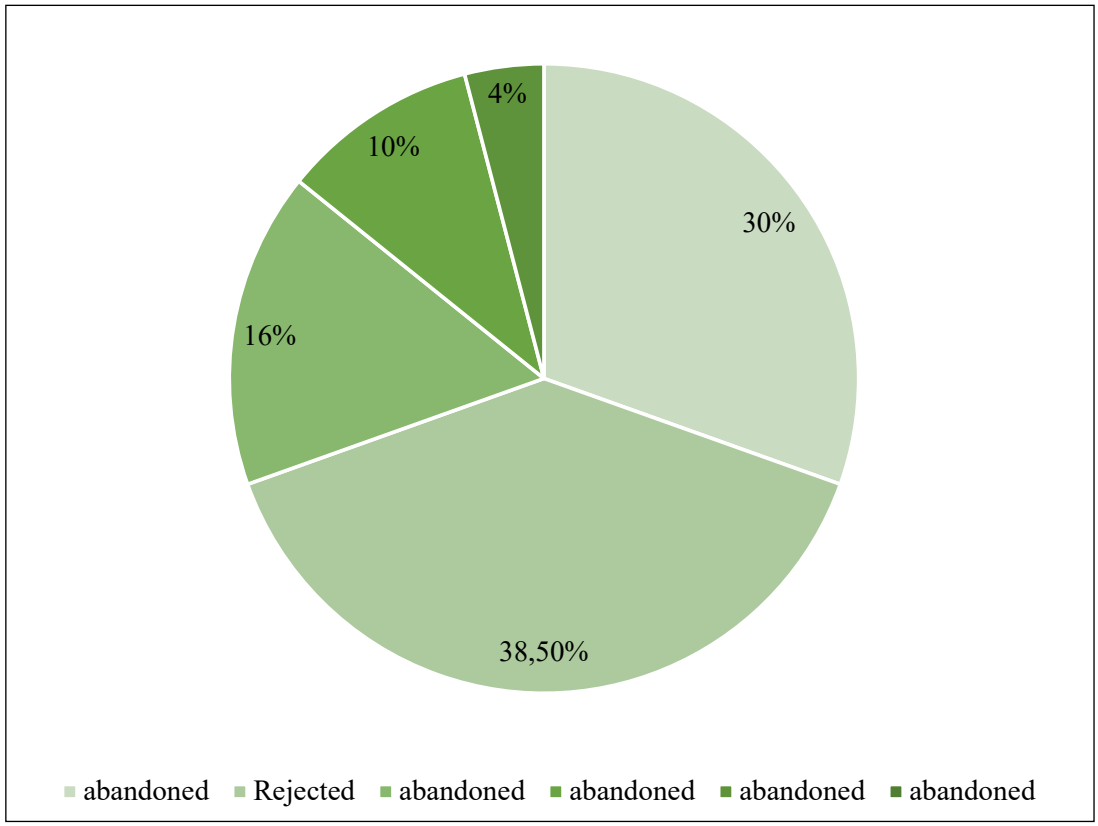

Fig. 1. Visualisation of publication selection according to PRISMA recommendations
Picture taken by the authors

AIM

To analyse current approaches to monitoring sports performance and health of athletes by developing an intelligent system that combines wearable devices, cloud computing and deep learning methods.

MATERIALS AND METHODS

The hypothesis of the study is that the use of health monitoring technologies, such as Fitbit Charge 5, Garmin Venu 2, Samsung Galaxy Watch 4, and Oura Ring Gen 3, increases the effectiveness of athletes' self-regulation, which in turn helps to improve their sports performance and reduce the risk of injury.

The study used a comprehensive approach that involved bibliometric and documentary analysis methods. The bibliometric analysis allowed us to systematise and evaluate scientific publications on the impact of health monitoring technologies on athletes' self-regulation. The documentary analysis included a review of regulations, reports and recommendations related to the use of modern wearable devices and mobile applications in sports practice.

DATABASES FOR SEARCHING PUBLICATIONS

For the analysis, we used leading scientometric databases, such as: PubMed is a specialised platform for searching for publications in the field of medicine and sports. It was chosen because of its reputation and a large number of articles on clinical and sports research. Scopus is a database with interdisciplinary publications that allows for bibliometric analysis. It was used to search for articles on computer science, sports science and technology. Web of Science is a database that provides access to high-quality scientific sources and enables citation analysis. IEEE Xplore is a specialised platform for technology research that contains articles on health monitoring devices and artificial intelligence. These databases were selected because of their ability to provide access to up-to-date and reliable information in the relevant fields of study.

SELECTION OF SCIENTIFIC PUBLICATIONS

The selection of publications was carried out in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The process included several stages: formulation of search queries using the following keywords: wearable devices, mobile applications, analytics, self-regulation, sports performance, and psychological well-being (Fig. 1).

INCLUSION CRITERIA

Publications related to the impact of technology on athletes' self-regulation. Works published in English from 2019 to 2024. Empirical studies describing the im-

Table 1. Criteria for including related publications

Inclusion criteria	Rationale	Publications that meet the criterion
The impact of technology on athletes' self-regulation	Research should focus on the impact of wearable devices and mobile applications on physical condition or behaviour	All publications in the list
English language of publication	To ensure accessibility and standardisation of results	All publications in the list
Publications 2019-2024	Ensuring the relevance of the research results	All publications in the list
Empirical research	Publications should contain practical results, not just theoretical generalisations	All publications in the list

Source: compiled by the authors of this study

Table 2. The most effective wearable devices for athletes' self-regulation

Model	Key functionality
Apple Watch Series 8	ECG, heart rate, sleep tracking, GPS
Fitbit Charge 5	Heart rate, GPS, Sleep tracking, Stress
Garmin Venu 2	Heart rate, GPS, Sleep tracking, Music
Samsung Galaxy Watch 4	ECG, heart rate, GPS, pulse oximeter
Oura Ring Gen 3	Heart rate, sleep tracking, temperature

Source: compiled by the authors of this study

pact of wearable devices or mobile applications on the physical condition and behaviour of athletes (Table 1).

EXCLUSION CRITERIA

Publications that describe general aspects of technology without their relation to sports. Articles without access to the full text. After filtering, 50 works that met the criteria remained.

ANALYSIS OF THE DATA OBTAINED

The data obtained were systematised into categories (Fig. 2).

The data were analysed using text processing software (NVivo) and bibliometric analysis (VOSviewer). This allowed us to identify the main trends, research gaps and areas for further work.

Thus, the chosen approach allowed us to obtain a systematic picture of the role of technology in monitoring the health of athletes and its impact on optimising self-regulation.

RESULTS

The use of health monitoring technologies is key to optimising athletic performance and supporting athletes' self-regulation. Modern wearable sensors and intelligent analysis systems allow you to track physical parameters and provide personalised recommendations to improve self-management. The latest technologies, such as Bi-STAN, DST-LSTM and GRU, provide more accurate recognition of activity types, facilitating better adaptation of training plans.

Innovative devices, such as brain-computer interfaces (BCIs), achieve 98.2% accuracy in determining motor representations, helping athletes to adapt their workload and avoid injury [2]. CNN-LSTM models allow for efficient classification of sports activity, optimising the use of wearable device resources [3]. Such systems collect data on physiological indicators, analyse them in real-time, and generate recommendations available through a mobile application.

Wearable devices are becoming an integral part of the training process due to their ability to provide real-time monitoring of health indicators. Table 2 shows the most effective device models:

Among the latest devices, brain-computer interfaces (BCI) are innovative. They analyse ECG data to determine motor representations with 98.2% accuracy. Such a system can help increase athletes' awareness of the state of their nervous system, affecting their ability to self-regulate.

Various deep learning models also allow for efficient classification of sports activity, using statistical feature extraction to distinguish between static and dynamic states, reducing computational costs and optimising wearable devices [4].

When researching health monitoring technologies, protocols aimed at analysing performance in different settings should be conducted, as they can improve self-regulation, although their use is limited by the small scale of the datasets [5].

Table 3. The process of processing data received on wearable devices

Process	Explanation
Filtering	This stage removes noise and unwanted signals from the sensor data. The use of various filters (low-pass, high-pass, bandpass) helps to cleanse the data from noise, which improves its quality.
Smoothing	This technique removes sharp fluctuations in the data by applying a moving average filter. Smoothing helps reduce the impact of noise, making the data more stable and understandable.
Selection of features	At this stage, significant features of the data are identified that can contribute to the prediction of the target variables. Thanks to these processing steps, we get a clean and normalised dataset ready for further work in machine learning models. The quality of pre-processing directly affects the accuracy and reliability of the final model.

Source: compiled by the authors of this study

Table 4. The process of protecting data received on wearable devices

Protection of personal data	Process
De-identification	Using strategies that make it impossible to identify individuals by removing or modifying unique identifiers such as names and contact information.
Data security	Focusing on security issues to protect athletes' medical data from leaks and unauthorised access.
Encryption	Implementation of encryption mechanisms (AES) to ensure secure data transmission between wearable devices, communication gateways and cloud servers, preventing data interception.
Access control	Implementing strict access controls that restrict access to data to authorised personnel only, preventing data manipulation.
Data leakage protocols	Develop protocols to respond to potential data breaches, including notification procedures and recovery plans. This helps maintain the confidentiality and integrity of athletes' medical data.

Source: compiled by the authors of this study

Visual methods, such as Inturi's approach to detecting falls without wearable devices, provide new opportunities to improve safety and adapt athletes to different environments. The latest technologies offer multifunctional systems for fusing data from different sensors that can support athletes in monitoring complex parameters of their condition.

In general, the latest technologies, such as Bi-STAN, DST-LSTM and GRU, provide more accurate activity recognition, facilitating better adaptation of training plans. For example, using CNN-LSTM models with self-regulation for activity analysis allows for personalised recommendations for athletes based on their unique conditions [6]. Thus, research shows that innovative health monitoring technologies improve sports performance and create conditions for more conscious self-regulation, helping athletes avoid overload and injury.

Effective health monitoring is key to maintaining high performance and preventing injuries in modern sports. Athletes increasingly use technologies that monitor physiological parameters such as heart rate, body temperature and activity level. Wearable technologies are increasingly important in sports training, allowing real-time health data. Improving athletes' self-regulation levels largely depends on accurately collecting and analysing information from these devices. This requires the implementation of modern data processing methods, in particular, machine learning algorithms. Innovative gadgets based on cloud platforms and artificial intelligence cannot only track physical indicators but also predict possible risks during training or competitions [7]. Such systems have two main parts: a wearable device and a cloud server. The device records key physiological indicators during physical activity, and the server processes them using complex algorithms. Convolutional neural networks (CNN) are used to analyse spatial characteristics, and LSTM networks estimate dynamics over time to achieve maximum accuracy in predictions. The processed data is transmitted to the athlete via a mobile application in the form of a report on his physical condition.

This helps you quickly respond to changes, adjust training intensity, and prevent potential injuries. The report may also include recommendations for recovery, load optimisation, or a temporary break from training.

Data preprocessing plays a key role in this process. It ensures data quality and accuracy, which is the basis for further analysis. Preprocessing includes noise removal,

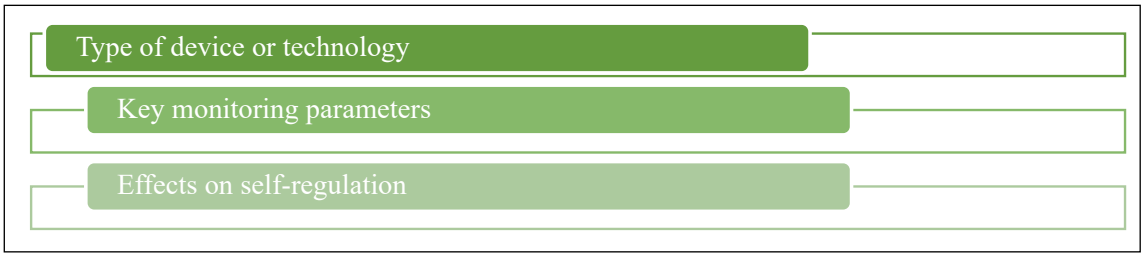

Fig. 2. Categories of data obtained *Picture taken by the authors*

Fig. 3. Smart gadgets for sports

normalisation, and data preparation, which significantly increases the efficiency of machine learning algorithms. Accordingly, the role of health monitoring technologies in optimising athletes' self-regulation and the integration of health monitoring technologies into the training process of athletes not only increases the efficiency of their training, but also contributes to the preservation of physical health, which is an important aspect in achieving sporting success.

In modern sports, health monitoring technologies play a key role in optimising athletes' self-regulation, and one of the most important stages in working with data obtained from sensors is their preprocessing. This process includes several stages (Table 3).

In the process of working with athletes' medical data, we also explored methods of removing direct identifiers to protect privacy (Table 4).

When modelling an athlete's health status, health monitoring technologies use neural network architectures such as CNN (convolutional neural networks) and LSTM (long-term memory with short-term memory) with self-attention. Accordingly, the input data passes through CNN layers, which are processed using a set of filters to extract features. At this stage, the data undergoes a nonlinear activation process that generates the final result. The LSTM model plays a key role in recognizing temporal dependencies in the data, which is important for analyzing health-related indicators. The data processed using CNN and LSTM are combined and passed through an attention layer that focuses on the most significant aspects of the information. The final stage involves the work of a fully connected layer that transforms the received data into predictions about the athlete's health status [8]. This complex data processing process allows monitoring technologies to assess the athlete's physical condition and promote the development of their self-regulation skills. Thus, monitoring systems play an important role in increasing the ability of athletes to independently assess their well-being, providing accurate information about physical performance and overall condition. At the heart of such systems is using deep neural networks, particularly CNN and LSTM models, supplemented by attention mechanisms, to create more accurate predictions about health status. Researchers are actively working on implementing these models in cloud platforms, providing athletes with convenient access via mobile applications. The process includes setting up the

server infrastructure, installing the necessary software, loading the model, creating an API, and conducting comprehensive system testing. After successful testing, the model becomes available for use, allowing users to enter data and receive personalized health predictions [9]. The development of such systems requires funding to purchase wearable devices, create a cloud infrastructure, implement machine learning technologies, develop mobile interfaces, ensure cybersecurity, and regularly update. In addition, the system must be designed to easily scale, process increasing amounts of data and the number of users, integrate with modern wearable devices, and ensure stable operation of the cloud infrastructure. Integration of the system with the existing sports infrastructure is essential for its effective implementation, which includes ensuring data compatibility, API development, interoperability, user acceptance and data privacy. The experimental environment for the athlete health monitoring system consists of several components, such as wearable sensor devices, Google Cloud Platform for deployment, Compute Engine and Cloud Storage for data processing and storage (Fig. 3).

This environment ensures efficient data processing and maintains accurate predictions, critical to optimising athletes' health and performance. Modern health monitoring systems have become an important tool for improving the ability of athletes to analyse their condition independently. Innovative wearable gadgets with advanced sensors provide detailed information about physical condition, stress level and sports performance. In particular, data obtained from devices with accelerometers and gyroscopes allow for a deeper assessment of everyday activities such as running, walking or climbing. Thanks to this information, it can effectively improve the exercise technique and adjust training programs to achieve higher results.

Monitoring systems encompass diverse activities, enabling the assessment of how different factors influence physical fitness and overall health. For instance, examining actions like opening a door or drinking from a bottle can offer valuable insights for refining performance techniques. Leveraging machine learning models such as CNN-LSTM, these technologies achieve remarkable precision in identifying physical activities. This paves the way for designing personalised training programs and enhancing the efficiency of athletic performance.

Models with integrated self-focusing mechanisms demonstrate even greater efficiency in complex tasks, such as recognising and classifying sports actions. Studies show that implementing such technologies not only provides accurate control of physical condition but also helps reduce the risk of injuries, avoid overloads, and improve overall performance.

Thus, health monitoring systems have become an important part of modern training, providing coaches and athletes with tools to manage physical fitness and health better. They contribute to a more effective training organisation and achieve high results.

DISCUSSION

In modern sports, health monitoring technologies play an increasingly important role, especially in the context of self-management of recovery and self-regulation, and they are actively being researched [10-12] in contrast to the analysis of the prevalence of sleep app users. The study by Afsar et al. [13] showed that among athletes, the prevalence of sleep app users, for example, is quite low – less than 20%. In this context, the researchers analysed why so few athletes use these technologies despite their potential benefits for optimising sleep and recovery. In this context, according to Baltabay, Yazici, Sterling, and Ever [14], on the one hand, the results of longitudinal studies show that fitness apps that track physical activity are more popular. Scientists attribute this to the traditional focus on physical activity in the sports community, while sleep as a component of recovery remains underestimated. Górriz with colleges [15] attribute this to a lack of awareness of the importance of sleep for sports performance. In the context of the role of health monitoring technologies in optimising athletes' self-regulation, researchers have shown that users of sleep apps have demonstrated higher levels of self-regulation, which may indicate that those who are more interested in their recovery are more likely to seek out self-regulation tools [16]. In this context, Khater, Hadhoud, and Fayek [17] argue that self-regulation is a key factor that influences the use of monitoring technologies. Mekruksavanich and Jitpattanakul [18] explore strategies that can be applied to encourage more athletes to use apps and the features and capabilities that are most attractive to athletes. The development of apps that incorporate behavioural designs to support healthy sleep hygiene is also being actively explored [19]. From the point of view of scientists, health monitoring technologies have great potential to support athletes in their recovery and development. However, for their effective implementation, more research is needed that focuses on user motivation, app functionality, and their impact on physical and mental health. In this context, it is worth exploring what next steps can be taken to improve the use of these technologies in sports practice.

Technological advances, including artificial intelligence, big data and the Internet of Things, have changed the way people exercise. Digital platforms

and mobile apps allow people to train at home, access personalised coaching advice, and analyse their progress together in real-time. According to von Haaren-Mack, Schaefer, Pels, and Kleinert [20], smart gadgets provide athletes with data about their health status that was previously only available in the laboratory. In this context, a study by Yin, Xu, and Ren [21] shows that sleep monitoring technologies can detect the phases of deep and shallow sleep, which is important for recovery. Tools that track physical activity can signal the need to adjust loads, helping to avoid overexertion. At the same time, data analytics platforms, according to Park & Choi, provide valuable insights that help to achieve goals more effectively.

While technology offers enormous potential for sports development, there are also challenges. Pan, Brulin, and Campo [22] highlight technical issues, the need for users to adapt to new tools, and the accessibility of such solutions to a broad audience. The authors emphasise the importance of considering the dependence on technology, which can lead to decreased autonomy in decision-making and a reduction in the intuitive approach to training.

Digital innovations in sports are a significant factor in creating conditions for optimising athletes' self-regulation. Studying their impact allows us to understand better how these tools can contribute to improving physical performance and developing critical skills that allow athletes to achieve more sustainable results. Zhang, Chen, Fan, Xin, Wu, and Lv [23] analyse how technology affects these processes, what research gaps remain unresolved, and what the future holds.

The sports industry is evolving thanks to technological advances, particularly in artificial intelligence and health monitoring, which help athletes optimise training, monitor performance and prevent injury [10]. Modern wearable devices can collect data on parameters such as heart rate, energy expenditure, speed, distance covered, and sleep quality. The information collected allows athletes and coaches to closely monitor their physical condition and adjust training programs according to individual needs. In particular, machine learning algorithms analyse this data, identifying patterns that contribute to more effective organisation of training and recovery. One of the key aspects of health monitoring is the ability to predict the risk of injury. By analysing heart rate variability and other indicators, modern technologies can detect signs of overfatigue or excessive physical exertion. In their study, Yun and Choi [24] note that this approach allows athletes to react quickly and reduce the likelihood of injury.

In their opinion, self-regulation becomes more effective as athletes are able to respond to their body's signals in a timely manner. Health monitoring technologies can create personalised training programmes based on each athlete's individual characteristics, significantly increasing the effectiveness of training. The devices help to avoid overloading, which can lead to injury [25]. Thanks to real-time feedback, it becomes possible to adjust one's technique and strategy, ensuring athletes' competitiveness.

Thus, the proposed work is relevant since health monitoring technologies play an important role in optimising athletes' self-regulation. The results obtained will provide detailed information on the feasibility of implementing such technologies in sports practice, as the latest technologies open up new horizons for achieving high sports results and improving athletes' overall health.

Rapid advances in sensor technology have opened up new opportunities for the development of high-performance wearable devices used to monitor human health, including that of athletes. Given that health is a key aspect of sports activities, a variety of equipment has been developed to continuously monitor physical condition. Wearable sensors, due to their unique characteristics, have become indispensable tools in sports medicine, as they allow for the timely detection and diagnosis of health problems.

Modern technologies are significantly changing approaches to the training process, providing new opportunities for monitoring and improving athletes' physical performance. However, the importance of technology in sport is not limited to physical aspects; its impact on the psychological state, motivation and self-regulation of athletes requires more detailed study. As the study results show, technologies such as wearables, mobile applications and analytics systems open up new horizons for managing health and training performance, but their implementation is accompanied by certain challenges.

The scientific novelty of the proposed research is that despite significant progress in the use of technology, many aspects of its impact on the psychological state and quality of sleep of athletes remain insufficiently studied. Based on a literature review and a practical study of the effectiveness of wearable devices such as Fitbit Charge 5, Garmin Venu 2, Samsung Galaxy Watch 4 and Oura Ring Gen 3, the aim was to demonstrate how these tools can not only provide objective information about physical condition but also contribute to the development of psychological well-being. In the same context, Basso-Bert, Detre, Gobert, Hassanaly, and Pige describe how regular tracking of metrics such as heart rate and sleep quality can increase athletes' awareness of their needs and capabilities, which in turn can affect

their motivation and desire to reach new heights.

However, Kurkdjian emphasizes that, despite the significant benefits, it is important to consider possible disadvantages, such as information overload, which can cause stress or anxiety about personal health. This highlights the need to create guidelines for the responsible use of these technologies to reduce possible negative consequences.

The proposed study aims not only to examine the benefits of monitoring technologies, but also to investigate in detail their impact on the mental health of athletes. In this context, Sun's study supports the view that addressing these issues can significantly improve training programs and increase athlete performance, opening up new avenues for research in this area.

The rise in popularity of sleep and fitness tracking apps can be attributed to the connection between wearables and cloud-based technologies. These apps analyse sleep quality and stress levels and provide recommendations for improving fitness. A study by Cojocaru et al. [26] found that the most popular features included heart rate monitoring, sleep analysis, and stress levels. Researchers have found a relationship between athletes' self-regulation and their use of monitoring technologies. These technologies play an important role in increasing self-discipline among athletes. As Castelli and Mitchell [27] point out, these technologies allow for adjustments in training loads based on objective data such as heart rate, body temperature, and activity level. Wearables provide athletes with personalised reports that help them make informed training decisions.

The CNN and LSTM algorithms described in this paper have also been analysed by Cheung [28]. According to the author, they allow analysis of the temporal and spatial characteristics of activity, improving the accuracy of health forecasts. The collected data is transferred to cloud servers, where it is processed to identify potential risks. Brusseau, Erwin, Darst, and Pangrazi demonstrate how the system can recommend a reduction in training intensity to prevent overload. Scientists agree that the use of wearable devices improves sports performance and creates conditions for conscious self-regulation [29].

Smart technologies provide the ability to monitor indicators such as heart rate, blood pressure and body temperature, which are critical for optimising athletes' training and recovery. In their article, Beaudet and Deveaux summarise the achievements and challenges in the production of wearable sensors for health monitoring, particularly in the context of athletes' self-regulation. The authors classify wearable sensors into three main areas: biophysical tracking, biochemical monitoring, and real-time data detection. They are made of different materials and technologies, which allows them to be adapted to the specific needs of athletes. Similar studies demonstrate significant progress in this area but also point to existing challenges, such as measurement accuracy and comfort during use.

Thus, modern wearable devices create new opportunities for monitoring the physical condition of athletes, contributing to the optimisation of their self-regulation, which is an important factor in achieving high sports performance.

Innovative technologies in the field of health monitoring show great potential in improving training processes and self-monitoring of athletes [30]. The combination of wearable devices with machine learning algorithms allows not only to reduce the risk of injuries, but also to maintain high performance through personalised analysis of physical condition.

Despite the significant value of the analysis, the study has some limitations. One key factor is the time frame: the work focuses exclusively on publications published between 2019 and 2024. This limitation may result in the omission of important developments and technologies that have appeared earlier or were not included in the selected databases. Another important aspect is the language factor, as only English-language works were considered. This may make it difficult to access important studies published in different languages that could improve the overall understanding of the topic. The studies focus mainly on the impact of wearable devices and mobile applications on self-regulation, which limits the study of other technologies, such as data analysis systems or social networks, which may also have an impact on this area. The use of only four databases may reduce the quality of the review, as important studies may be available from other sources. In addition, the exclusion criteria for studies that address general technological aspects not directly related to sports may prevent the acquisition of valuable information useful for sports practice. These limitations are important to consider when interpreting the results and formulating recommendations for future research, as they may significantly affect the validity and relevance of the data obtained.

CONCLUSIONS

Monitoring athletes' health can change how we assess their physical fitness, which is critical for achieving the best results. Innovative technologies such as wearable devices, cloud solutions and machine learning algorithms provide accurate and timely information about physiological status. This allows athletes to adjust their training programs and competition schedules, reducing the risk of overload and injury. The models used for assessment demonstrate high accuracy, which surpasses many traditional methods

of predicting physical fitness. For further development of this technology, it is important to expand the database to include a variety of athletes, especially those who use gadgets to monitor their activity and sleep. This will allow for the creation of more comprehensive health monitoring solutions, taking into account individual physiological characteristics. An individual approach is key to the successful integration of monitoring systems. Considering each athlete's specific training methods and physical characteristics, recommendations can be developed that meet their personal needs. Adding real-time feedback and alerts about potential health risks can significantly improve the effectiveness of such systems. Thus, health monitoring technologies contribute to better self-monitoring of athletes and open up new opportunities for future development. They pave the way for achieving outstanding results while putting health and supporting athletes' physical and mental well-being first.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Peculiarities of stress manifestation in women under war conditions and measures for its prevention

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ABSTRACT

Aim: To investigate the peculiarities of stress manifestation in women under war conditions and to substantiate a set of measures for its prevention.

Materials and Methods: The research, which was conducted from 2022 to 2024, involved 157 women of different ages (from 18 to 70). Research methods were bibliosemantic, medical and sociological, statistical, system analysis, and logical generalization.

Results: The peculiarities of stress manifestation in women under war conditions have been investigated. It has been found that 42.0 % of women are constantly in a state of fatigue and exhaustion and assess their stress as maximum. A persistent negative emotional state is experienced by 72.6 % of women, and the inability to experience positive emotions – 52.8 %. More than 70.0 % of the respondents say they do not know how to cope independently with stressful conditions. A set of preventive measures to overcome stress has been proposed and practical recommendations for preventing stress among women have been developed.

Conclusions: Effective stress prevention measures include reducing the likelihood of stressors through self-realization, developing knowledge of the value of health, raising awareness of danger, determining one's life strategy, providing timely psychological assistance, learning to cope with stress using anti-stress techniques, and monitoring and adjusting one's reactions to stress. The developed practical recommendations can be used in awareness-raising activities by public health professionals to prevent stress in women under martial law.

KEY WORDS: stress, health, prevention, women, war

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INTRODUCTION

Modern life is full of various stressors that negatively affect a person's mental state, weakening not only their mental health but also their physical and social health. This process has become especially acute in the context of the full-scale war unleashed by russia. The emergence of new deep stressors related to the hostilities – missile attacks, air raids, bombings, leaving their homes, moving to other regions, loss of property jobs, fear for their lives and the lives of children and other family members, grief over the death of loved ones, etc. – has affected the mental health of the entire population of Ukraine, especially women. Given this, it is important to study the peculiarities of women's stress as a psychophysiological phenomenon and to substantiate a set of measures for its prevention in the context of war within the public health system.

Stress is a physiological state characterized by the reaction of the human body to prolonged negative events, namely danger, excessive mental and emotional stress, grief, obligations imposed on a person, making important decisions that occur at a fast pace, and often a combination of several negative events happening simultaneously. [1]. The stress reaction has gender differences. The "fight or flight" response is activated in men, while in women, the brain areas responsible for visualization and cognitive and emotional processing of experience are activated [2, 3]. Therefore, women tend to focus on traumatic events and relive them over and over again. From the point of view of physiology, this condition is accompanied by a high level of stress hormones. In addition, the multifunctionality inherent in all women increases the psychological burden, which is why women are in a state of complete "combat readiness" [4].

Modern scientific research in public health focuses on developing and implementing measures to prevent and manage stress and overcome its negative consequences for the entire population [5, 6]. At the same time, the problem of stress prevention in women is not sufficiently studied, which determined the choice of the research topic. This issue has become extremely relevant and important in our time – in times of war.

AIM

The aim is to investigate the peculiarities of stress manifestation in women under war conditions and to substantiate a set of measures for its prevention.

MATERIALS AND METHODS

The research was conducted in 2022-2024 at Zhytomyr Medical Institute of Zhytomyr Regional Council and Zhytomyr Ivan Franko State University. It involved 157 women of different ages (from 18 to 70 years) and with different educations, and their geography of residence was Zhytomyr, Zhytomyr oblast.

Research methods: bibliosemantic – to study the nature and types of stress, causes of its occurrence, and effective methods of overcoming; medical and sociological – to determine women's awareness of the peculiarities of the occurrence and course of stress, measures for its prevention; statistical – to analyze the results of the women's survey; system analysis and logical generalization – to develop practical recommendations and formulate conclusions.

The research was conducted in three stages. The first stage was based on the study of a sufficient number of literary sources and provided for the analysis of physical and psychological signs of the impact of stress on the health of the population, including women. This made it possible to clarify the essence of the concept of "stress" and identify its types, manifestations, methods of assessing the stress level, and basic preventive measures. The second stage included the development of a special questionnaire to determine the level of women's psychological state, their anxiety and its impact on the respondents' daily lives, and women's knowledge of effective ways to overcome stress. The questionnaire contained 54 questions intended to study the peculiarities of women's reactions to stress and identify their predominant types and preventive measures. The questionnaire was anonymous without any references to the authors of the article in the answers. The results were used for scientific purposes only. Questionnaire was assessed by the experts in this field (2 professors and 4 associate professors) and was approved by the Academic Council of Zhytomyr Ivan Franko State University (Protocol No. 7 dated 21.11.2022). The third research stage involved conducting surveys, analyzing them, and statistically processing the study results. This stage provided for the scientific substantiation of a set of measures to prevent stress in women and the formulation of general conclusions and practical recommendations.

Data collection, processing, and analysis were performed on a personal computer using MS Excel, a software package that can use statistical data processing methods. Consent to voluntary participation in the survey was obtained from all the respondents involved in the study. This research followed the regulations of the World Medical Association Declaration of Helsinki – ethical principles for medical research involving human subjects.

RESULTS

After analyzing the signs of stress in women during the war, we found that 42.0 % of the respondents are constantly in a state of fatigue and exhaustion and rate their stress with a maximum score of "5," with other answers of "4" – 28.7 %, "3" – 19.8 %, "2" – 7.6 %, and "1" – 1.9 %. It has also been found that women experience no less irritability and mood deterioration. The largest part of the respondents rated their level of irritability with the highest score of "5" – 43.9 %, "4" – 26.1 %, "3" – 17.2 %, "2" – 10.1 %, and "1" – 2.5 %. When investigating the causes of irritability, the war and a chronic state of psychological and physical exhaustion are mentioned first. When we asked women about their level of concentration, we got opposite results: "1" – 12.1 %, "2" – 17.2 %, "3" – 51.5 %, "4" – 13.3 %, "5" – 5.7 %. Due to stress and constant anxiety, the ability to concentrate and focus on work or study is extremely low. This leads to a decrease in working capacity while performing duties at work, provoking an even greater stress level.

It has been found that women have recorded cases of appetite disorders or overeating, especially for a night, over the past two years. One-third of the respondents emphasized that they periodically suffer from overeating or complete lack of appetite – 30.5 %; the rest rated their appetite disorders as follows: "1" – 21.0 %, "2" – 21.0 %, "4" – 17.2 %, "5" – 8.9 %. Fear, anger and anxiety, pain, despair, confusion, powerlessness, shame, guilt, apathy and sadness, excitement – all these emotions are normal to experience in any situation, but during the war, these emotions can prevail over positive ones. During war, the main emotions are fear, anger, powerlessness, and guilt. The analysis of the answers showed that most often the respondents felt

Table 1. Aspects of the war that cause stress or severe nervousness in women (n = 157)

Aspects of war	Absolute frequency of responses	Share of responses
Safety of loved ones	156	28,4%
Loss of source of income/job	87	15,8%
Lack of opportunity to leave their town or village in case of possible hostilities	39	7,1%
Fear of moving to a new settlement	36	6,5%
Fear of what awaits abroad	34	6,2%
Risk of dying during hostilities	31	5,6%
Loss or risk of loss of property	29	5,2%
Lack of opportunity to leave the country	27	4,9%
Risk of injury	23	4,2%
Wounds received during the war	22	4,0%
Problems with access to products	21	3,8%
Problems with communication with friends/family	19	3,4%
Problems with access to medicines	17	3,1%
Problems with buying clothes and shoes	7	1,2%

Source: compiled by the authors of this study

Table 2. Situations that women faced during the war that led to stress

Situations	Absolute frequency of responses	Share of responses
Losing your job and being forced to be unemployed	34	12,2%
Feeling helpless	32	11,5%
Surviving the death of loved ones	31	11,1%
Surviving other stressful situations	29	10,4%
Surviving a serious illness of loved ones	25	9,0%
Living in a state of near-suicide	21	7,5%
Losing faith in your abilities	19	6,8%
Surviving bombing, shelling	19	6,8%
Serious conflict with others	14	5,0%
Surviving a serious illness or surgery	13	4,6%
Losing faith in people, facing meanness	12	4,3%
Suffering from an attack or robbery	11	3,9%
Applying to the court for help	6	2,1%
Losing your livelihood	4	1,4%
Suffering from theft or fraud	3	1,0%
Being subjected to threats, intimidation	3	1,0%
I did not experience any stressful situations	1	0,3%

Source: compiled by the authors of this study

aggression – 12.7 %, fear – 12.4 %, fatigue – 11.3 %, anger – 11.2 %, and despair – 9.8 %. Only 1.0 % of the respondents felt joy. This distribution of the responses indicates that a significant number of the women surveyed are in a state of constant stress. It has been found that 56.7 % of the respondents assessed their emotional state as characterized by the emotions of hatred, fear, and anger; another third of the respondents stated the prevalence of fatigue, sadness, apathy, insomnia, tearfulness – 35.6 %, only a small percentage noted a state of calm and peace – 7.6 %.

Constant uncontrollable thoughts about traumatic events, disturbing memories, dreams about them, a sense of continual danger, and excessive agitation – all these are symptoms of being in a state of prolonged stress. When asked whether they had experienced

disturbing memories or dreams, most respondents answered in the affirmative – 64.3 % said "yes," and 35.7 % said "no." The overwhelming majority of the respondents (72.0 %) reported experiencing severe physical or emotional stress from things that remind them of negative events over the past year. The desire to avoid talking about negative events was expressed by 88.5 % of the women, and the desire to avoid activities, places, and people reminiscent of negative events was expressed by 69.4 %, which confirms the state of stress among the women surveyed.

Negative attitudes toward others and distancing or withdrawing from them are signs of a devastated emotional state. When asked whether they felt a negative attitude towards themselves or other people, 55.4 % of the women surveyed answered "yes"; 69.43 % of the respondents felt a sense of detachment. The inability to feel positive emotions, depressed mood, and persistent negative emotional state are also signs of stress. It has been found that 52.8 % of the women answered affirmatively to the question, "Have you noticed your inability to feel positive emotions over the past year?" A persistent negative emotional state over the past year was reported by 72.6 % of the women surveyed.

Below are the results of the analysis of avoidance of mentions of traumatic events or situations that cause anxiety. Answers to the question "Do you avoid recalling events or situations that cause anxiety?" were distributed as follows: "very often" – 23.6 %, "often" – 29.3 %, "sometimes" – 21.0 %, "rarely" – 15.3 %, "never" – 10.8 %. The analysis shows that a third of the respondents try to avoid mentioning unpleasant events or talking about them in one way or another; the majority state that they do not follow the news about the war or do not watch TV to avoid stress or nervousness. When asked how often they are irritated, the respondents gave the following answers: 36.9 % of the respondents answered "very often," 26.1 % answered "often," 19.8 % answered "sometimes," 12.1 % answered "rarely," and 5.1 % answered "never." It should be noted that psychologists define the state of irritability as a temporary reaction with various somatic manifestations, which can be caused by an increased emotional response to any external or internal factors.

The following questions provide an opportunity to assess whether women can cope with stress and overcome nervous conditions independently. The analysis of answers to the question "Is it difficult for you to "switch off," to give up worrying, even if it seems justified?" showed the following results: 38.8 % of the women answered "very often," 31.2 % – "often," 17.2 % – "sometimes," 8.3 % – "rarely," and 4.5 % – "never." The analysis of the answers shows that more than 70.0 % of the respondents state that they are unable to cope with stressful conditions on their own: 40.8 % "very often" and 32.5 % "often" state difficulties in overcoming anxiety, even when the problem is solved and the stressor is eliminated.

By studying the peculiarities of the war's impact on the manifestation of stress symptoms in women, we found out the main aspects of the war that cause stress or severe nervousness: "safety of loved ones" – 28.5 %, "loss of a source of income/job" – 15.9 %, "inability to leave their town or village in case of possible hostilities" – 7.1 %, "fear of moving to a new settlement within Ukraine" – 6.6 % (Table 1).

During the last two years of the war, the women surveyed experienced situations of job loss (12.3 %), feelings of helplessness (11.6 %), death of loved ones (11.2 %), and other stressful situations (10.5 %) (Table 2).

When asked how women respond to stress, the majority of the respondents (72.6 %) said, "I enter into negotiations"; "I go into a state of numbness" – 15.9 %; "I try to escape" – 11.5 %. This distribution of responses confirms the judgment that women resort to dialog to resolve problems. At the same time, 77.1 % of the women verify their inability to overcome stress and demonstrate the ability to cope with stressful situations independently. To overcome stress, the women most often use the following methods: "take stress medication to calm down" – 19.6 %, "watch TV, movies, TV series" – 12.3 %, "get deeper into work" – 12.3 %, "surf the Internet" – 11.8 %, "eat more sweets/delicious food" – 9.8 %.

An important task of specialists is to prevent stress in the population during the war. The main goal of stress prevention is to avoid stressors, eliminate negative manifestations of stress, and increase the body's stress resistance. Depending on the actors involved in preventive measures, the following types of prevention are distinguished: individual, interpersonal, and public. Individual prevention includes a system of socio-psychological and medical measures aimed at an individual. The interpersonal level of prevention involves the impact of measures on the person's social environment. As a rule, this is done through group therapy, including family therapy. Public prevention includes educational activities conducted by public health professionals in cooperation with government agencies and NGOs to prevent stress, teach the community to overcome its consequences and inform citizens about the health risks of stress.

Preventing stressful conditions involves a systemic impact on a personality's emotional, motivational, volitional, and behavioral components, as well as on reducing the negative effects of external stressors, to

prevent stressful conditions and create a high quality of life. The basis of a person's stress resistance is their lifestyle. Therefore, targeted adjustments to lifestyle and behavior are most useful for resilience to stressors. Here are simple methods for preventing stressful conditions in women. Good sleep: the human body and psyche recover best during sleep. Sleep loss leads to increased stress. Balanced diet: following basic nutritional rules helps prevent stressful conditions. A balanced daily diet helps to replenish energy losses, provide the body with nutrients, and restore working capacity. Physical activity: active recreation, regular walks in the fresh air for 30-40 minutes, and medium and high-intensity sports for 10-20 minutes will help restore the body and overcome negative stress. Positive emotions: spend more time on things that bring pleasure and are in line with a person's values (music, movies, nature, etc.). Planning and daily routine: a planned daily routine and strict adherence help to have more certainty, orderliness, and consistency and help avoid overload. Communication with important and close people: psychological relief is provided by communication with close people, which eases the psychological state.

DISCUSSION

The founder of the stress theory, Hans Selye, considered stress as a protective reaction of the body to external and internal stimuli and dangers that act on the biological, chemical, and physiological levels [7]. According to experts [8], isolated stressful situations are the norm, inherent and provided by nature, and the reaction to stressful situations is aimed at preserving life and health. The body quickly becomes exhausted if traumatic events or episodes occur frequently, especially daily. A feeling of loss of strength and a complete lack of energy compensation leads to a sense of uncontrol over one's own life, which in itself becomes a powerful stressor.

The imbalance between the human body and environmental events results from a sudden, often unexpected, and tense situation. This results in a certain nonspecific body reaction as a response to this event – stress [9]. Scientists [10], describing the signs of stress, distinguish the following: personal and medical, physiological and psychological. They also add that stress of any nature is accompanied by emotional tension and has its causes.

Currently, the main objective reason for the stress of the Ukrainian population is the war waged by russia against our country. Living in conditions of uncertainty and constant threats to life leads to a decrease in labor productivity and the emergence of health problems of various kinds. Stress is especially dangerous for women, especially pregnant women. Due to being in a state of stress that disrupts the adaptation processes inherent in physiological pregnancy, cases of miscarriages and premature births have become more frequent in Ukraine in recent years [11, 12].

Scientists [13] note that to manage and overcome stress, in addition to specific measures of psychological influence or assistance, methods should be used to promote health and prevent the onset and development of diseases. Psychologists advise combining various methods of preventing and dealing with stressful conditions. Prevention of many diseases, especially cardiovascular disorders caused by stress, should include a whole range of measures: reducing physical inactivity, optimizing daily routine, alternating tension or excitation of the nervous system with rest, walking in the fresh air, and balanced nutrition with strict adherence to meals [14].

In addition to the scientific developments in stress management offered by psychologists, simple traditional methods of relaxation and doing your favorite things should be combined with walks and good sleep. Such common simple ways to overcome stress include being outdoors, playing music, sleeping, pets, socializing with friends, doing extreme sports and recreation, watching movies, reading books, etc. [15].

Given the current situation in Ukraine, practical psychologists advise using various methods [16]. Public health professionals should join the prevention activities in this area by conducting awareness-raising activities among women of different age groups. Prevention of occupational stresses should be carried out through planning working hours and strict adherence to them; arrangement of the workplace and working tools in accordance with personal preferences; development of a regime of alternating work and rest that will not lead to exhaustion; creation of a favorable psychological climate in the work team; increasing personal responsibility for the results of work. Prevention of information stresses should be aimed at reducing the share of negative information, limiting the time spent on social networks, etc.; communication stresses – by prioritizing communication only with pleasant, positive, "safe" people for a given woman; traumatic stresses – avoiding situations that can lead to physical and, as a result, psychological trauma, observing safety precautions in the context of military operations; emotional and domestic stresses – constructive resolution of family and domestic conflicts with relatives, neighbors, etc., demonstrating understanding and tolerance, resisting crossing personal boundaries, seeking help for domestic violence, etc. Based on our research, we

have developed practical recommendations for improving the awareness-raising activities by public health professionals on stress prevention among the female population of Ukraine under martial law: 1) Development of a model for stress prevention in women and its implementation in the awareness-raising activities by public health professionals in the following areas: a) avoidance of exposure to stressors; b) development of mechanisms for "hardening" women's psyche to the negative effects of stress; c) use of coping strategies to overcome existing stress (self-control, distancing, acceptance of responsibility, positive reassessment, confidential actions to change the situation, seeking social support, drawing up a plan to solve the problem). 2) Organization of counseling, medical, and psychological assistance to women by public health professionals to help them overcome stresses that cause psycho-emotional disorders and depression and refer them to specialized professionals (psychologists, psychotherapists, doctors of various specialties) if necessary. 3) Conducting awareness-raising activities at the community level to prevent stress in women of different age groups (training, simulation games, conversations, etc.). 4) Posting information materials on the websites of the Public Health Center of Ukraine, regional centers for disease control and prevention, and online educational platforms on approaches to avoiding and overcoming stress in women, creating relevant applications, apps, films, etc.

CONCLUSIONS

The peculiarities of stress manifestation in women under wartime conditions have been investigated. It has been found that 42.0 % of women are constantly in a state of fatigue and exhaustion and evaluate their stress with the highest score. Most often during the war, the women felt aggression – 12.7 %, fear – 12.4 %, fatigue – 11.3 %, anger – 11.2 %, and despair – 9.8 %, which indicates that a significant number of the surveyed women were in a state of constant stress. The inability to feel positive emotions and depressed mood are experienced by 52.8 % of women, and a persistent negative emotional state – by 72.6 %. At the same time, more than 70.0 % of the respondents state that they do not know how to cope with stressful conditions independently.

The main aspects of the war that cause stress or severe nervousness in women are: "the safety of loved ones" – 28.5 %, "loss of a source of income/job" – 15.9 %, "inability to leave their town or village in case of possible hostilities" – 7.1 %. At the same time, 77.1 % of the women confirm their inability to overcome stress independently and demonstrate the ability to cope with stressful situations. Stress prevention is based on the need to avoid or reduce the impact of stressors, "harden" the human body to their possible effects, and develop the ability to overcome the effects of stress on their own. Effective stress prevention measures include reducing the likelihood of stressors through self-realization of the individual; developing knowledge about the value of health; raising awareness of the danger (military operations, exposure to toxic substances, etc.); determining one's life strategy; providing timely psychological assistance; learning to cope with stress using anti-stress techniques and coping strategies; monitoring and adjusting one's reactions to stress, etc.

Based on our research, we have developed practical recommendations for improving the awareness-raising activities by public health professionals on stress prevention among the female population of Ukraine under wartime conditions.

PROSPECTS FOR FURTHER RESEARCH

The research aims to investigate the level of post-traumatic stress disorder in military personnel who participated in combat operations.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Effect of topically applied simvastatin plus Luteolin on enhancing the development of hair in male mice

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ABSTRACT

Aim: The aim of this study to examine the effect of simvastatin and Luteolin in regrowing hair and stop hair loss in male mice.

Materials and Methods: 25 adult male mice, weighing 25–35 g and aging 6-7 weeks, were employed. Male mice had their coat hairs on their dorsal skin, which was then carefully trimmed by an electrical machine and colored with a dye. Mice were divided into five equal groups (5 mice in each group) as follows: sham group (ethanol-treated group); Minoxidil-treated group; simvastatin-treated group; Luteolin-treated group; simvastatin and Luteolin coadministration group. The drugs were applied on the skin once daily for three weeks.

Results: We demonstrated that the tissue levels of total antioxidant capacity (TAC), vascular endothelia growth factor (VEGF) and keratinocyte growth factor (KGF) in the Minoxidil-treated group, simvastatin-treated group, Luteolin-treated group, and simvastatin and Luteolin coadministration group were considerably greater than those of the sham (ethanol) groups. Furthermore, these groups revealed significant increases in hair growth, hair count, and hair follicle diameters.

Conclusions: these results have identified that simvastatin and Luteolin significantly reduced hair loss due to their anti-inflammatory and antioxidant capabilities.

KEY WORDS: simvastatin, Luteolin, effect of topically, Simvastatin and Luteolin

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INTRODUCTION

The skin of a fetus is coated in lanugo hairs throughout pregnancy. This hair is usually lost throughout the eighth month of growth. The first three or four months of the additional uterine life are finished before a second generation of lanugo hairs begins to form. Two forms of hair, known as vellus and terminal hairs, occur after all lanugo hairs have vanished [1]. Vellus hairs are brief (under 2 cm), thin (less than 0.1 mm), and occasionally colored. Except for the skin on the palms, soles, volar side of the fingers, penile glans, and labia minora et majora, all skin is covered with vellus hairs (only on the internal side) [1]. Hairs are converted to terminal hairs in some locations under the effect of several local and systemic stimuli. Terminal hairs are long (> 2 cm), thick (up to 0.6 mm), pigmented, and modulated [2]. One of the traits that distinguish mammals is the hair follicle, which functions as a special miniorgan. Human hair has a variety of purposes, including defense from the environment, sebum, apocrine sweat, pheromone synthesis, and thermoregulation. The individual's social and sexual interactions are significantly influenced by their hair as well. The hair root is located inside the follicle, and the piece of the hair shaft that extends beyond the level of the epidermis is known as the hair shaft. Vellus hairs lack a medulla, while terminal hairs are made up of a cortex, cuticle, and medulla [3]. The medulla, which is located in the center of the hair shaft, is made up of a few rows of incompletely keratinized cells. The cortex, which provides the hair with strength, is composed of numerous rows of fusiform cells that have undergone full keratinization. The cuticle, which is made up of a single row of flat, keratinized cells organized like roof tiles, covers the cortex. The follicle houses the root of the hair. Sheaths of connective tissue and epithelial cells make up the hair follicle. There are two layers to the epithelial sheath, which is in close proximity to the hair root [1]. Three sublayers make up the inner layer: (a) the cuticle, which is identical to and in close contact with the hair cuticle; (b) the Huxley's layer, which is made up of a few rows of square cells; and (c) the Henle's layer, which is made up of one row of polygonal, flattened cells. With the spinous layer within and the basal layer and basal lamina outside, the outer epithelial layer is thought to represent a down growth of the epidermis. The vitreous membrane is a thicker portion of the basal lamina. An extension of the dermis, the connective tissue sheath contains two layers: an inner papillary layer and an outer reticular layer. The cells toward the bottom of the hair root are larger and have a high capacity for cell division and differentiation. The so-called "hair matrix" is made up of these cells. The

Fig. 1. A photograph showing hair removal at the dorsal area
Picture taken by the authors

Fig. 2. A photograph showing the dorsal area stained with Hoffmann dye
Picture taken by the authors

cells that make up the hair matrix divide as they ascend up the follicle and either becomes hair cells or cells that make up the inner epithelial sheath. Melanocytes, which create the color of the hair, are found among matrix stem cells. The enzyme phenol-oxidase catalyzes the pigment's synthesis from the amino acid tyrosine, which is then converted to dopaquinone by the enzyme dopa. Dopaquinone undergoes two more transformations: either a spontaneous conversion to indolequinone or a change involving the amino acid cysteine. Only the dark pigment, melanin, is produced when indolequinone is polymerized. The yellow pigment, pheomelanin, is produced when indolequinone and dopaquinone are polymerized with the addition of cysteine. Melanin or pheomelanin from melanocyte dendritic elongations is ingested by matrix cells throughout their development process (by phagocytosis). Hair takes on its color in the following ways: black if melanin predominates, and yellow or red if pheomelanin predominates [1]. The dermal papilla is the area of the connective tissue root sheath that is directly in touch with the hair matrix. It significantly influences how hair grows. Topical Minoxidil has been the standard

Table 1. Types of 25 mice groups

Study group	Concentrations
Sham group	100 % of ethanol
Minoxidil-treated group	5 % of Minoxidil solution
Luteolin-treated group	0.5 % of Luteolin solution [8]
Simvastatin-treated group	0.8 % of simvastatin solution [9]
Luteolin- and simvastatin-coadministered group	0.5 % of Luteolin solution and 0.8 % of simvastatin solution

Source: compiled by the authors of this study

therapy for treating and rogenetic alopecia and is also used off-label to treat other hair loss problems. Despite being widely used, minoxidil's precise mode of action is still not entirely known. Due to the minimal risk of negative sexual effects, several publications with strong data back up the safety of finasteride and dutasteride in both men and women with androgenic alopecia (AGA) [4]. The PGF2 analogs latanoprost and bimatoprost are known to enhance hair growth by extending the anagen phase among prostaglandins (PG) [5]. In this study we use Luteolin and Simvastatin. Luteolin has pleotropic mechanisms. The mechanism that can show a beneficial effect on Luteolin in treating hair fall is the antioxidant mechanism. It can be employed for the management of cancer and inflammatory diseases. Simvastatin can induce hair growth by many mechanisms: vasculogenesis, immunomodulatory, anti-inflammatory, blocking induction of nitric oxide (NO) synthesis. Mice were chosen as experimental model for our study due to easy availability and suitability for this type of research [6-8].

AIM

The aim of this study to examine the effect of simvastatin and Luteolin in regrowing hair and stop hair loss in male mice.

MATERIALS AND METHODS

A twenty-five of Wister Albino mice aged and weighted 6-7 weeks and 25-35 grams respectively were obtained from the Centre for Control and Pharmaceutical Research, Iraq. The animals were maintained in the animal laboratory of the Faculty of Sciences, University of Kufa, Iraq. They kept in cages under the conditions of a 20-25 °C and 60-65 % of the humidity with a 12 hr. light: 12 dark cycles.

ETHICS STATEMENT

The present study was conducted at University of Kufa, College of Medicine and obtained approval from the Bioethics Committee at the same University with a license number, AEC: 65 October 2022

EXPERIMENTAL PROTOCOL

After a period of acclimatization, diethyl ether was applied as an aesthetic agent at the area where the hairs were being removed. The hairs of mouse in the dorsal area were then removed using electrical clipper. After removal of the hair, a pink color of the skin was appeared indicating the rest phase signal. A photograph was captured for each mouse using digital camera, Fig. 1 [6]. A Hoffmann dye was used to stain the dorsal area to differentiate between the black area (no hair growth) and the white area (hair is growing). This dye is useful to calculate the ratio between the two areas [7]. A photograph for each mouse was taken, Fig. 2.

STUDY DESIGN

A total of 25 mice were randomly divided into five groups with five animals in each as follows: the sham group or ethanol applied group; Minoxidil-treated group; Luteolin-treated group; simvastatin-treated group; Luteolin- and simvastatin-coadministered group, table 1. A 0.3 ml of each drug prepared was applied once daily on the skin for three weeks.

PHOTOGRAPHIC ANALYSIS

MATLAB 2015 software was used to analyze the photos. This program was calculated the ratio between the black area (hair mice covering the dorsal region) and the white area (the hair-growing components that were stripped of their hair) [10].

PREPARATION OF DRUGS

The medications were prepared immediately by dissolving the drugs in specified volumes of a 100% of ethanol (simvastatin 0.002 mg in 0.3 ml and Luteolin 0.001 mg in 0.3 ml).

HISTOLOGICAL SECTIONS ANALYSIS

In the end of the experiment, hair in the dorsal region were removed, a 5 mm of the skin was cut. The piece of

skin from each mouse was put in a 10% of formalin and visualized under microscope by independent pathologist who blinded to the study groups [11].

ASSESSMENT OF THE TISSUE LEVELS OF TAC, VEGF AND KGF

After the experiment was finished, the small skin fragments were cut and washed in cold a phosphate buffer saline (PBS). The pieces of skin were then weighed, and a PBS containing a 1 % of protease inhibiter cocktail, 1% Triton X100 was added in a ratio of 1:10 w/v for each sample. These samples were homogenized ultrasonic processor. The homogenates were centrifuged for 15 minutes at 14000 rpm and 4°C. Supernatants were employed to examine the concentrations of total antioxidant capacity (TAC), vascular endothelial growth factor (VEGF) and keratinocyte growth factor (KGF) [12].

STATISTICAL ANALYSIS

Analysis of data was performed using SPSS version 26 software. Data were expressed as mean ± standard error of mean unless otherwise stated. For comparison among the study groups, a one-way ANOVA followed by post-hoc test. Chi-square test was used to analyze the histological data among the study groups.

ETHICAL APPROVAL

The study was approved by the Bioethics Committee of the University of Kufa and its representation in the Faculty of Medicine (Approval: AEC: 65 October 2022). The entire procedure was carried out in accordance with the Committee's recommendations.

RESULTS

EFFECT OF TREATMENT ON HAIR GROWTH

In comparison to the sham group (ethanol), there was a marked increase in hair growth (p-value <0.05) in Minoxidil-treated group, Luteolin-treated group, simvastatin-treated group, and their combination group (Luteolin and simvastatin), Fig.3. This combination revealed a significant increase in hears growth as compared with Minoxidil-treated group.

EFFECT OF TREATMENT ON THE NUMBER AND DIAMETER OF HAIR FOLLICLES

The results showed a substantial increase in the number of hair follicles (p≤0.05) in Minoxidil-treated group, Luteolin-treated group, simvastatin-treated group, and their combination group (Luteolin and simvastatin) as compared with the sham (ethanol group), Fig.4. Treatment with combination revealed a marked increase in diameter of the hair follicles in comparison with Minoxidil-treated group, Fig. 5.

EFFECT OF TREATMENT ON LEVELS OF TAC

The present study demonstrated that tissue levels of TAC were considerably elevated in Minoxidil-treated group, Luteolin-treated group, simvastatin-treated group, and their combination group as compared with the sham (ethanol group), furthermore, the combination (Luteolin and simvastatin) was significantly greater than that of the Minoxidil-treated group, Fig.6.

EFFECT OF TREATMENT ON VEGF

In combination with the sham (ethanol group), treatment with Minoxidil, Luteolin, simvastatin or Luteolin and simvastatin coadministration resulted in a marked increase in the levels of VEGF. This combination of Luteolin and simvastatin showed a statistically significant increase in the levels of VEGF as compared to the Minoxidil-treated group, Fig.7.

EFFECT OF TREATMENT ON THE LEVELS OF KGF

The current study revealed that treatment with Minoxidil, Luteolin, simvastatin or Luteolin and simvastatin coadministration resulted in a marked increase in the levels of KGF as compared to the sham (ethanol group), Fig. 8. Treatment with combination (Luteolin and simvastatin) increased the levels of KGF in comparison with mice treated with Minoxidil, Fig. 8.

DISCUSSION

Alopecia can be described as loss of hair from a specific area of the head or body with the head being more involved some people experience psychological anxiety due to hair loss [9-13]. Recently, an attention has made to some of preparations that are being investigated in preclinical studies for their significant effects as antioxidant and anti-inflammatory properties in comparison to traditional ones such as minoxidil. Minoxidil is topically formulated drug that is widely used for treatment of androgenic alopecia, however, multiple side effects like skin irritation, abnormal hair growth and poorly understood mechanisms have increased the search for safe and effective preparations [14, 15]. The antioxidant and anti-inflammatory effects of simvastatin and

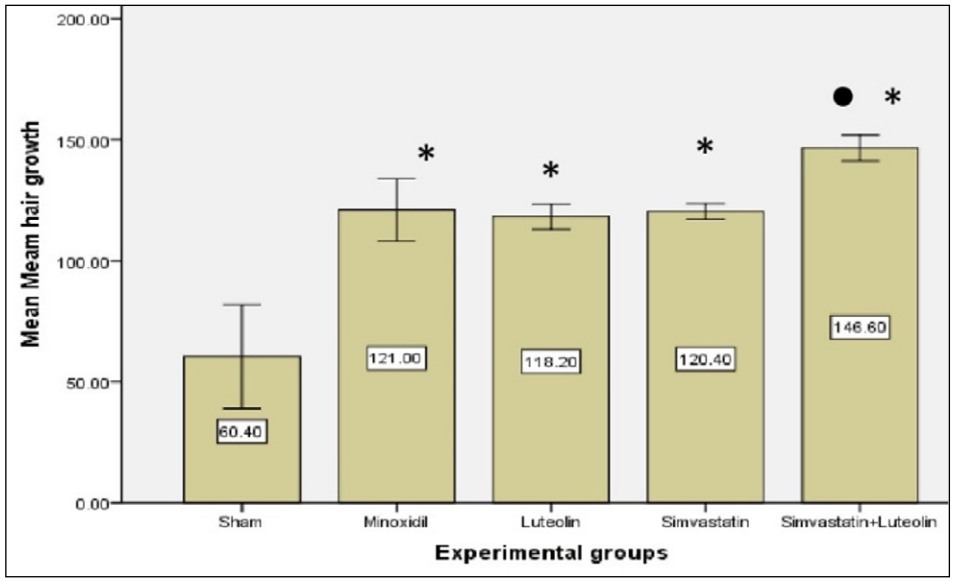

Fig. 3. Shows the average hair growth ratio using MATLAB software among the study groups.
Data are expressed as Mean ± SD,
*p-value<0.05 vs. sham (ethanol group),
·p-value<0.05 vs. Minoxidil group
Picture taken by the authors

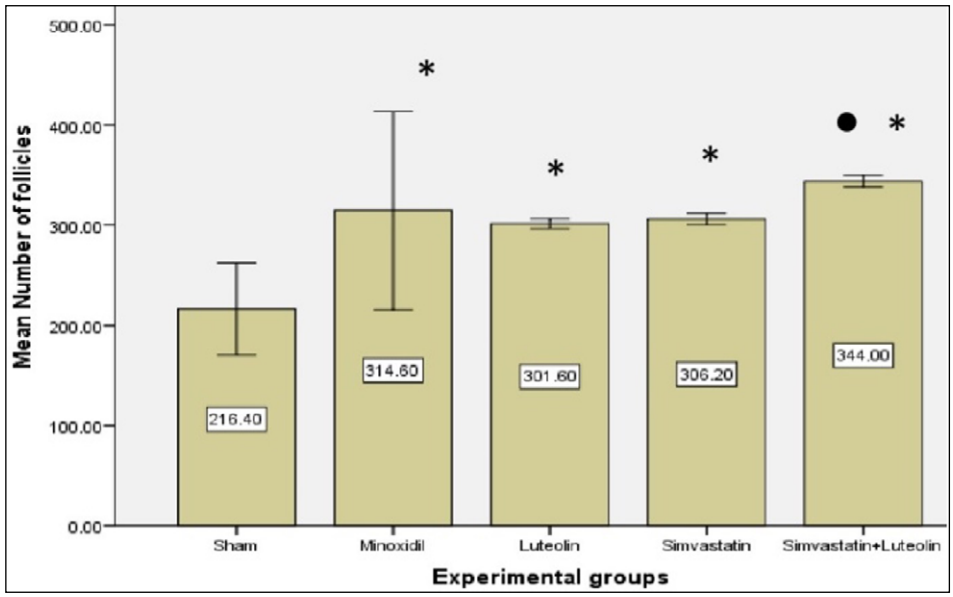

Fig. 4. Average number of hair follicles of hair follicles among the experimental groups.
Data are expressed as Mean ± SD,
*p-value<0.05 vs sham (ethanol group),
·p-value<0.05 vs. minoxidil group
Picture taken by the authors

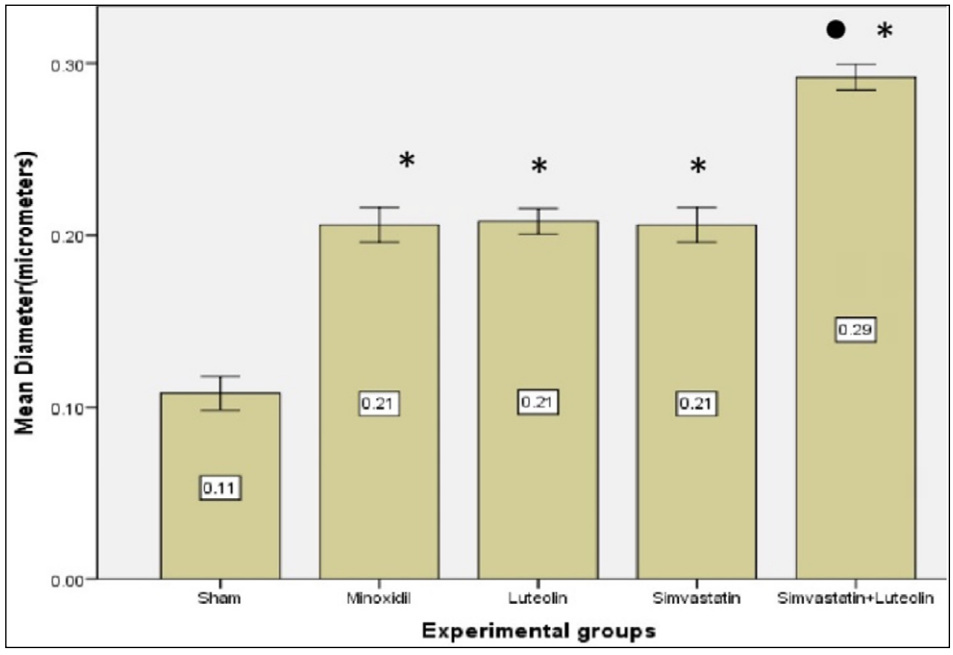

Fig. 5. Mean diameter (in micrometers) of the hair follicles among the study groups.
Data are expressed as Mean ± SD,
*p-value<0.05 vs. sham (ethanol group),
·p-value<0.0 5 vs. Minoxidil group
Picture taken by the authors

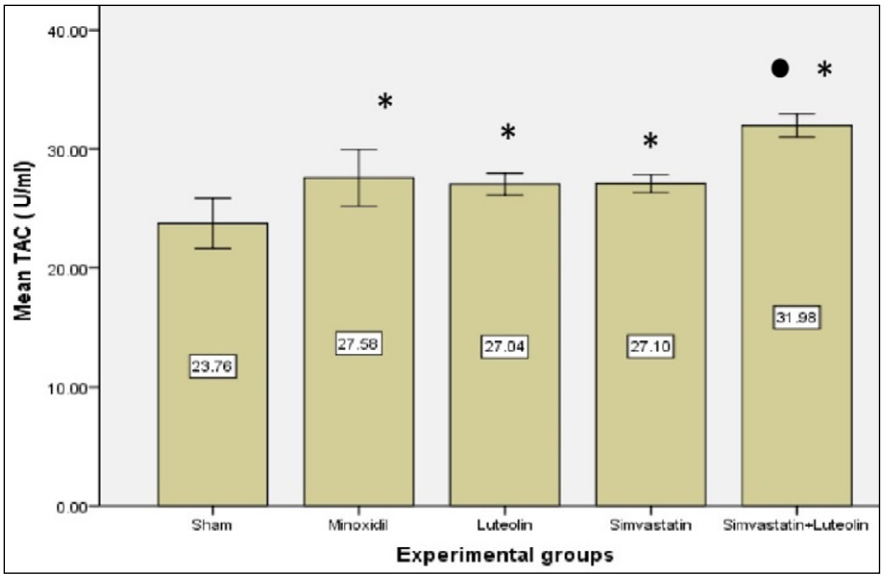

Fig. 6. Mean levels of TAC (in U/ml) among the study groups
Data are expressed as Mean ± SD,
*p-value<0.05 vs. sham (ethanol group),
·p-value<0.05 vs. Minoxidil group
Picture taken by the authors

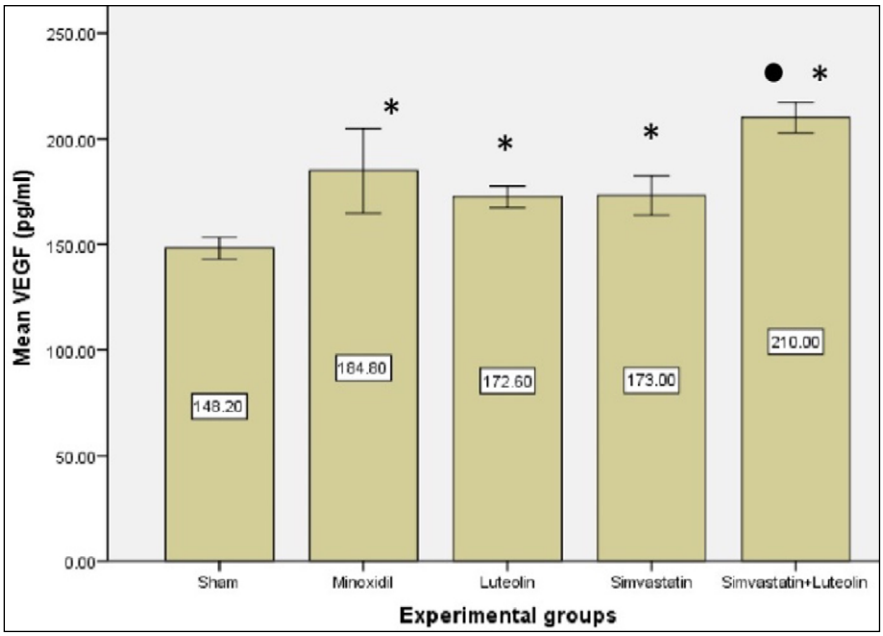

Fig. 7. Levels of VEGF (pg/mL) among the experimental groups
Data are expressed as Mean ± SD,
*p-value<0.05 vs. sham (ethanol group),
·p-value<0.05 vs. Minoxidil group
Picture taken by the authors

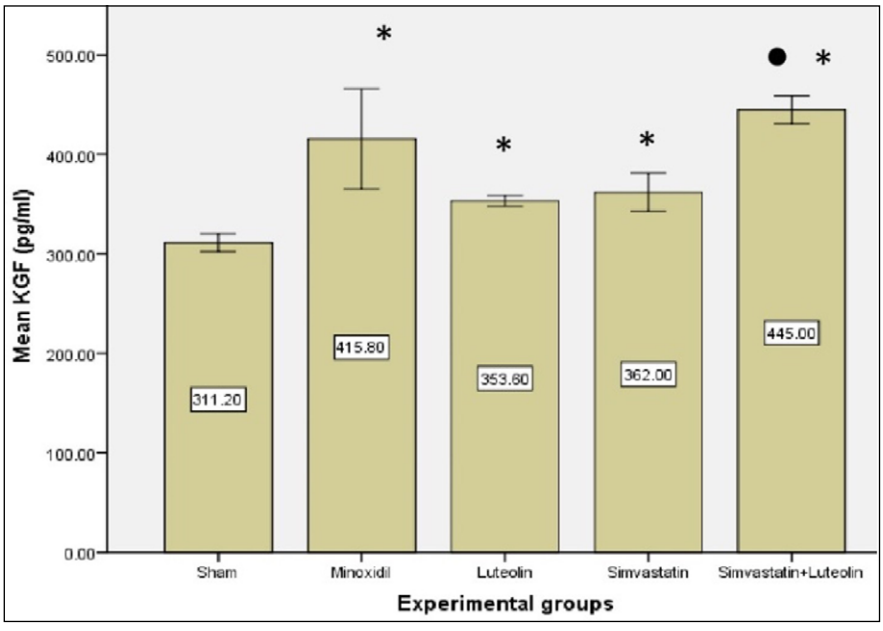

Fig. 8. levels of KGF (pg/ml) among the experimental groups
Data are expressed as Mean ± SD,
*p-value<0.05 vs. sham (ethanol group),
·p-value<0.05 vs. Minoxidil group
Picture taken by the authors

luteolin could be preliminary ground for restoration of microenvironment that is crucial for hair growth and addressing the reasons for alopecia. Supporting this hypothesis was evident by reports showing the role of antioxidant rich foods in mitigating androgenic alopecia while the risk of this condition is aggravated by ingesting of proinflammatory food [16]. Targeting these two pathways by simvastatin and luteolin may not only enhance hair growth but also provide alternative to existing medications with fewer unwanted effects.

Luteolin has pleotropic mechanisms, particularly the antioxidant effect that has been found to play a beneficial role in hair loss simvastatin is lipid lowering agent having vasculogenesis, immunomodulatory, anti-inflammatory effects suggesting its potential to induce hair growth. The present study shows that treatment with simvastatin resulted in an increase in the hair growth and number of follicles as compared to the sham. These results seem to be consistent with other research which found that statins reduced hair loss in patients with alopecia Areata via their immunomodulatory properties [17-18]. In addition, simvastatin treatment increased the diameter of hair follicles suggesting its role in increasing hair growth. The current study demonstrated that treatment with simvastatin elevated the levels of TAC in tissues of the skin as compared to the sham group. Simvastatin has been found to decrease the production of free radicals, TNF-α and elevate the antioxidant capacity of the human abdominal aortic aneurysm wall tissue, probably through inhibiting NF-kB activity [19-20]. The present study showed that treatment with simvastatin markedly increased the level of VEGF in comparison with the sham group. It has been reported that simvastatin treatment increased the VEGF levels at mRNA levels and protein levels, and improved wound healing in a mouse model of diabetes [21]. Indeed, administration of anti-VEGF monoclonal antibody reversed the effect of simvastatin in wound healing in diabetic mice suggesting a role of VEGF in modulating hair growth [21]. In a rat model of brain injury, there is a correlation between therapeutic improvement and VEGF upregulation with simvastatin [22]. Furthermore, simvastatin improved a burn wound healing via ameliorating the wound closure percentage, epithelial thickness, collagen remodeling and VEGF expression [23]. The current study showed that treatment with simvastatin notably increased levels of KGF as compared to the sham group. High concentrations were found following injection simvastatin and mesenchymal stem cells in oleic acid induced lung injury suggesting its role as catalyst in increasing the levels of KGF [24]. The current research demonstrates that Luteolin treatment enhanced the growth of hair, number of hair and diameter of hair follicles. Consistent with the literature, Luteolin-loaded Nanoemulsion has been found to increase hair growth [25]. This type of flavonoids has antioxidants properties may be able to both slow hair loss and promote hair growth [26]. The present study reveals that high levels of TAC in the skin tissues as compared with the sham group. These results are in line of previous studies showing that Luteolin increased levels of TAC following intestinal ischemia-reperfusion injury in mice [27]. Luteolin-treated while cleaved caspases 3, NF-B, and MIP-1 levels were decreased, CNTF expression was upregulated, and cAMP and TAC levels significantly increased in the experimental autoimmune encephalomyelitis group [28]. The current study demonstrated high levels of VEGF in mice treated with Luteolin as compared to the sham group. The study showed the primary components of Methanolic shallot extract have been determined to be phenolic chemicals. Quercetin and Luteolin Reduced NO generation and release from shallot extract results in anti-inflammatory action. SRD5A1 and SRD5A2 expression were reduced by shallot extract in DU-145 cell lines. SHH, SMO, GIL1, CTNNB1, and VEGF expressions, however, were elevated in hHFDPC. These results show that shallot extract inhibits androgen and inflammatory pathways to promote hair development. Additionally, the VEGF, Sonic Hedgehog, and Wnt/-catenin pathways were also active [29]. The current study shows that treatment with Luteolin resulted in high levels of KGF as compared with sham group. KGF in the dermal papillae is crucial for the growth of hair. It regulates the migration, proliferation, differentiation, and survival of keratinocytes [30]. The current investigation revealed that the combination of simvastatin and Luteolin showed notable increases in hair growth and diameters of follicles and increased tissue levels of TAC, VEGF, and KGF after three weeks of treatment. To best our knowledge, no studies have examined the effect of this combination on hair growth and further studies need to be done. It is unclear what potential mechanisms might underlie the combined effects of these drugs but may be through their antioxidant and anti-inflammatory properties.

CONCLUSIONS

Simvastatin and Luteolin solution significantly promote hair growth, increase hair counts and hair follicle diameter, and elevate the levels of TAC, VEGF, and KGF. Taken together, these results show that simvastatin and Luteolin reduce hair loss that could be by their effects as anti-inflammatory and antioxidant capabilities.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval of the article

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ORIGINAL ARTICLE

CONTENTS

Prognostic role of age and body weight in enhancing the physical component of quality of life for participants of combat actions through physical and sports rehabilitation

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ABSTRACT

Aim: To assess the influence of age and body weight on the improvement of the physical component of quality of life in combatants participating in the course of physical and sports rehabilitation. This will be evaluated using analysis based on the SF-36 questionnaire.

Materials and Methods: The study involved 40 participants of combat actions (males with an average age of 42,35 ± 8,98 years). During the period from 2020 to 2021, these participants were involved in physical and sports rehabilitation, and training for both national and international competitions in running disciplines within athletics.

Results: The study developed models that describe how age and body weight influence on the dynamics in the quality of life components for combatants. Analysis of the data indicated that the model illustrating the impact of age and body weight on the absolute increase in the PHC was statistically significant (F=3,899; p=0,0286). The model that aimed to predict the increase in indicators of the mental health component as a result of the implementation of physical and sports rehabilitation measures turned out to be statistically insignificant (F=0,036; p=0,9642).

Conclusions: The obtained results hold practical value for planning and implementing physical and sports rehabilitation programs for combatants.

KEY WORDS: physical and sports rehabilitation; quality of life; SF-36; combatants; age; body weight; physical component of health; prediction

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INTRODUCTION

Physical and sports rehabilitation (PSR) is an essential element in the system of reintegration of combatants (DDR) into active social and professional life. In the conditions of a full-scale war in Ukraine, when the number of veterans and injured servicemen is constantly growing, the issue of the effectiveness of PSR measures has become exceptionally relevant. According to the Ministry of Defense of Ukraine, as of 2023, approximately one million individuals hold the status of combatant [1-14], and this requires the expansion of scientifically based approaches to their physical and psychological support.

An analysis of the current scientific literature indicates a growing interest in integrating FSR into the healthcare system and rehabilitation services [3, 12]. The impact of physical exercise on the quality of life of individuals with combat experience is being studied in particular, using the SF-36 questionnaire, which is considered as a valid tool in clinical psychology and rehabilitation [4, 7]. Foreign studies have established the positive impact of structured physical activity programs on the physical functioning and vital activity of veterans [6, 8].

At the same time, Ukrainian scientific discourse has not yet sufficiently studied which biological factors (in particular, age and body weight) influence the effectiveness of FSR, and whether rehabilitation outcomes are consistent across different subgroups of veterans. The preliminary results of the author's study [9] confirmed FSR's overall effectiveness in improving the quality of life of DDR, but the question of the dependence of this effect on the individual characteristics of the contingent remains open.

In this context, it is relevant to study the prognostic role of age and body weight for the dynamics of the physical component of quality of life as one of the

main outcomes of rehabilitation intervention. Such analysis allows a shift from a universal to a personalized approach in PSR program planning, which is crucial under limited resources and the need for priority-based assistance. Therefore, the conducted study has both scientific and applied value for the practice of war veterans rehabilitation in Ukraine.

AIM

To assess the influence of age and body weight on the improvement of the physical component of quality of life in combatants participating in the course of physical and sports rehabilitation. This will be evaluated using analysis based on the SF-36 questionnaire.

MATERIALS AND METHODS

PARTICIPANTS

The study involved 40 DDRs who participated in FSR events during 2020–2021, in particular as part of preparation for all-Ukrainian and international competitions in running disciplines of track and field athletics. All participants were informed about the specifics of the research and provided their consent to participate in them.

RESEARCH METHODS

The study was conducted on a sample of 40 combatants who completed a PSR course. Inclusion criteria included age between 18 and 60 years, absence of serious chronic diseases, and informed consent to participate. Data were collected via questionnaires that evaluated the participants' quality of life, as well as their age and body mass.

PROCEDURE (ORGANIZATION OF THE STUDY)

The survey was conducted at the National Sports Complex "Olympic" during training sessions in preparation for international and all-Ukrainian competitions in running disciplines of track and field athletics. The study involved 40 combatants who had completed military service. The survey was conducted by the trainer at the first training session and a year after regular training. All participants were informed about the use of testing materials and gave consent to their processing.

The SF-36 Online Instrument was used to assess the quality of life of the combatants, administered at the start of the study and again after one year of observation. The 36 items of the questionnaire are grouped into eight scales: physical functioning, role limitations due to physical health, bodily pain, general health, vitality, social functioning, role activity, bodily pain, general health, life activities, social functioning, emotional state and mental health. Each scale score ranged from 1 to 6, where higher values indicated better results. The 8 scales were grouped into two indicators: physical and psychological components of health.

The physical component of health (PCH) included: Physical Functioning (PF), Role Functioning due to Physical Condition (RF), Pain Intensity (PI), General Health (GH).

The mental component (MC) of health included: Life activities (LA), Social functioning (SF), Role functioning due to emotional state (RF), Mental health (MH).

STATISTICAL ANALYSIS

During the study, we formulated the following hypotheses:

- H_1 – physical and sports rehabilitation measures have a positive effect on the quality of life of combatants;
- H_2 – the effectiveness of physical and sports rehabilitation measures aimed at improving the quality of life depends on the age and body weight of the military.

To verify the hypotheses, statistical analysis methods were employed. Normal distribution of the data was tested using the Shapiro–Wilk W-test, recommended for samples up to 50 observations. As the indicators did not correspond to the normal distribution law, the median (Me) and 25th and 75th quartiles were used to represent the central tendency and dispersion of empirical data, the Kruskal-Wallis H-test was used to compare the estimates of the components of the quality of life of the DDR, and the Wilcoxon T-test was used for comparative analysis before and after the study.

When testing H_2, we used regression analysis, choosing the generalized linear model GLM, which allows modeling categorical variables of various types, including binary ones. In addition, they can be applied to data that are not normally distributed and model nonlinear relationships between dependent and independent variables. All this makes GLM a powerful tool for analysis in various fields of knowledge. So, the predictors in the model were binary variables: age and BMI of the contingent. Previously, the variables were coded: 1 – age up to and including 45 years and normal body weight and length ratio; 0 – over 45 years old and overweight. The dependent variables were the absolute increases in the PHC and MHC of the DDR quality of life during the period of implementation of the FSR measures. It is important to note that we considered the absolute increases in the quality of life components

as the criteria for evaluating intervention effectiveness.

Homogeneity of variances for PHC and MHC increases, adjusted for age and body weight, was confirmed using Levene's test ($p > 0,05$). For the PHC age groups, the F-statistic and p-value were 1,048 and 0,3122 in accordance; for the MHC – 1,795 and 0,1879; for the PHC of the body weight groups – $F=0,048$ at $p=0,8267$; for the MHC – $F=0,715$ at $p=0,4029$.

The hypotheses were tested at a significance level of 0,05.

MS Excel and STATISTICA 16.0 software were used for calculations.

LIMITATIONS

It is important to note that our study has certain limitations. Firstly, it was conducted on a sample of combatants who were preparing for running events in track and field athletics competitions. This group may possess a higher level of physical fitness and motivation compared to those combatants who do not engage in such competitions. Consequently, the findings of the study cannot be directly generalized to less physically active combatants. In addition, the study had a relatively small sample size, which may limit its statistical power and make the results less reliable. Lastly, the research was based on self-reported data from the participants, which may introduce certain biases into the findings.

COMPLIANCE WITH ETHICAL REQUIREMENTS

The study was conducted in accordance with the principles of the Helsinki Declaration of the World Medical Association «Ethical principles of medical research involving a person as an object of research». All study participants provided informed consent in writing to participate in the study.

RESULTS

In the current context of full-scale Russian military aggression, both individual and collective traumatization can be observed among the population of Ukraine [5, 11]. Wars are one of the most destructive traumatic events of our time [13]. War in Ukraine is considered as a distress that negatively affects the personality and its functioning, psyche and mental health of the individual [15, 16]. Among the primary causes of distress during war, O. R. Tkachyshyna identifies factors such as the prolonged inability to meet physiological needs; unsuitable, unusual living conditions (such as extended stays in shelters or other non-residential facilities etc.); physical injuries, exacerbated illnesses, persistent pain; sustained negative emotions (experiences of fear, anxiety, anger, rage).

To assess health-related quality of life, a survey was conducted among combatants (n=40) who regularly participated in PSR programs.

The study showed that after the implemented measures of physical and sports rehabilitation – specifically, participation in running disciplines of athletics – the most significant improvements were observed in the mental health component, role functioning due to the emotional state, social functioning, general health, pain intensity, role functioning, and physical functioning of the participants. The results obtained are evidence of the positive impact of PSR measures on the state of combatants at the stage of restoring mental and physical health and their return to civilian life. After the study, the maximum absolute median increases were 100 points for PR and RE, that is, for the lowest components of quality of life [9].

PSR measures are an important component of military recovery after combat actions. Its impact on the quality of life of combatants requires thorough study. In this study, we not only studied whether physical and sports rehabilitation activities affect the quality of life of combatants, but also whether the effectiveness of these activities depends on the age and body weight of the military.

To evaluate hypothesis H_1, a visual analysis was conducted, which demonstrates the presence of a relationship between the dynamics of quality of life components under the influence of PSR measures with age and body weight of the combatants. Using the figures, it can be seen that the implemented measures had a different effect on the PHC and MHC depending on the age and body weight of the combatants (Fig. 1, Fig. 2).

During the study, models were developed to describe the effect of age and body weight on the dynamics of quality of life components in combatants. The parameters of the models are presented in Table 1.

Analysis of the data showed that the model describing the impact of age and body mass on the absolute increase in the PHC was statistically significant ($F = 3,899$; $p = 0,0286$). Furthermore, the coefficients within this model were also statistically significant, with p-values ranging from 0,0003 to 0,0445. Its analytical form is expressed as:

$$\Delta PHC=2,51+1,24*age(0)+1,31*body\ weight(0) \quad (1),$$

Where ΔPHC – on absolute increase of PHC;

Age – age up to 45 years;

Body weight – normal body weight.

On the other hand, the model for predicting the increase in MHC resulting from physical and sports rehabilitation interventions was not statistically significant ($F = 0,036$; $p = 0,9642$). The lack of the statistical

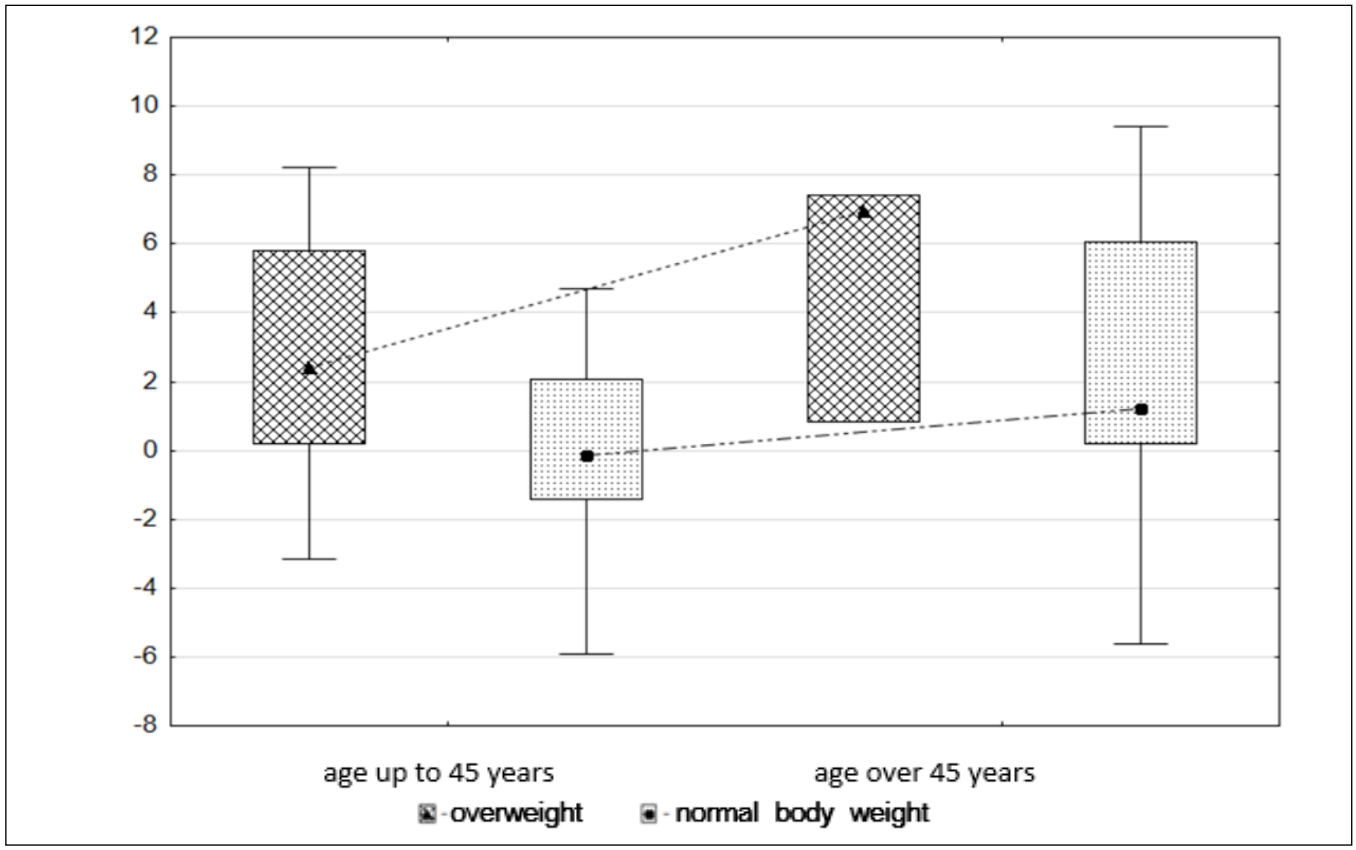

Fig. 1. The relationship between the dynamics of the PHC under the influence of physical and sports rehabilitation measures with the age and body weight of the combatants (n=42)
Picture taken by the authors

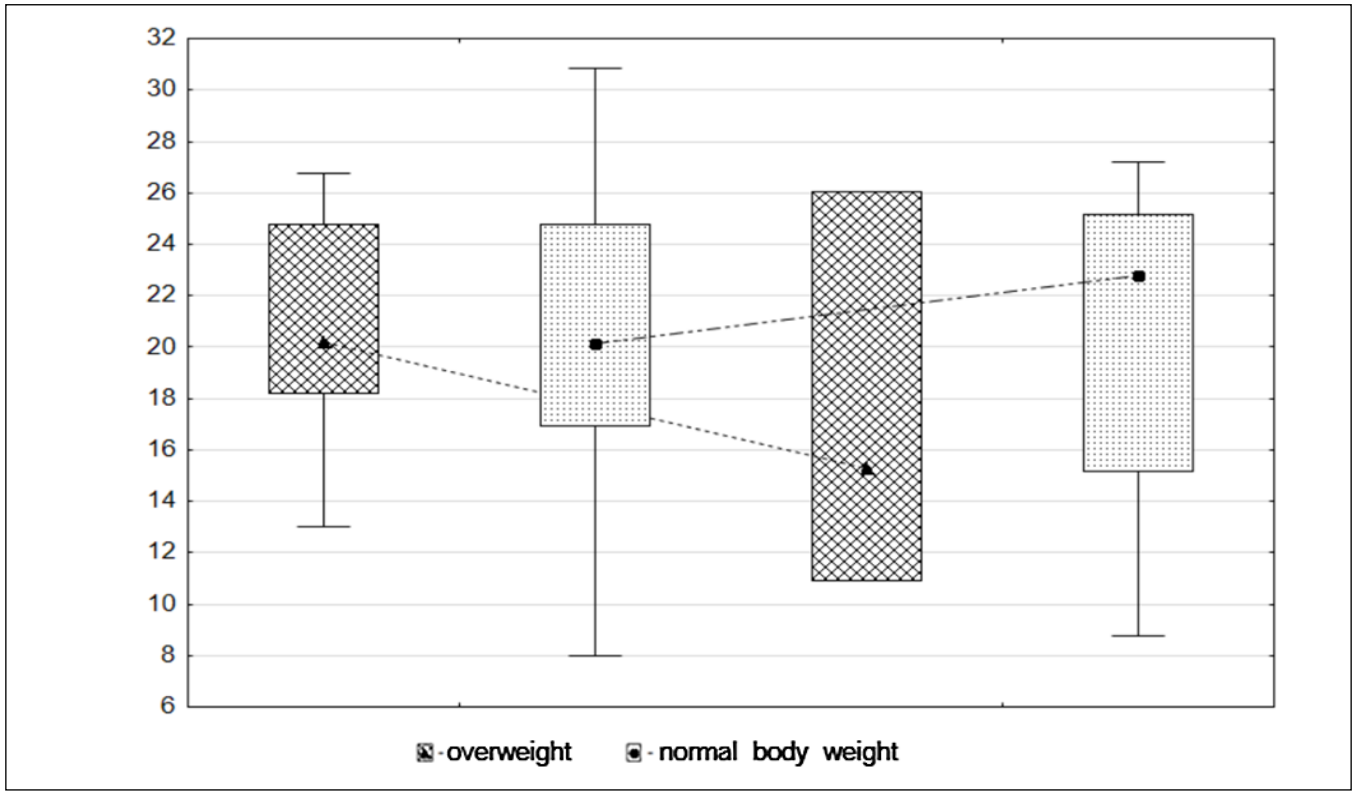

Fig. 2. Relationship between the dynamics of the MHC under the influence of physical and sports rehabilitation interventions with age and body weight of combatants (n=42)
Picture taken by the authors

Table 1. Evaluation of the parameters of the model of the influence of stress-associated states on the overall assessment of psychophysiological indicators of students

Dependent variables	Regression components	Regression coefficients and their estimates					
		α	S(α)	t	p	CI	
						-95%	+95%
PHC Increase	**Constant term**	2,51	0,63	3,987	0,0003	2,51	0,63
	Age ≤ 45 years	1,24	0,60	2,076	0,0445	1,24	0,60
	Normal body weight	1,31	0,60	2,208	0,0332	1,31	0,60
MHC Increase	**Constant term**	20,14	1,02	19,787	<0,05	18,08	22,20
	Age ≤ 45 years	-0,21	0,96	-0,215	0,8311	-2,15	1,74
	Normal body weight	-0,19	0,96	-0,199	0,8429	-2,14	1,75

Note: S(α) – standard error of the regression coefficient; t – Student›s t-test to assess the significance of the regression coefficient α; p – achieved significance level; CI – confidence interval

Source: compiled by the authors of this study

significance does not permit to make a definitive conclusions about the influence of age and body weight on the MHC of combatants' quality of life.

Thus, we can say that hypothesis H2 was partially proven and related exclusively to the physical component of quality of life.

DISCUSSION

Due to the systematic nature of training and high-quality execution of exercises, combatants had the opportunity to improve their quality of life and reduce the negative effects of experienced stress. Our study demonstrated a statistically significant dynamic in the Physical Health Component (PHC) among military personnel who underwent PSR. The most pronounced changes were recorded in groups of respondents over 45 years of age with excess body weight, what allows us to speak about the effectiveness of the PSR in the context of the specific biological characteristics of veterans.

The model we constructed confirms that BMI and age make a prognostically significant influence on the increase in PHC. The average increase across the entire sample was 2,51 points, however, among participants over 45 years of age with excess body weight, the expected increase was more than 5 points. These results are consistent with scientific views on the reactivity of veterans' adaptive systems to physical activity in later life. In particular, Martz E. [12] emphasizes that systematic fitness programs can compensate for age-related and somatic limitations of veterans, if they are implemented for a long time, as well as if the classes have a rehabilitation-oriented focus.

Furthermore, research by Dekel et al. [6] indicates that group-based physical activity not only serves as a means of functional recovery but also contributes to post-traumatic growth. Training participants who share combat experience may form supportive networks, enhancing the rehabilitative effect even in the absence of specialized psychological care. Nevertheless, contrary to expectations, our study did not demonstrate a statistically significant influence of biological variables on the increase in the Mental Health Component (MHC) of quality of life. This finding contrasts with the conclusions of Joseph and Linley [8], who describe a universal psychological benefit from regular physical activity.

A potential explanation for this discrepant result may be the specificity of the sample: the study was conducted among individuals who voluntarily joined the training process in running disciplines and already had a sufficient level of physical activity and self-regulation. The reduction in emotional stress may have occurred earlier or may not have been sensitive enough to be registered using the SF-36.

Additional support for the significance of psychosocial factors is found in the works of Kravchenko O. [2] and Kohut I. et al. [1, 10]. Their works emphasize that the psychological adaptation of veterans depends on the depth of the trauma experienced, the level of social support, motivation to participate in the program, and even the type of previous combat experience. Therefore, assessing PSR effectiveness in improving the MHC requires not only a physiological but also an interdisciplinary approach—incorporating psychodiagnostics, life event analysis, and motivational component.

It is worth noting that the results we obtained complement the existing empirical base and enable the development of more personalized PSR program planning. Specifically, target beneficiaries of such programs may include individuals over 45 years of age with excess body weight, for whom the expected effectiveness is highest. At the same time, unified approaches should

be avoided, and systems for stratifying combatants according to their functional and psycho-emotional resources should be developed.

Future research should focus on creating more complex models that combine physiological, psychosocial, and behavioral parameters. Longitudinal studies may be particularly valuable to assess the sustainability of rehabilitation interventions over time. It is also worth considering the possibilities of multicomponent programs that include not only physical but also cognitive, motivational, and emotional-reflective modules.

CONCLUSIONS

Based on the conducted research, the prognostic role of age and body mass in improving the physical component of quality of life among combatants participating in physical and sports rehabilitation programs was confirmed. The generalized linear model demonstrated a statistically significant effect of these factors on the increase in the Physical Health Component (PHC) as measured by the SF-36 questionnaire. The greatest effect was observed in veterans over 45 years of age with excess body weight. This allows us to recommend a personalized approach to planning rehabilitation activities, focusing on the biological characteristics of the target group. At the same time, the influence of age and body weight on the dynamics of the mental component of quality of life was not statistically significant, what requires further interdisciplinary study taking into account psychosocial factors. The results obtained can be used to improve the effectiveness of state programs for the physical and social reintegration of military personnel.

PROSPECTS FOR FURTHER RESEARCH

In further research, it is advisable to study the influence of psychosocial factors on the dynamics of the mental component of veterans' quality of life and to develop personalized rehabilitation models.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Influence of strength training on physical development and physical fitness of young men

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ABSTRACT

Aim: To investigate the influence of strength training on the physical development and physical fitness of 16-17-year-old young men.

Materials and Methods: The research, which was conducted in 2024-2025, involved 117 high schoolers of 10-11 grades (16-17-year-old young men). Two groups of young men were formed: the experimental (EG, n = 56) and the control (CG, n = 59): the CG young men were engaged in a generally accepted program; the EG young men were engaged in strength training. Research methods: bibliosemantic, medical and biological methods, testing, methods of mathematical statistics.

Results: The positive influence of strength training on the physical development and physical fitness of 16-17-year-old young men was revealed. The EG young men showed significant ($p < 0.05$-0.001) improvement of such indices as Pignet (by 3.6 c. u.), Brugsch (by 18.9 c. u.), strength (2.5 c. u.), Erisman (by 0.8 c. u.), body weight (by 1.4 kg/m^2), as well as results in pull-ups (by 4.5 times), in push-ups (by 7.3 times), in a standing long jump (by 6.6 cm), in sit-ups (by 9.3 times). In the CG, there were no significant changes in all tests ($p > 0.05$). At the end of the research, most of the EG indicators were significantly better compared to the CG.

Conclusions: The introduction of strength training in the physical education of senior high schoolers is one of the important factors for improving their health, harmonious physical development, and increasing physical fitness.

KEY WORDS: strength qualities, strength training, young men, health, physical development, physical fitness

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INTRODUCTION

The health of the younger generation is one of the indicators of social well-being, so ensuring the optimal physical condition of school children, adequate to the needs of the individual and society, is one of the main tasks of education. However, in Ukraine, in recent years, especially during the war, the level of physical fitness of the younger generation has been declining; the incidence of morbidity among children of all ages is increasing, and the health of school children is deteriorating [1-3].

Scientists argue [4, 5] that to ensure the comprehensive physical fitness of school children, especially senior high schoolers (16-17-year-old), during physical education, it is necessary to develop, first of all, strength, speed and power qualities, and endurance. A high level of development of these physical qualities is the basis for mastering new types of motor actions, successful adaptation to labor and household operations, and an important component of health status [6-8].

At present, various systems of physical exercises and sports are used for health purposes at school: athletics, sports games, martial arts, aerobics, and many others. However, not all of them can be recommended for high schoolers' recreational activities for psychological, pedagogical, and physiological reasons. One of the types of physical exercises suitable for health promotion and improvement of the physical development of young men aged 16-17 is strength training. Strength training is a system of weight-bearing exercises designed to en-

gage high schoolers in regular physical activity, develop skills and abilities for a healthy lifestyle, improve their physical condition, and ensure high working capacity during the school period. Strength training does not involve participation in competitions and achievement of ultimate sports results. During strength training, exercises with weights (barbells, dumbbells, kettlebells), expanders and rubber harnesses, exercises with body weight, on gymnastic and strength training equipment are used [9, 10].

The health-promoting effect on the body, the possibility of using individual training methods, a wide range of loads and exercises, the absence of shock load, and compatibility with other physical exercises make strength training an effective means of physical development for 16-17-year-old young men [11, 12].

AIM

The aim is to investigate the influence of strength training on the physical development and physical fitness of 16-17-year-old young men.

MATERIALS AND METHODS

PARTICIPANTS

The research, which was conducted in 2024-2025, involved 117 high schoolers of 10-11 grades (16-17-year-old young men) from Lyceum #21 in Zhytomyr (Ukraine). Two groups of young men were formed: the experimental (EG, n = 56) and the control (CG, n = 59). The EG included all young men in grades 10-11 (grades A, B, C) with no health problems; the CG included all young men in grades 10-11 (grades D, E, F) with no health problems. All young men in the EG and the CG belonged to the main medical group and had no contraindications to physical exercise, which was the main criterion for including young men in the study groups. The research was conducted from September 2024 to May 2025. The CG young men were engaged in a generally accepted program for general secondary education institutions during the academic year. In the educational process of physical education of the EG young men, along with the generally accepted program, sets of exercises of strength orientation were additionally included. The criterion for exclusion of young men from the EG was their not personal desire to engage in strength training; they could stop participating in the research at any time. Indicators of young men's physical development and physical fitness were not considered when forming the EG and the CG. Also, our research did not consider additional physical exercises and the motor activity of the EG and the CG young men outside school hours. The total hours spent on physical education training sessions in the EG and the CG young men during the entire research period was the same (3 training sessions per week). The lyceum medical staff monitored the health status of the EG and the CG young men systematically during the academic year.

The structure and content of strength training developed and implemented in physical education training sessions of the EG included exercises with barbells, dumbbells, kettlebells, exercises on simulators, and gymnastic equipment (with own body weight). The total number of exercises per session was 6-8 (2 for each muscle group). Each exercise was performed in 3-4 sets. Each training session began with 5-7 minutes of warm-up and ended with relaxation exercises. Physical activity was gradually increased during training with the EG young men: increased dosage, weight of the load, reduced rest time between exercises, and individual approaches. The load was regulated, taking into account the individual characteristics of young men and in compliance with the basic principles of physical training.

RESEARCH METHODS

Bibliosemantic, medical and biological methods, testing, methods of mathematical statistics. Bibliosemantic method was used to conduct an analytical review of scientific sources on the outlined range of issues (21 sources from PubMed, Scopus, Web of Science, and Index Copernicus were analyzed).

The following indices were used to assess the physical development of young men: the Pignet index, the Brugsch index, the strength index, the Erisman index, and the body mass index. The Pignet index (PI, c. u.) characterizes the strength of the physique of young men and is determined by the formula: PI = l – (m + d), where l is height (cm), m is body weight (kg), d is chest circumference at exhalation (cm). The physique of young men is assessed as strong if the PI is 10-15 c. u., good – 16-20 c. u., average – 21-25 c. u., weak – 26-30 c. u., very weak – more than 30 c. u. The Brugsch index (BI) characterizes the harmony of the physique of young men and is determined by the formula: BI = (d x 1000) / l. A value from 500 to 550 indicates a harmonious physique, less than 500 – an underdeveloped physique, more than 550 – an inharmonious physique (overweight). The strength index (SI, c. u.) characterizes the development of the muscular system of the body of young men and is determined by the formula: SI = (D / m) x 100, where D is the indicator of hand strength (determined by a hand dynamometer in kg). The norm

Table 1. Dynamics of physical development indicators in young men of the EG (n = 57) and the CG (n = 59) during the research

Research stages	Study groups		Difference	Significance of the difference (t / p)
	EG	CG		
Pignet index, c. u.				
Beginning	27,2±0,73	26,9±0,69	0,3	t=0,30 / p>0.05
And	23.6±0.65	26,1±0.71	2.5	t=2.60 / p<0.05
t / p	t=3,68 / p<0.001	t=0,81 / p>0.05		
Brugsch index, c. u.				
Beginning	518.7±4,68	519,1±4.55	0.4	t=0,06 / p>0.05
And	537.6±4.51	522,5±4,62	15,1	t=2.34 / p<0.05
t / p	t=2,91 / p<0.05	t=0,52 / p>0.05		
Strength index, c. u.				
Beginning	52.7±0.71	51.3±0.67	1,4	t=1,43 / p>0.05
And	55.2±0.73	52.9±0.69	2,3	t=2.29 / p<0.05
t / p	t=2.45 / p<0.05	t=1,66 / p>0.05		
Erisman index, c. u.				
Beginning	2.3±0.21	2.1±0.19	0.3	t=0.71 / p>0.05
And	3.1±0.23	2.3±0.20	0.8	t=2.62 / p<0.05
t / p	t=2.57 / p<0.05	t=0.72 / p>0.05		
Body mass index, kg/m^2				
Beginning	19,2±0.27	19,5±0.25	0.3	t=0.82 / p>0.05
And	20,6±0.29	19,9±0.26	0.8	t=2.05 / p<0.05
t / p	t=3,53 / p<0.01	t=1,11 / p>0.05		

Note: t – Student's t-test value; p – p-value
Source: compiled by the authors of this study

for young men is 50-70 c. u. The Erisman index (EI. c. u.) characterizes young men's chest development and is determined by the formula: EI = d – 0.5 x l. If the EI is 1-5 c. u., it indicates normal chest development in young men; if less than 1 c.u., it is poor development; if more than 5 c. u., it is very good development. The body mass index (BMI, kg/m^2) characterizes the body weight to height ratio and is determined by the formula: BMI = m / l^2. If the BMI is less than 18.5 kg/m^2, this indicates a deficiency of body weight; 18.5-24.9 kg/m^2 is normal, and more than 25 kg/m^2 is overweight.

The level of physical fitness of young men was assessed by the following tests: pull-ups (strength qualities, development of back and arm muscles), standing long jump (speed and strength qualities, development of leg muscles), push-ups (strength endurance, development of shoulder girdle muscles), sit-ups (strength endurance, development of abdominal muscles), trunk lean forward from a sitting position (flexibility).

STATISTICAL ANALYSIS

The methods of mathematical statistics were used to process the data obtained. The compliance of the sample data distribution with the Gauss' law was assessed using the Shapiro-Wilk W test. The reliability of the difference between the indicators was determined using the Student's t-test. The significance of the difference was set at p<0.05. The results were presented as Mean ± se, where Mean is the arithmetic mean and se is the standard error of the arithmetic mean. All statistical analyses were performed using SPSS software, version 10.0, adapted for medical and biological research.

ETHICS

Data processing was carried out at the Department of Physical Education of S. P. Koroliov Zhytomyr Military Institute (Zhytomyr, Ukraine). This study followed the regulations of the World Medical Association Declaration of Helsinki. Informed consent was received from all participants who took part in this study.

RESULTS

The concept of "physical development" unites a set of morphological and functional indicators that study physical working capacity and a high schooler's age de-

Table 2. Dynamics of the physical fitness indicators of young men of the EG (n = 57) and the CG (n = 59) during the research

Research stages	Study groups		Difference	Significance of the difference (t / p)
	EG	CG		
Pull-ups, times				
Beginning	8.6±0,41	9.1±0,45	0,5	t=0.82 / p>0.05
And	13.1±0,46	10.3±0,47	2.3	t=4,26 / p<0.05
t / p	t=7,30 / p<0.001	t=1,84 / p>0.05		
Standing long jump, cm				
Beginning	221,7±2,21	223,2±2,06	1,5	t=0.44 / p>0.05
And	228,3±2,15	224,9±2,09	3,4	t=1,15 / p>0.05
t / p	t=2,14 / p<0.05	t=0,58 / p>0.05		
Push-ups, times				
Beginning	27.5±0.85	26.6±0.81	0,9	t=0.77 / p>0.05
And	34.8±0.89	28.8±0.84	6,0	t=4,90 / p<0.001
t / p	t=5,95 / p<0.001	t=1,89 / p>0.05		
Sit-ups, times				
Beginning	35,2±0.98	34,7±1,02	0,5	t=0.35 / p>0.05
And	44.5±0.97	36,2±1,06	8,3	t=5,78 / p<0.001
t / p	t=6,74 / p<0.001	t=1,02 / p>0.05		
Trunk lean forward from a sitting position, cm				
Beginning	6,9±0.75	7.1±0.63	0,2	t=0.20 / p>0.05
And	8,2±0.78	7,7±0.68	0,5	t=0,48 / p>0.05
t / p	t=1,20 / p>0.05	t=0,65 / p>0.05		

Note: t – Student's t-test value; p – p-value
Source: compiled by the authors of this study

velopment level. It is the most important parameter for reflecting the physiological processes in the body at the transitional stage of ontogenesis. Physical development is used as an indicator of health status that responds to the impact of social and hygienic environmental factors. Harmony of physical development is the ratio of body weight, body length, chest circumference, and other anthropometric indicators. Our research used several indices to determine the physical development of 16-17-year-old young men (Table 1).

The comparative analysis of the physical development indicators of the EG and the CG young men at the beginning of the research showed that no significant difference ($p > 0.05$) was found for all studied indicators, which indicates homogeneity of the groups and the absence of any special selection of young men for participation in the research. During the research period, there was a tendency to improve the physical development of young men in both groups, but it was more pronounced in the EG. Thus, the analysis of the PI shows that at the end of the research, the indicators were significantly ($p < 0.05$) better in the EG than in the CG, by 2.5 c. u. During the research period, the indicators of the PI changed unreliably by 0.8 c. u. in the CG and significantly ($p < 0.001$) improved in the EG by 3.6 c. u. At the same time, in both groups at the beginning of the research the physique of young men was assessed as weak, then at the end – in the EG – as average; there were no changes in the CG.

Evaluation of harmony of young men's physique by the BI shows that, in general, both at the beginning and end of the research, the physique of young men of both groups is assessed as harmonious. However, in the EG, the BI during the research period improved by 18.9 c. u. ($p < 0.05$), and in the CG – by 3.4 c. u. ($p > 0.05$). Moreover, at the end of the research, the BI in the EG young men was significantly ($p < 0.05$) better, compared with the CG, by 15.1 c. u. proving the efficiency of strength training in forming a harmoniously physically developed personality.

The analysis of the SI showed that at the end of the research the indicators of the EG young men were reliably ($p < 0.05$) better than in the CG by 2.3 c. u. In addition, in the EG young men during the research period, the strength indicators improved reliably ($p < 0.05$) by 2.5 c. u., and in the CG, the changes made 1.6 c. u. and were unreliable ($p > 0.05$). The indicators of the EI, which characterize the development of the chest of young

men, at the end of the research in the EG were also significantly ($p < 0.05$) better than in the CG, by 0.8 c. u. It should be noted that in the EG, the EI indicators during the research period significantly ($p < 0.05$) improved by 0.8 c. u., and in the CG – only by 0.2 c. u. ($p > 0.05$). The BMI in both groups tends to improve and is within the age-related norm, but the changes in the EG are significant (1.4 kg/m^2, $p < 0.01$), and in the CG – unreliable (0.4 kg/m^2, $p > 0.05$). At the end of the research, the BMI in the EG young men was significantly ($p < 0.05$) better than in the CG by 0.4 kg/m^2, which confirms the effectiveness of strength training in improving the physical development of 16-17-year-old young men.

The comparative analysis of the physical fitness indicators of the EG and the CG young men shows that at the beginning of the research, statistically significant differences were not revealed. During the research period, young men of both groups improved their indicators on all tests, but greater expressed changes were observed in the EG (Table 2).

The most expressed reliable changes for the research period in the EG young men were observed in the tests on the development of strength qualities: in pull-ups – by 4.5 times ($p < 0.001$), in push-ups – by 7.3 times ($p < 0.001$), in a standing long jump – by 6.6 cm ($p < 0,05$), in sit-ups – by 9.3 times ($p < 0,001$). In the CG, there were no significant changes in all tests ($p > 0.05$). At the end of the research, in most of the tests, the results of the EG young men were significantly better compared with the CG, which testifies to the positive influence of strength training on the level of physical fitness of young men.

DISCUSSION

Scientists [13, 14] note that many health problems begin in childhood. Then, about 75 % of preschool children have serious health problems. Healthy children among primary school students make up 10-12 %, and among older ones – only 5 %. More than 50 % of children of all ages are diagnosed with chronic diseases. School children are performing worse than their peers 10-15 years ago. Only about 10 % of young people have a level of physical condition and health close to normal, and about 40 % of children suffer from chronic diseases. Cardiovascular and musculoskeletal diseases (bone and muscle systems) are progressing rapidly, largely due to insufficient motor activity. About 50 % of high school graduates have 2-3 diagnoses of diseases; generally, only 15 % of graduates can be considered practically healthy [15].

According to scientist [16], the main negative factors affecting health are physical inactivity (lack of movement), unhealthy diet (and above all, overweight) and bad habits (use of alcohol, nicotine, drugs and other chemicals). Therefore, active exercise is an integral part of a healthy lifestyle and is essential for school children's physical and personal development.

Based on the results of their research, scientists [17] found that the most effective means of preventing the impact of negative factors on the body of young people is physical activity of a strength nature. However, literature data [18] show that almost half of Ukrainian school children have unsatisfactory strength development; more than 60 % of them have posture disorders. Insufficient amount of muscle tissue can lead to corset function disorders (spinal diseases), development of respiratory and cardiovascular diseases, obesity, etc. [13, 15].

Our research demonstrated the effectiveness of strength training in improving the physical development and physical fitness of 16-17-year-old young men. The results of our research confirm the conclusions of other scientists about the complex influence of strength loads on the body of young men: in the process of strength training the development of physical qualities (first of all, strength qualities) and main indicators of physical development (body weight, chest circumference, etc.) improves. Experimental data from scientists [19] show an increase in the volume of the shoulder in young men over nine months of strength training by 12 %, and the hip by 10 % from the baseline. Exercise particularly affects the development of those muscle groups whose strength increases slowly during ontogeny, mainly the extensor muscles.

Scientists [20] note that the development of physical qualities in school children largely depends on the characteristics of puberty, so when developing physical qualities, it is necessary to consider sensitive periods when the ontogeny of body functions creates prerequisites for targeted influence on the relevant qualities. At the age of 15-17 years, an increase in the concentration of hormones (somatotropin, gonadotropin, testosterone) in young men leads to a rapid increase in muscle mass, growth of strength indicators [21]. The results of our research confirm the above conclusions and prove that strength training can be an effective and affordable means of physical education for 16-17-year-old young men. Strength training has an integral influence on school children: it helps to eliminate their motor deficit, to expand their physical potential, to increase the level of physical condition and personality development, allows to develop strength, speed and power qualities, strength endurance, coordination abilities, flexibility and thus to promote effective optimization of high schoolers' physical condition. In addition, regular

strength training fosters high schoolers' moral and volitional qualities, self-confidence, and encourages them to adopt a healthy lifestyle.

CONCLUSIONS

The positive influence of strength training on the physical development and physical fitness of 16-17-year-old young men was revealed. In the EG young men there was a significant ($p < 0.05$-0.001) improvement of the Pignet index (by 3.6 c. u.), the Brugsch index (by 18.9 c. u.), the strength index (2.5 c. u.), the Erisman index (by 0.8 c u.), the body weight index (by 1.4 kg/m^2), as well as results in pull-ups (by 4.5 times), in push-ups (by 7.3 times), in a standing long jump (by 6.6 cm), in sit-ups (by 9.3 times). In the CG, there were no significant changes in all tests ($p > 0.05$). At the end of the research, most of the EG indicators were significantly better compared to the CG.

The introduction of strength training into the physical education of senior high schoolers is one of the important factors in improving their health, harmonious physical development, and increasing the level of physical fitness.

PROSPECTS FOR FURTHER RESEARCH

It is planned to investigate the influence of strength training on the physical development and physical fitness of 16-17-year-old girls.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Osteomas in pediatric oral surgery practice

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ABSTRACT

Aim: To present the findings of our own research regarding the frequency, clinical and morphological characteristics, and treatment strategies for osteomas of the maxillofacial region in children.

Materials and Methods: The study is based on the analysis of outpatient records and inpatient medical histories of 17 children who underwent examination and treatment for osteomas over a 10-year period. To establish a preliminary diagnosis, general clinical and additional diagnostic methods were used, including radiography and computed tomography. The microscopic structure of the postoperative material was examined using histological slides.

Results: It was established that among the 17 patients, there were 10 boys (58.8%) and 7 girls (41.2%), and the highest number of diagnosed cases were observed in the older age group (12 patients (70.6%)). The course of the disease was predominantly asymptomatic; in some cases, complaints were limited to the presence of painless hard protrusions on the vestibular surface of the mandible, which, even when small in size, caused some facial asymmetry. Radiological diagnostic methods enabled the confirmation of the diagnosis. The microscopic structure of the postoperative material fully corresponded to the morphological features of osteomas described in adult patients. The treatment strategy was determined based on the patient's complaints and the clinical symptoms in each individual case.

Conclusions: 1. Osteomas of the maxillofacial region in children are most commonly observed in the older school-age group, with the most frequent localization being the body of the mandible and the area of the paranasal sinuses. Inflammatory processes and trauma against a background of hereditary predisposition are among the provoking factors for their development. 2. The clinical presentation and morphological structure of osteomas in children do not significantly differ from those in adults. The generally accepted treatment approach, namely, dynamic monitoring of small-sized tumors and complete surgical removal in cases of disease progression or the development of deformities is fully justified. 3. Not with standing the advancements in scientific and technological progress and improved diagnostic capabilities, the issues of the etiology, pathogenesis and nosological classification of osteoid osteomas remain debatable and require further in-depth investigation.

KEY WORDS: children, benign tumors, osteoma, osteoid osteoma, maxillofacial region

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INTRODUCTION

Osteomas (OS) are neoplasms composed of mature bone tissue, detected in 2.73% of patients with benign tumors of the maxillofacial region (MFR) and occur 2–3 times more frequently in males. Depending on the type of bone tissue from which the tumor is formed, compact and cancellous (spongy) forms of solid osteomas are distinguished, along with a mixed variant. Many researchers also classify osteoid osteoma (soft osteoma) as a separate type [1–3].

According to statistical data, with a general population prevalence of 1%, osteomas in the jaws and cranial bones are diagnosed in 80–96% of cases in the mandible and sinonasal region, particularly involving the frontal sinuses. In 2–5% of cases, these tumors are located directly in the maxillary sinuses [4–6].

Osteomas can develop at any age; however, the risk of their occurrence is highest in young individuals, particularly during periods of active bone tissue growth. In the maxillofacial region, this is explained by the traumatic-infectious and embryonic theories of origin of OS. According to these theories, such tumors arise either as a result of bone tissue remodeling in response to trauma or inflammation, or due to bone proliferation at the junction of the bones [7–9].

The first mention of an osteoma dates back to 1506 (Viega), while it was Vallisnieri who first described it as a tumor composed of bone tissue in 1733 [10]. Since then, the symptomatology of OS has been studied in considerable detail. In 4–10% of all cases, osteomas of various localizations show no distinct clinical manifestations, and at the early stages, the disease is typically asymptomatic. However, as the tumor grows, with an average growth rate of 0.44–6 mm per year, the clinical symptoms may vary depending on the size of the

Table 1. Localization of MFR osteomas in children

No.	Anatomical areas	Number of cases	
		abs	%
1	Body of the mandible	3	17.7
2	Nasal bones and accessory sinuses	3	17.7
3	Various anatomical areas of the maxilla	2	11.8
4	Frontal bone	2	11.8
5	Alveolar process of the mandible	1	5.8
6	Submental region	1	5.8
7	Other bones of the facial skull	5	29.4
Total		17	100

Source: compiled by the authors of this study

neoplasm and the involvement of adjacent anatomical structures. In the MFR, depending on the osteoma's localization, this may lead to jaw and cranial bone deformities, headaches, dental pain, sinusitis and symptoms of ophthalmologic or neurologic origin [6, 11, 12].

In clinical practice, the diagnosis and differential diagnosis of osteomas usually pose no difficulties, and they are often discovered incidentally during radiological examinations conducted for other reasons [2, 9, 13].

However, despite the awareness among a broad range of healthcare professionals regarding the prevalence and clinical features of this pathology in the MFR, diagnostic errors still occur [5, 14]. Partially, this is exacerbated by the fact that not all clinically and morphologically confirmed cases of osteomas can be explained by the aforementioned theories of their origin.

Therefore, in our opinion, comparing the results of our own observations at this stage of medical development with the generalized literature data on MFR osteomas in children is relevant and serves as an important reminder to the medical community that in pediatric practice, there are no secondary issues.

AIM

To present the findings of our own research regarding the frequency, clinical and morphological characteristics, and treatment strategies for osteomas of the maxillofacial region in children.

MATERIALS AND METHODS

The study is based on the analysis of outpatient records and inpatient medical histories of 17 children who underwent examination and treatment for osteomas over a 10-year period at the clinic of the Department of Pediatric Oral Surgery of Poltava State Medical University, affiliated to CE "City Children's Clinical Dental Polyclinic" and "Children's City Clinical Hospital" of the Poltava City Council.

10 boys (58.8%) and 7 girls (41.2%) have been involved into the study.

To establish a preliminary diagnosis, general clinical and additional diagnostic methods were used, including radiography and computed tomography.

Six children (35.3%) underwent tumor removal in a hospital setting based on indications, while dynamic observation continues for 11 children (64.7%).

The microscopic structure of the postoperative material was studied on 6 histological slides, prepared using standard techniques, which allowed for the final diagnosis to be determined.

To ensure confidentiality and protect patient identity, personal data and any identifying information were excluded from the analysis. These data are standardized and stored in an electronic format with restricted access. The study was conducted in accordance with the principles of the Helsinki Declaration.

RESULTS

The highest number of the 17 diagnosed cases of osteomas occurred in 12 children (70.6%) of the older school-age group (ages 15 to 17). Table 1 shows the distribution of the anatomical areas of localization of the neoplasms, which indicates that they were most commonly found in the mandible and in the nasal area and its accessory sinuses.

When collecting the medical history, it was established that the children's relatives were unaware of the presence of the tumor, as in all cases, the tumor grew very slowly, and they did not pay attention to it. In 5 cases (29.4%), the existence of the osteoma was unknown, and its growth activation was attributed to previous inflammatory processes in the periapical tissues of the tooth, caused by both complicated dental caries and other odontopathologies. In 2 cases (11.8%),

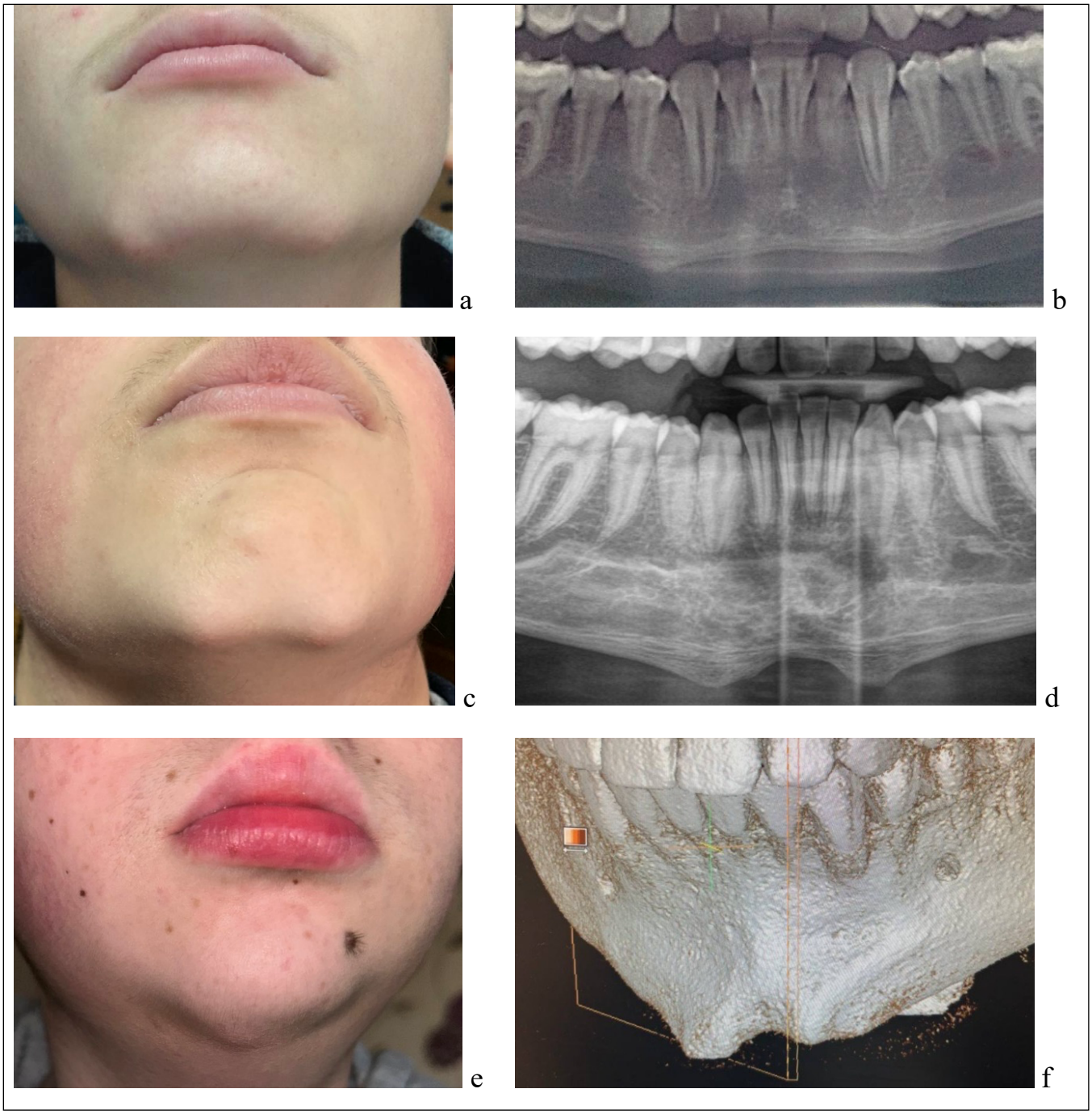

Fig. 1. Overall appearance (a, c, e) and fragments of orthopantomograms (b, f) and computed tomography with 3D visualization (f) of children with "bony spurs." The "extraoral protrusions" in the submental area and the corresponding bone changes in the mandible region are clearly visible
Picture taken by the authors

the growth was believed to have been provoked by traumatic facial injuries. In the remaining 10 patients (58.8%), no provoking cause was identified, and the presence of the tumor in the bone tissue of various anatomical areas was discovered during radiological examinations, which were most often conducted for orthodontic purposes.

The parents of 4 children (23.5%) reported a history of this pathology in family members.

In 3 cases (17.7%), the complaints were limited to the presence of painless hard protrusions on the vestibular surface of the mandible. Even with small sizes, these protrusions caused some facial asymmetry.

We also classified 4 cases (23.5%) as "bony spurs" (Fig. 1), although some researchers consider the classification of these as osteomas to be debatable [13-15].

In all cases, one of the types of radiological examination was used; however, the most commonly

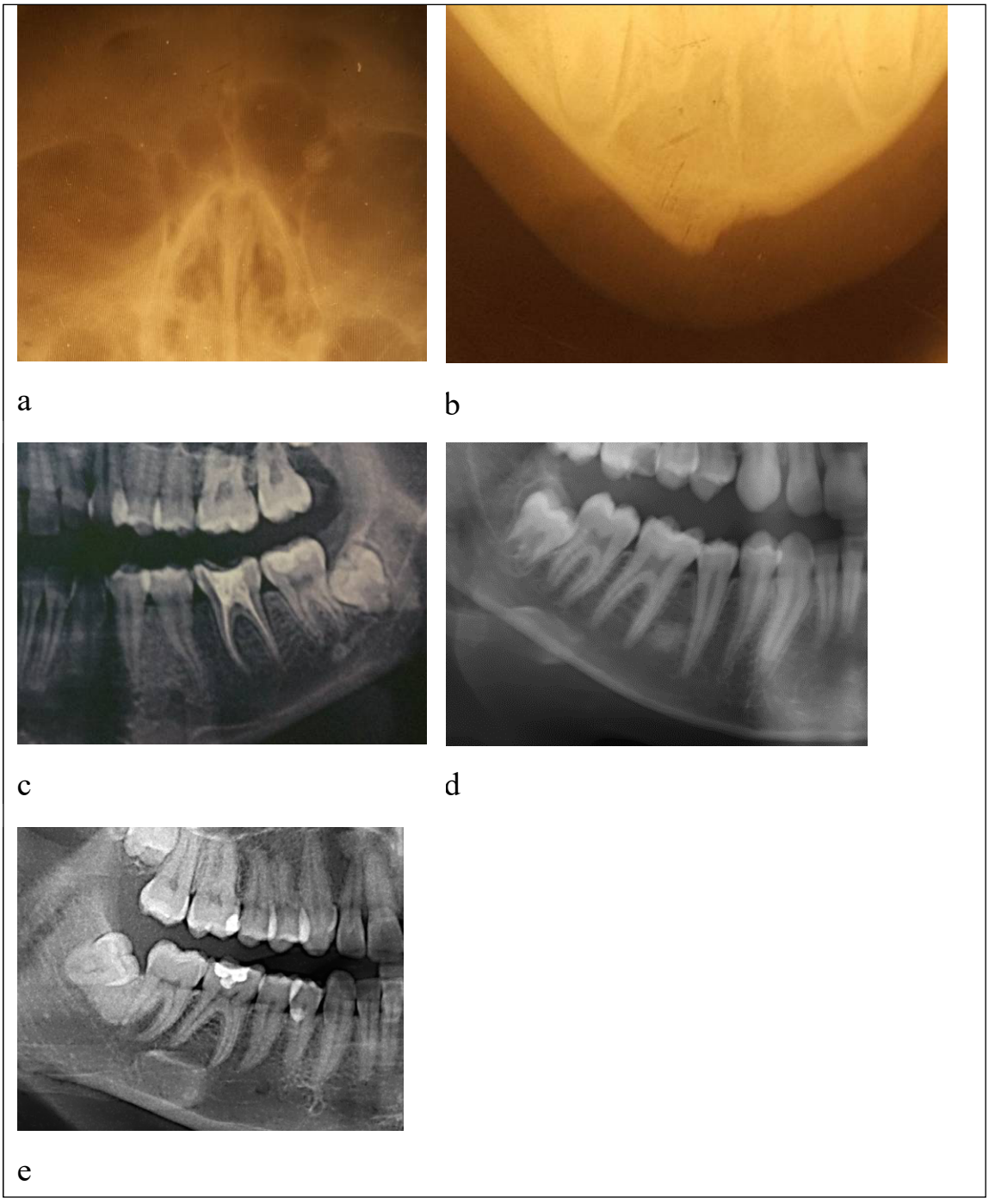

Fig. 2. Radiological images of osteomas (in the area of the medial wall of the orbit and the frontal sinus on the left (a); in the submental region (b); in the body of the mandible in the area of tooth 37 (c); in the body of the mandible in the area of teeth 45 and 46 (d); in the body of the mandible in the area of tooth 48 (e), which fully correspond to the description presented in the text
Picture taken by the authors

employed were orthopantomography and computed tomography. These methods revealed a homogeneous mass with clear borders, significantly denser than the adjacent bone tissue. A distinct "plus-tissue" symptom was typically observed. This radiological picture is characteristic of solid compact osteomas (Fig. 2).

No radiological signs of cancellous osteomas were observed.

We observed 2 cases of asymptomatic course of osteoid osteomas (soft osteomas), which were radiologically identified as a defined zone of radiolucency at the periphery with increased radiolucency in the central part of the tumor (Fig. 3), and the diagnosis was confirmed morphologically.

Based on the recommendations of the researchers [1, 4, 5-7, 15-19], the differential diagnosis of oste-

Fig. 3. Radiological image of an osteoid osteoma of the maxilla in the area of teeth 25 and 26. The mass shows a "layered cake" pattern
Picture taken by the authors

omas was carried out with other benign processes that localize in bone tissue and have similar clinical symptoms (osteoblastoclastoma, solid ameloblastoma, bone dysplasias, osteophytes, exostoses, chronic periostitis, etc.).

11 children (64.7%), in whom the asymptomatic course of the disease was not accompanied by functional disorders or cosmetic defects, underwent dynamic observation.

In another 6 patients (35.3%), radical surgical removal of the tumor was performed under general anesthesia in a hospital setting (Fig. 4).

No complications were observed during the surgical intervention or in the postoperative period. The wounds healed with primary tension.

The postoperative material was sent for histological examination, which revealed that microscopically, solid compact osteomas differed from normal compact bone by disrupted architecture and narrow vascular channels (Fig. 5).

The morphological signs of cancellous osteomas were not observed in any case, but according to researchers, they consist of spongy, porous bone tissue [20], which should be noted, as they can behave differently prognostically [14].

Osteoid osteomas macroscopically appeared as soft tissue mass of red color with a zone of ossification in the center and surrounding sclerotic white tissue, and microscopically (Fig. 6) they consisted of osseous substance characterized by large bone marrow cavities, which aligns with the description of their histological structure in the publications [20].

DISCUSSION

The analysis of the presented findings shows that, similar to other researchers, we consider the mandible as the "preferred" localization of osteomas. However, the literature sources report numerous cases of osteomas located on the inner wall of the maxillary sinus, in the nasal cavity, and even within the parotid salivary gland [5, 10, 12].

The findings of the study also confirm the researchers' opinion that the provoking factors for the growth of osteomas include traumatic injuries, inflammatory processes, hypothermia and the impact of infectious agents against the background of genetic predisposition. The likely sources of their development are remnants of embryonic cartilage or the periosteum of mature bone [1, 2, 4, 21, 22].

Taking into account the research data on the size variations of osteomas ranging from 2 to 30 mm, their predominant localization along the bony edge, and the absence of malignancy and metastasis (we did not find the description of any cases) [10, 12, 17], summarizing the findings of our own studies and material presented in other scientific sources, we can distinguish a general symptom complex characteristic of these tumors when located directly in the MFR:

- localization on the surface of the jaw and skull bones and in the walls of the nasal sinuses;
- density and immobility;
- density and smooth surface with clear borders;
- painlessness upon palpation.

Considering the asymptomatic course of the disease observed in our patients, it should not be forgotten that publications report complaints of patients caused by the anatomical localization and size of osteomas, as well as the specifics of the clinical situation. For example, osteomas developing within the body of the mandible can cause neuralgia of the inferior alveolar nerve and asymmetry of the lower half of the face; those localized on the coronoid process may gradually restrict movement of the mandible; and those growing into the nasal cavity can lead to breathing difficulties. Tumors that grow into the maxillary sinus typically manifest later, gradually filling and taking its anatomical shape. In such cases, the tumor is often detected incidentally during radiological examination of the nasal or maxillary sinuses due to the gradual onset of facial asymmetry or development of lower jaw contracture caused by deformation and outward displacement of the upper jaw ridge. Additionally, large tumors can also cause displacement of the eyeball [1, 4, 7, 8, 11].

The primary diagnostic method for osteomas, as in our study, is undoubtedly radiography. It is considered that for very small OS, conventional radiological

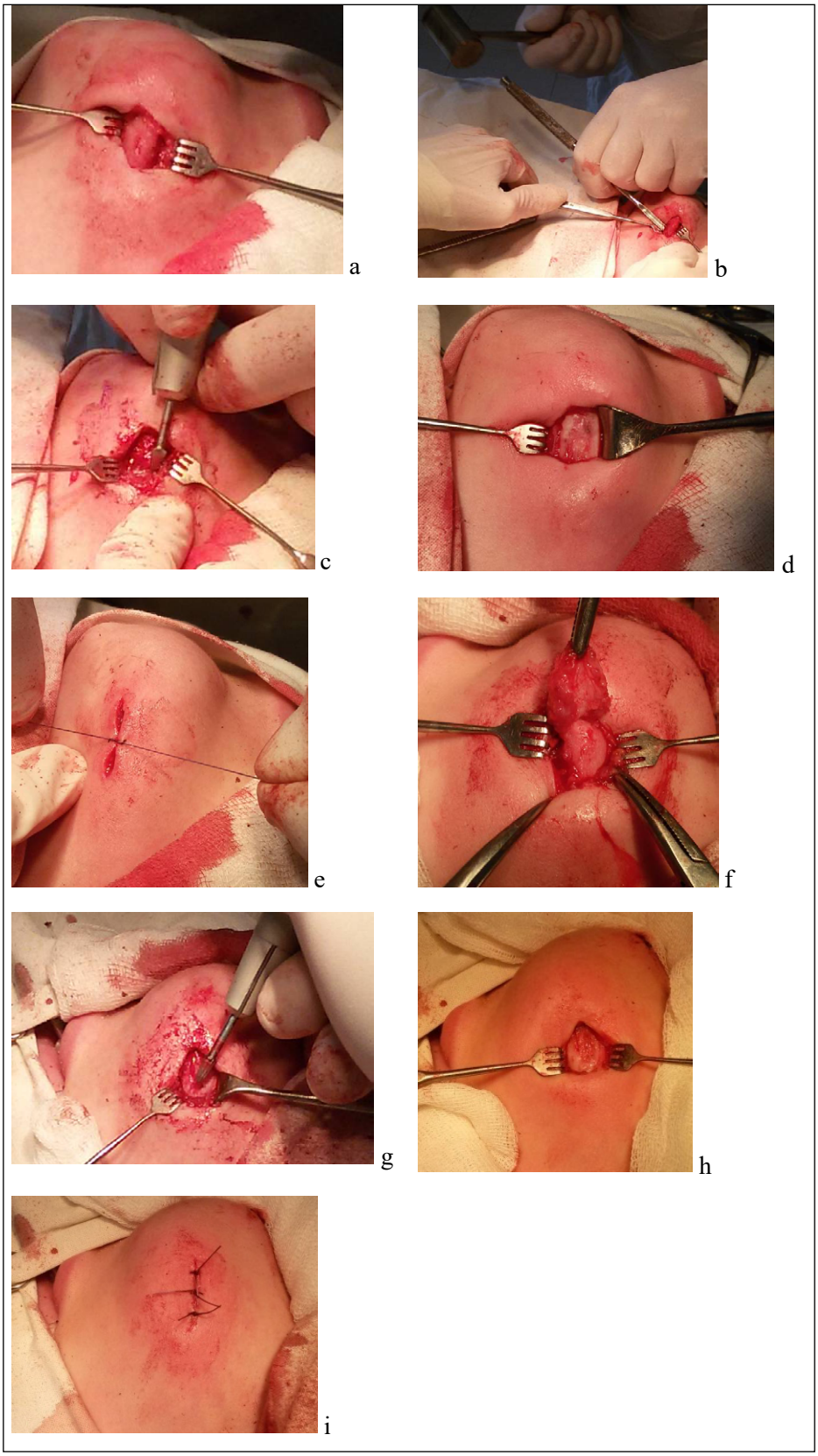

Fig. 4. Stages of surgical treatment of a patient with "bony spurs," presented in Fig. 1a, b. The surgical intervention was performed simultaneously and step-by-step from the left (a-e) and right (f-i) sides
Picture taken by the authors

examination is of limited informative value, which is why, to clarify certain parameters, the cutting edge high-information techniques such as computed tomography should be more widely used. This method allows for visualizing even the smallest details of the tumor structure and determining the extent of bone tissue destruction [6, 13].

A debatable issue remains the classification of osteoid-osteoma as an osteoma, which occurs in only 0.5% of patients with tumors, more commonly in individuals

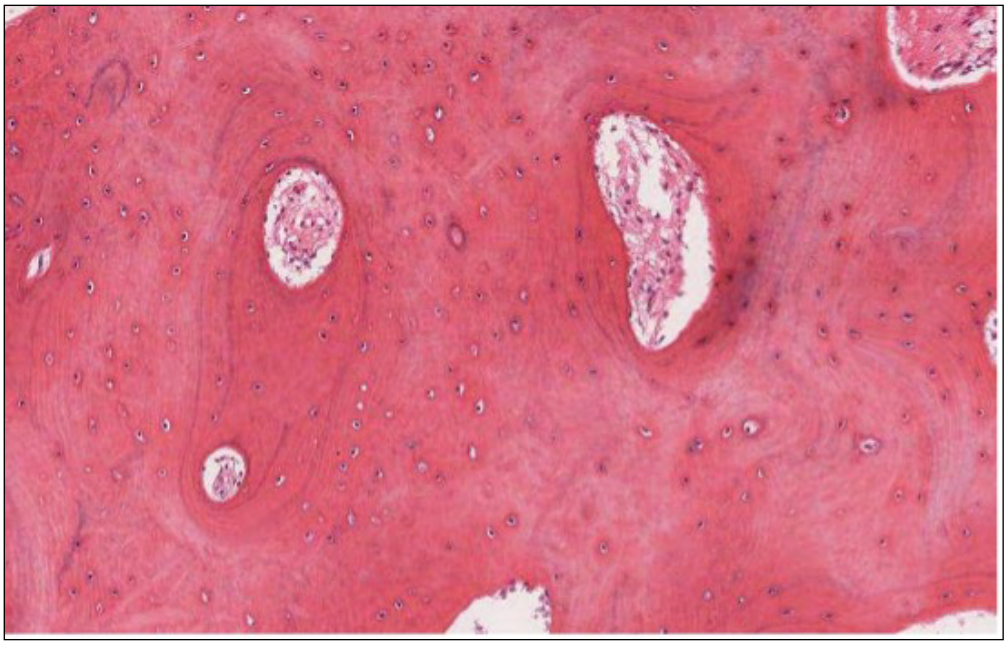

Fig. 5. Microscopic structure of compact osteoma. H&E stain. Objective lens: 10×magnification; Ocular lens: 7×magnification. Disruption of bone tissue structure is observed
Picture taken by the authors

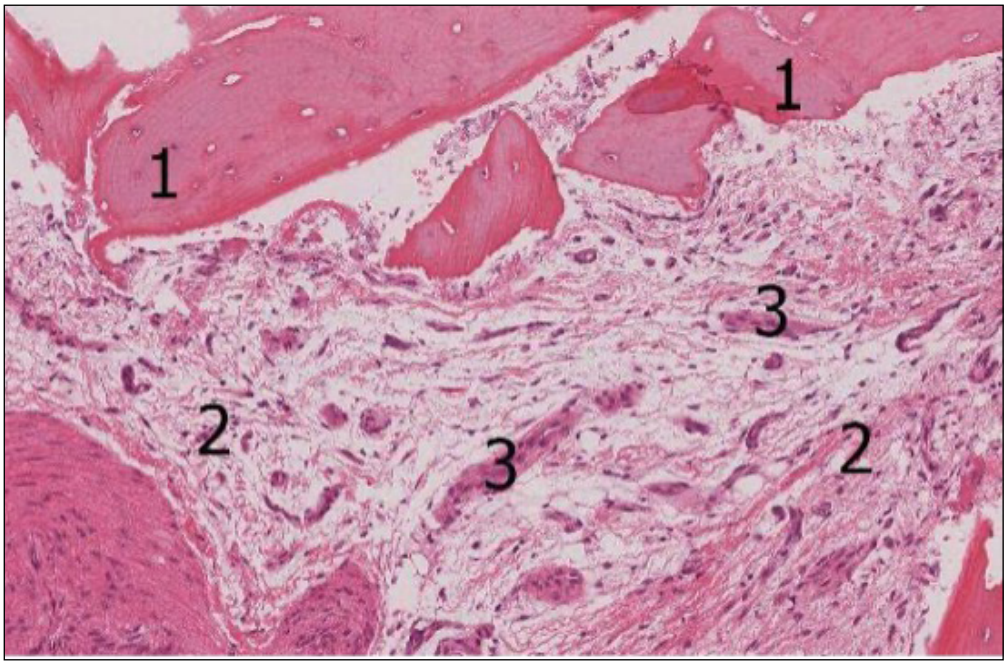

Fig. 6. Microscopic structure of osteoid osteoma. H&E stain. Objective lens: 10×magnification; Ocular lens: 7×magnification
1 – bone trabeculae;
2 – fibrous (osteogenic) tissue;
3 – blood microvessels
Picture taken by the authors

aged 20-30 years (with isolated cases reported in children). It typically localizes in the spongy or compact bone tissue or subperiosteally, with variable sizes ranging from 5 to 20 mm in diameter [5, 8].

Some researchers argue that osteoid-osteoma should not be classified as a true tumor but rather as a manifestation of reactive inflammation. They support this view with the clinical feature of osteoid-osteoma, which involves aching pain that periodically intensifies, especially at night, and is relieved by aspirin, as well as its radiological characteristics mentioned earlier [9, 14].

However, we believe that this issue requires further in-depth study, considering that in our two observations (a number that is certainly insufficient to draw any significant conclusions), the asymptomatic course of the disease in morphologically confirmed cases of osteoid-osteoma did not significantly differ from that in diagnosed cases of hard osteomas.

The treatment strategy applied to our patients fully aligns with the opinion of most other researchers, who suggest that in the case of small, asymptomatic osteomas, a wait-and-see approach should be adopted, with periodic monitoring of the tumor's condition. The only definitive treatment for osteomas remains their surgical removal, with follow-up care to prevent both general and local complications [23-28].

Relapses of tumors occurs rarely, with a relatively long development period, averaging 5-8 years, and is usually associated with incomplete removal of the tumor. In most cases, this concerns osteoid-osteoma, which

makes careful scraping of the tumor quite important [2, 6, 8, 9, 14].

Available literature sources do not provide data on the long-term outcomes of osteoma treatment, not only in children but also in adults. Therefore, we plan to continue long-term monitoring of the results of surgical interventions for the removal of these tumors, paying attention to patient age, the anatomical location of the formation, surgical access, as well as the extent and technique of surgical intervention.

CONCLUSIONS

1. Osteomas of the maxillofacial region in children are most commonly observed in the older school-age group, with the most frequent localization being the body of the mandible and the area of the paranasal sinuses. Inflammatory processes and trauma against a background of hereditary predisposition are among the provoking factors for their development.
2. The clinical presentation and morphological structure of osteomas in children do not significantly differ from those in adults. The generally accepted treatment approach, namely, dynamic monitoring of small-sized tumors and complete surgical removal in cases of disease progression or the development of deformities is fully justified.
3. Not with standing the advancements in scientific and technological progress and improved diagnostic capabilities, the issues of the etiology, pathogenesis and nosological classification of osteoid osteomas remain debatable and require further in-depth investigation.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval of the article

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ORIGINAL ARTICLE

CONTENTS

Peculiarities of ultrastructural remodeling of the respiratory portion of rat lungs caused by consumption of complex of food additives

Kostiantyn V. Shevchenko, Galina A. Yeroshenko, Ilona M. Donets, Alona S. Grygorenko, Angela V. Vatsenko, Natalia A. Ulanovska-Tsyba, Serhii V. Kononenko
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ABSTRACT

Aim: The aim of the study was to investigate the ultrastructural changes in the components of the respiratory portion of the lungs in rats under normal conditions and under the impact of the complex of food additives: monosodium glutamate, sodium nitrite and Ponceau 4R.

Materials and Methods: Rats in the experimental group were administered 0.6 mg/kg of sodium nitrite, 20 mg/kg of monosodium glutamate, and 5 mg/kg of Ponceau 4R in 0.5 ml of distilled water once daily orally. The animals were removed from the experiment after 1, 4, 8, 12 and 16 weeks. An electron microscopic examination was performed.

Results: The respiratory portion of the rat lungs has a typical structure and can be extrapolated to the human body. At the early stages, vasospasm of the capacitance vessels was observed, accompanied by erythrocyte stasis, which led to the initial impairment of blood perfusion through the vessels. This was reflected in the condition of the interalveolar connective tissue and manifested as edema. Destructive and dystrophic changes were observed in the alveolar type II cells, leading to a disruption of the normal surfactant structure, as well as destructive changes in alveolar type I cells and the hemocapillary wall. Additionally, signs of activation of the humoral branch of the immune system were noted, evidenced by the presence of actively phagocytizing alveolar macrophages.

Conclusions: The consumption of the complex of food additives leads to destructive-dystrophic changes in the structural components of the lungs in rats and reorganization of the components of the intercellular substance.

KEY WORDS: food additives, monosodium glutamate, sodium nitrite, Ponceau 4R, lungs, rats

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INTRODUCTION

Experimental modeling of various diseases in animals is one of the primary methods for studying the patterns of pathological processes that frequently occur in clinical practice. For an objective comparative evaluation of experimental data and their subsequent extrapolation to humans, it is important to know the key structural features of organs and tissues in the normal state [1].

Recent scientific studies explore the features of changes in the macro- and microelement composition of the lungs in young rats under the impact of various exogenous factors [2, 3]. However, the issue of the impact of food additives on the structure and function of the respiratory system organs, specifically the respiratory portion of the lungs, remains unresolved and requires further research, especially under conditions of their combined action.

Given the unprecedented scale of food additive use today, the relevance of studying their impact on the body is unquestionable. Our analysis of food additives in products from both domestic and foreign manufacturers revealed that monosodium glutamate, sodium nitrite and the synthetic dye Ponceau 4R are the most commonly used additives by producers

Preclinical studies by domestic and foreign researchers have linked the intake of monosodium glutamate to cardiotoxicity, hepatotoxicity, neurotoxicity, low-grade inflammation, metabolic disorders, precancerous conditions and behavioral changes. Furthermore, reports have suggested a connection between the consumption of monosodium glutamate and tumor processes, as well as increased oxidative stress. Therefore, it was concluded that further clinical and epidemiological research is needed. A critical review of the existing literature indicates that many of the negative reports on the health effects of monosodium glutamate are poorly informative, as they are based on excessive doses that do not correspond to the standard levels typically used in food products [4].

A number of studies on experimental animals investigate the impact of sodium nitrite on the development of

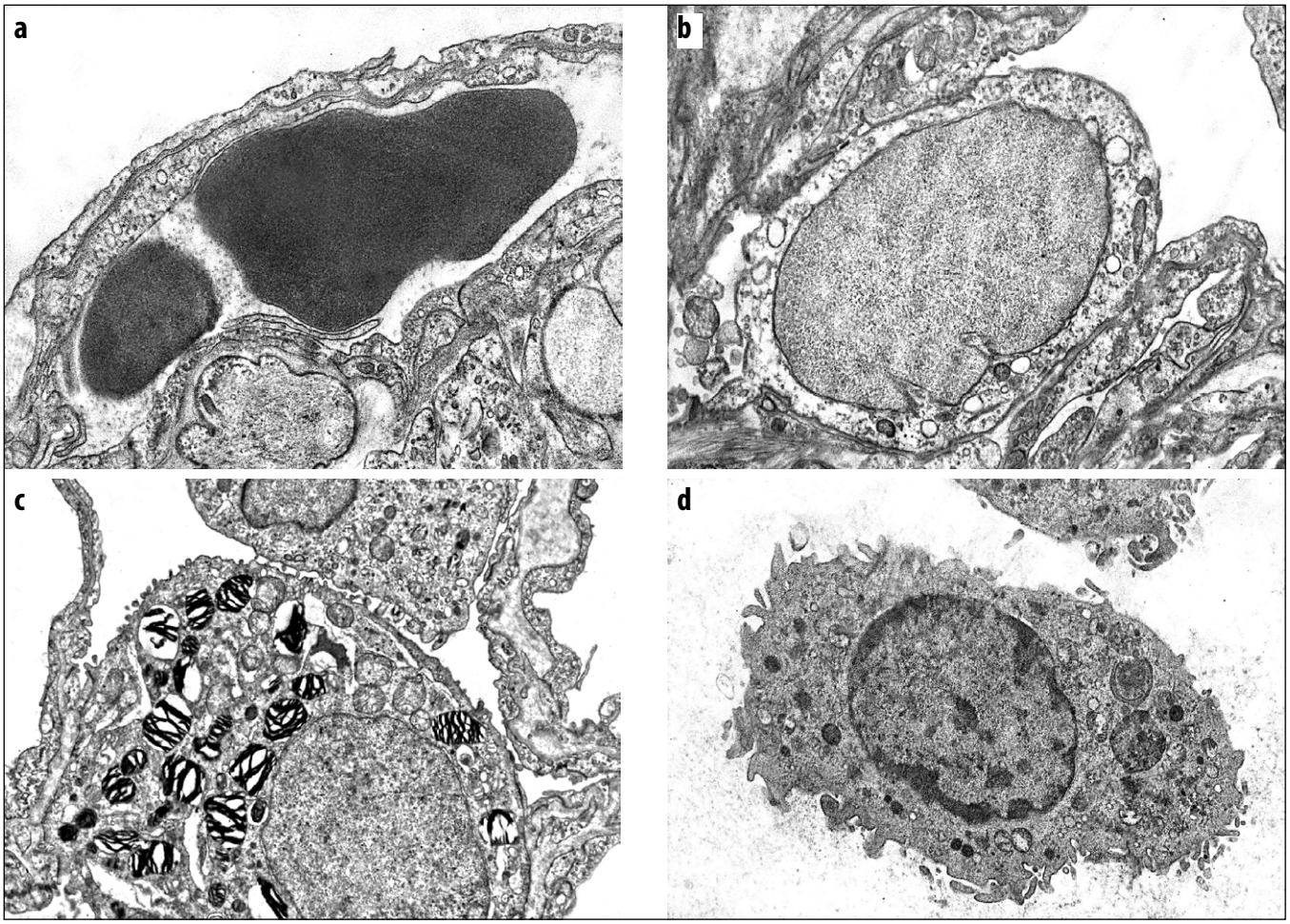

Fig. 1: a). Capillary as part of the air-blood barrier; b). Alveolar Type I cell; c). Alveolar Type II cell. d). Intra-alveolar macrophage of rats from the control group. Electron micrograph. Magnification ×8000
Picture taken by the authors

pulmonary hypertension induced by monocrotaline [5], as well as how the nebulization of acidified sodium nitrite reduces acute hypoxic pulmonary vasoconstriction [6].

Studies on the effects of food colorants have described numerous allergic reactions to food additives, such as urticaria, Quincke's edema, rhinitis, bronchitis and bronchial asthma [7-10]. Therefore, a thorough evaluation of the effects of azo dyes is needed.

AIM

The aim of the study was to investigate the ultrastructural changes in the components of the respiratory portion of the lungs in rats under normal conditions and under the impact of the complex of food additives: monosodium glutamate, sodium nitrite and Ponceau 4R.

MATERIALS AND METHODS

The study involved 84 sexually mature male rats. The animals in the control group received drinking water and were orally administered a physiological saline solution. The rats in the experimental group, with free access to water, were administered 0.6 mg/kg of sodium nitrite, 20 mg/kg of monosodium glutamate, and 5 mg/kg of Ponceau 4R in 0.5 ml of distilled water once daily. The doses of food additives were half of the maximum allowable norm. The adaptive behavior of the rats was assessed using the open field test [11].

The animals were euthanized by overdose of thiopental anesthesia at 1, 4, 8, 12, and 16 weeks. After euthanasia, fragments of the rats' lungs were fixed in 2.5% glutaraldehyde solution. Subsequently, lung tissue samples were embedded in Epon-812 using a conventional technique [12]. Electron microscopy studies were carried out at the electron microscopy laboratory of the Institute of Morphology at I. Horbachevsky Ternopil National Medical University, Ministry of Health of Ukraine. Ultrathin sections were prepared using the ultramicrotome LKB-3 (Sweden). The sections were contrasted first in a 1% uranyl acetate solution in methanol, and then with lead citrate according to Reynolds [13]. The

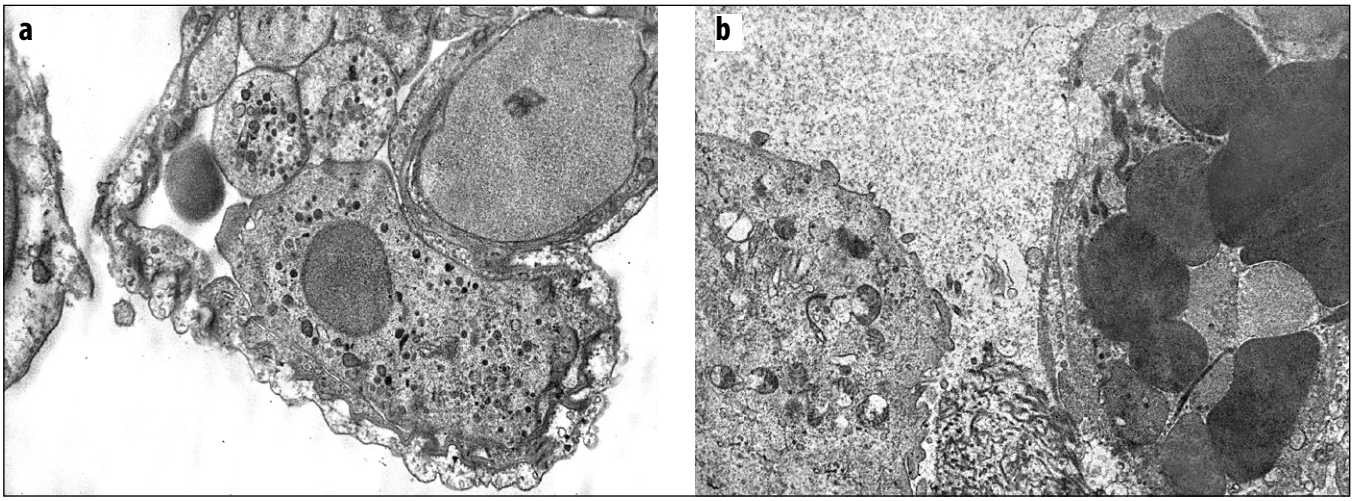

Fig. 2: a). Alveolar Type I cell; b). Stasis of erythrocytes in the venules of the respiratory portion of the lungs on week 1 of the experimental consumption of monosodium glutamate, sodium nitrite and Ponceau 4R. Electron micrograph. Magnification ×8000
Picture taken by the authors

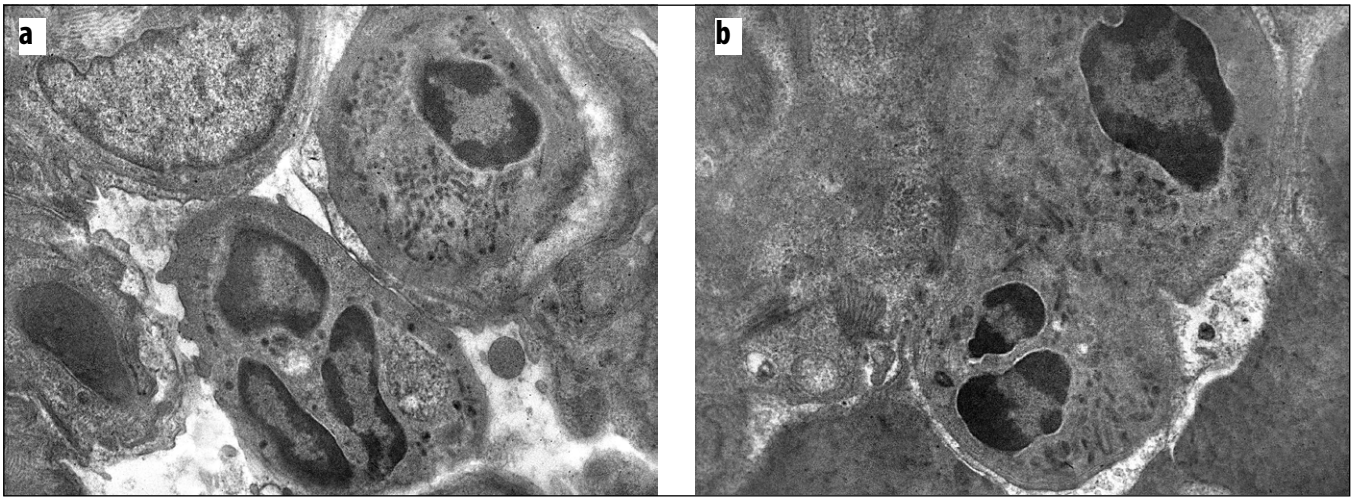

Fig. 3: a) Migration of neutrophils and macrophages through the vascular endothelium on week 4 of the experiment. Electron micrograph. Magnification ×8000. b) Migration of neutrophils and macrophages through the vascular endothelium on week 4 of the experiment. Electron micrograph. Magnification ×8000
Picture taken by the authors

specimens were analyzed under an electron microscope PEM-125 K (serial number 38-76, TU 25-07-871-70) at an accelerating voltage of 50-75 kW.

All animal experiments were carried out in compliance with the requirements of the European Convention for the Protection of Vertebrate Animals used for Experimental and Scientific Purposes (Strasbourg, 1986), in accordance with the rules for keeping experimental animals established by European Parliament and Council Directive (2010/63/EU) and the Order №134 of the Ministry of Education and Science, Youth and Sports of Ukraine as of 01.03.2012, No. 249 "On approval of the procedure for conducting tests, experiments on animals by research institutions", as well as the recommendations of the First National Congress of Ukraine on Bioethics (2001).

RESULTS

The study of the electron-microscopic structure of the respiratory portion of the lungs revealed that the alveolar walls of rats in the control group were formed by the alveolar type I and II cells, a basal membrane and endothelial cells of somatic-type capillaries. The peripheral part of the endothelial cells tightly adheres to the basal membrane, and the cytoplasm contains a large number of pinocytic vesicles. The nuclei of the endothelial cells have clear contours, and their internal content is almost homogeneous, represented by euchromatin. Erythrocytes are freely located in the lumen of the vessels. This arrangement of structures in the air-blood barrier ensures more efficient gas diffusion between the alveolar lumen and the blood vessels.

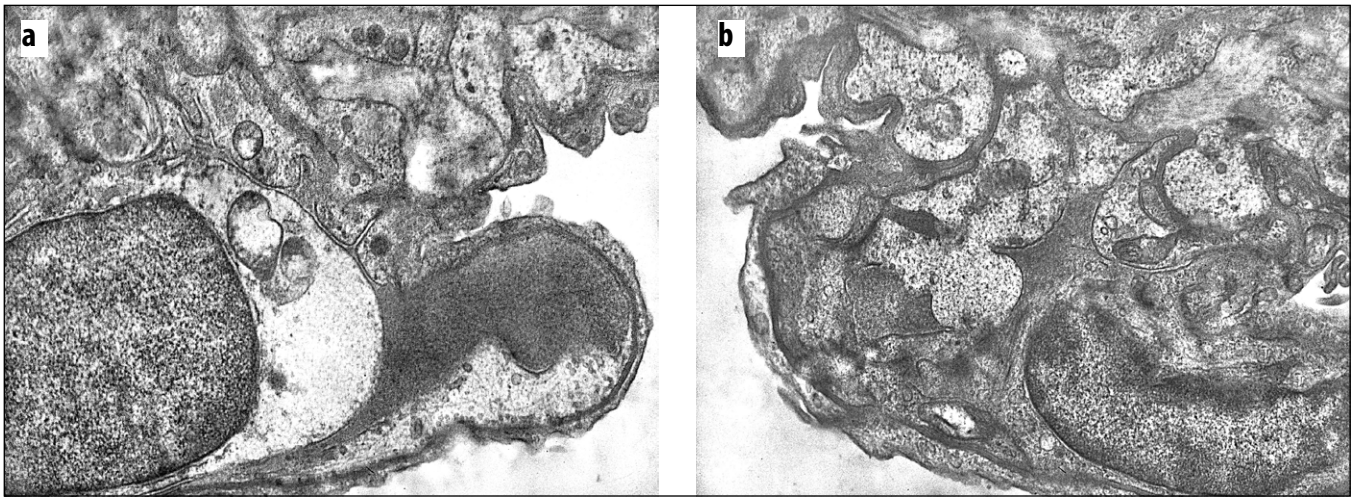

Fig. 4: a). Protrusion of the nucleus-containing part of capillary endothelial cells; b). Edema of the interalveolar interstitial tissue on week 4 under the impact of the complex of food additives. Electron micrograph. Magnification ×8000
Picture taken by the authors

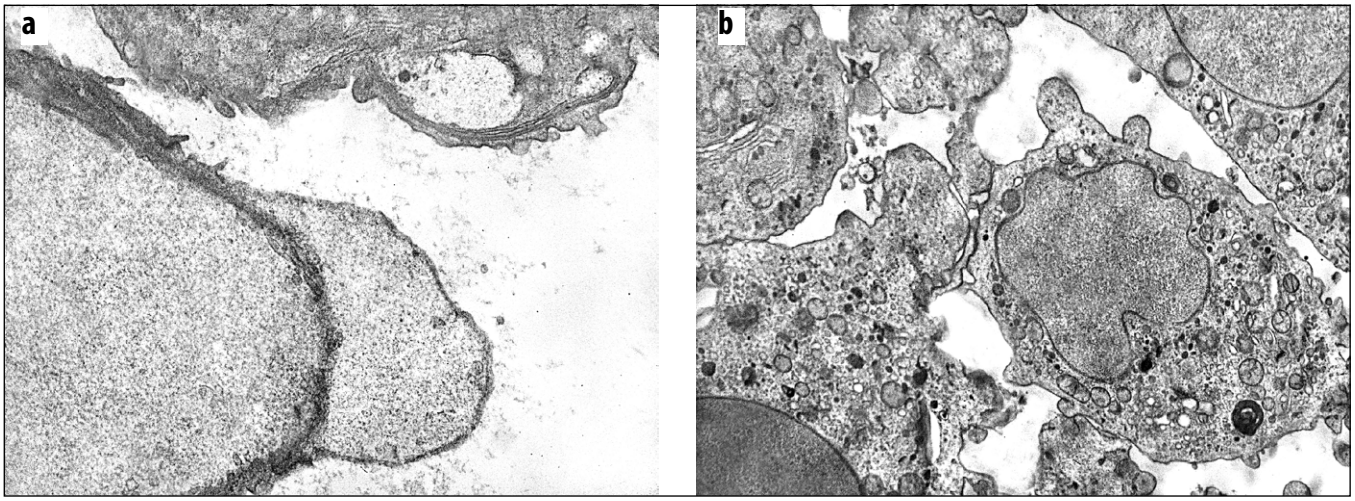

Fig. 5: a). Vacuolization of the cytoplasm in alveolar type II cells; b). Deformation of lamellar body membranes in alveolar type II cells on week 8 of the experiment. Electron micrograph. Magnification ×10000
Picture taken by the authors

Alveolar type I cells, which cover a large surface area of the alveolar wall, are involved in the formation of the air-blood barrier. They have a central region containing the nucleus and a peripheral region that is elongated and occupies a significant portion of the respiratory area of the alveolar cell, extending along the basal membrane. The cytoplasm of the peripheral part showed almost no organelles but contained a large number of pinocytic vesicles. Alveolar type II cells were located on the basal membrane, in such a way that they made contact with adjacent alveoli. On the apical surface, microvilli were present. The nucleus had an eccentric position, and the cytoplasm contained a large number of mitochondria, well-developed endoplasmic reticulum, and Golgi complex. Lamellar bodies, which exhibited osmiophilic properties, were found throughout the cytoplasm. Intra-alveolar macrophages of the control group of rats had varying shapes, from elongated to more rounded. The cytolemma was heterogenous due to the formation of various folds and invaginations, and the surface contained microvilli. The cytoplasm contained a large number of lysosomes with osmiophilic properties. The nucleus was centrally located, with euchromatin predominating in its composition (Fig. 1a, Fig. 1b, Fig. 1c, Fig. 1d).

After one week of consumption of the food additive complex, the nuclei of alveolar type I cells acquired an irregular shape, with invaginations present. Among the electron-dense euchromatin, dense areas of heterochromatin appeared. In the cytoplasm of the nuclear-containing portion, areas of transparency and darkening were observed. In the peripheral regions of alveolar type I cells, an increased number of pinocytic

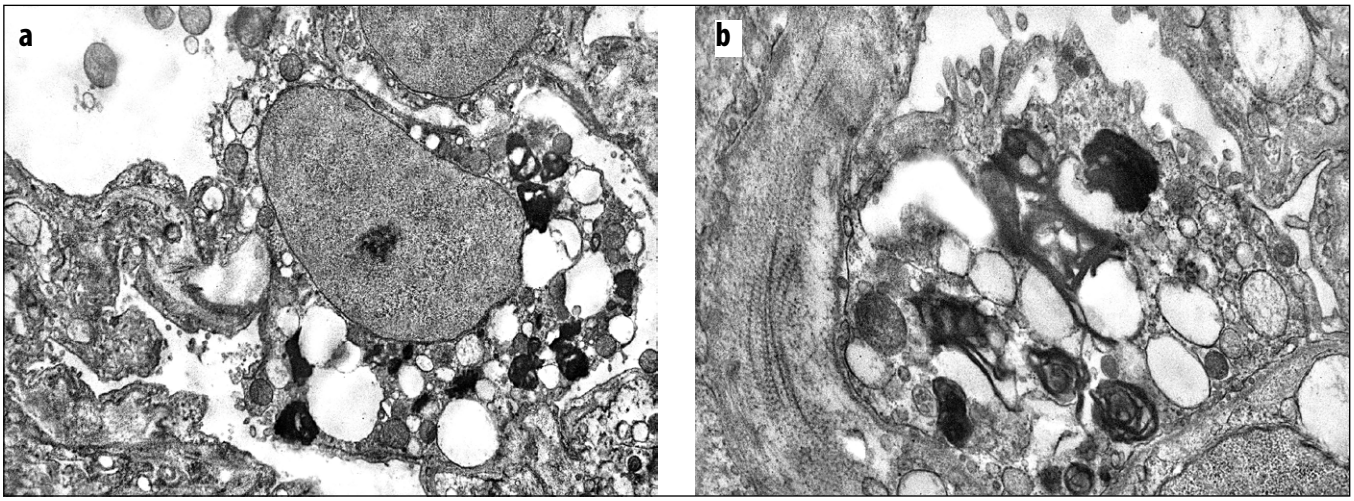

Fig. 6: a) Dilation of the capillary lumen in the alveoli of rat lungs; b). Phenomenon of vessel emptiness in the capacitance segment of the respiratory portion of the lungs in rats of the experimental group on week 12. Electron micrograph. Magnification ×8000
Picture taken by the authors

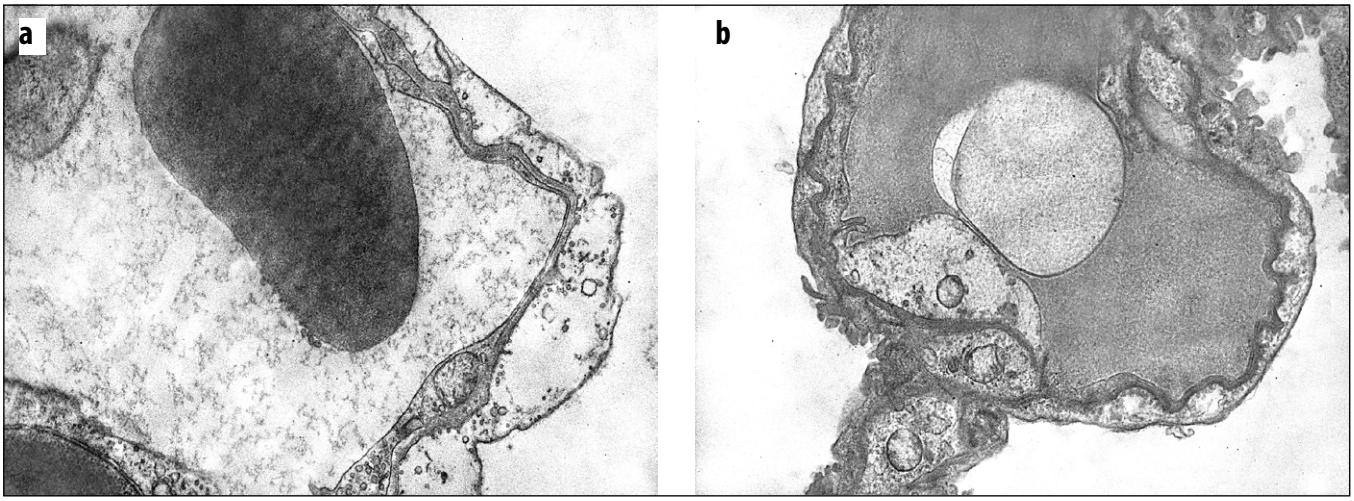

Fig. 7: a). Protrusion of the cytoplasmic portion of the alveolar type I cell into the alveolar lumen; b). Activation of macrophages on week 12 of consumption of monosodium glutamate, sodium nitrite, and Ponceau 4R. Electron micrograph. Magnification ×10000
Picture taken by the authors

vesicles was detected. The basal membrane mostly retained its normal structure, but focal thickening with indistinct contours and uneven course was noted. In the alveolar lumen, a significant increase in the number of intra-alveolar macrophages was observed, with cytoplasm containing a large number of osmiophilic primary lysosomes and a small number of secondary lysosomes. In the alveolar type II cells, a decrease in the number of lamellar bodies, which were in the process of degranulation, was noted, exhibiting signs of reduced osmiophilic properties. These bodies were of irregular shape with signs of local degeneration. A decrease in the number of microvilli on the plasmalemma and the appearance of numerous protrusions and invaginations were observed. A picture of vascular spasms in the capacitance vessels with erythrocyte stasis inside the vessels was evident. Collagen fibers in the adventitial layer of venules had a wavy shape (Fig. 2a, Fig. 2b).

By the 4th week of consumption of the chemical compound complex, folding and migration of leukocytes occurred in the vessels of the interalveolar interstitial tissue, with a predominance of neutrophils and macrophages. The connective tissue of the interalveolar septa showed signs of edema, with a large number of migratory cells whose cytoplasm was filled with granules of varying shape, size and electron density. A large number of primary lysosomes exhibited osmiophilic properties. In the segmented nuclei of neutrophils, euchromatin predominated, while the nuclei of macrophages had an oval shape, mostly with uneven edges, and their internal content was also filled with euchromatin (Fig. 3a, Fig. 3b).

Due to the increasing edema, the shape of alveolar

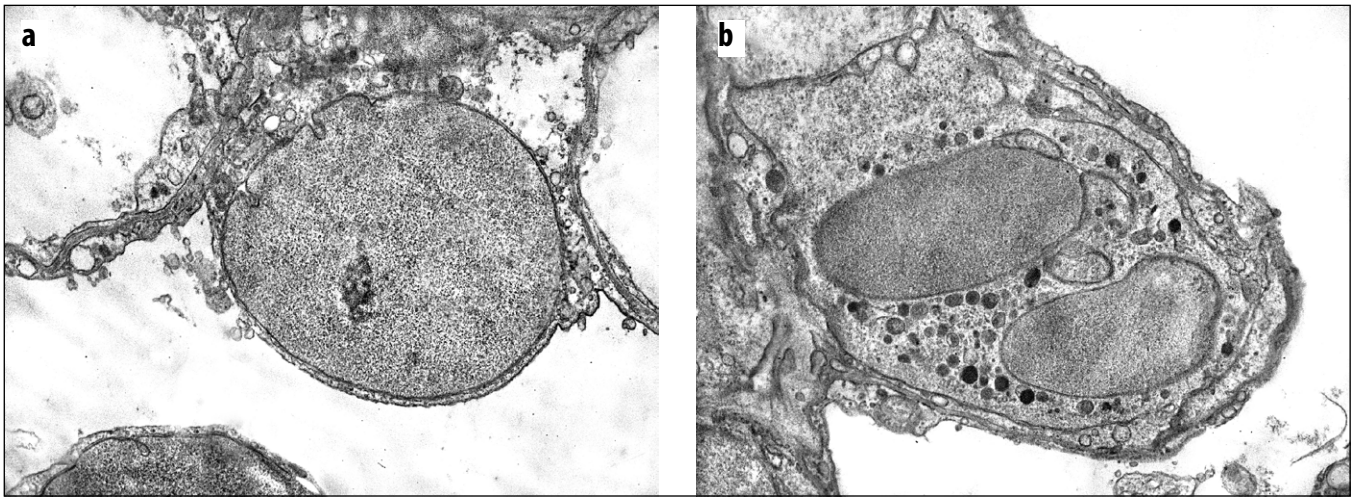

Fig. 8: a). Destructive phenomena in alveolar type I cells; b). Migration of eosinophils into the alveolar lumen on week 16 of consumption of monosodium glutamate, sodium nitrite and Ponceau 4R. Electron micrograph. Magnification ×10000
Picture taken by the authors

type I cells changed. The nuclei were hypertrophied, predominantly filled with heterochromatin. The cytoplasm contained a small number of organelles and pinocytic vesicles, appeared swollen, and translucent. The nuclear-containing portion of the endothelial cells of the capillaries in the aerogematic barrier was bulging. The basal membrane contained areas of thinning and thickening. The interstitial tissue showed signs of intensified edema. Locally, areas of electron-transparent material were identified, filling the gaps between cells in the interstitium and forming conglomerates. The aerogematic barrier thickened, with the basal membrane showing uneven thickness and indistinct edges on the interstitial side. The nuclei of endothelial cells were elongated and contained a moderate amount of euchromatin (Fig. 4a, Fig. 4b).

By the 8th week of consuming the complex of monosodium glutamate, sodium nitrite, and Ponceau 4R, changes were observed in the cytoplasm of alveolar type II cells, manifested by the appearance of numerous vacuoles and cavities containing remnants of lamellar material. The vacuoles varied in diameter, predominantly oval, and sometimes polygonal in shape, with differing electron density. The number of lamellar bodies was reduced, with some being deformed and partially filled with phospholipid material, exhibiting disoriented and deformed membranes, indicating a stage of destruction. The apical surface of secretory alveolar cells contained a small number of microvilli. The interstitial tissue showed a reduction in the intensity of edema (Fig. 5a and Fig. 5b).

By the 12th week of the experiment, in the blood vessels of the microcirculation, there was noticeable dilation of the capillary lumen, which was predominantly filled with blood plasma showing signs of low electron density. Sporadic erythrocytes were freely present within the lumen. The cytoplasm of endothelial cells was moderately edematous and contained a small number of pinocytotic vesicles. Similar changes were observed in the peripheral regions of the cytoplasm of respiratory alveolar cells, which were filled with electron-lucent substance. The basal membrane displayed an irregular profile with areas of local thickening and thinning. The venules exhibited signs of collapse, with regions of emptiness interspersed with substance of low electron density. Blood cellular elements were absent (Fig. 6a, Fig. 6b).

By the 12th week of the experiment, alveolar type I cells exhibited mild destruction of their structural components. Their cytoplasm appeared homogeneous and filled with an electron-lucent, almost transparent substance, indicating intracellular edema. This led to a noticeable bulging of cytoplasmic segments of the respiratory alveolar cells into the alveolar lumen. The cytoplasm of the secretory (type II) alveolar cells was heterogeneous, and their apical surfaces showed a near-total absence of microvilli. At this stage, an increased number of alveolar macrophages was observed, suggesting enhanced functional activity. Their surfaces were covered with numerous cytoplasmic projections. The nuclei were irregularly shaped with multiple invaginations, and euchromatin predominated within. The cytoplasm contained osmiophilic primary lysosomes as well as secondary ones. The matrix of small, variably shaped mitochondria exhibited moderate electron density. Cisternae of the rough endoplasmic reticulum were shortened and thickened, containing a moderate number of ribosomes (Fig. 7a, Fig. 7b).

At the 16th week of pollutant consumption, elec-

tron microscopy revealed alveoli with both collapsed lumens and emphysematously expanded ones. The peripheral regions of alveolar type I cells were locally edematous, showed destructive changes, and contained a small number of damaged organelles. A large number of eosinophils were observed in the alveolar lumen, characterized by increased functional activity. The nuclei were predominantly filled with euchromatin. The cytoplasm contained numerous osmiophilic primary lysosomes and specific granules (Fig. 8a, Fig. 8b).

DISCUSSION

Thus, electron microscopy of the respiratory apparatus of the lungs in rats from the control group revealed that the alveolar wall was composed of alveolar type I and type II cells, a basal membrane, and somatic-type capillary endothelial cells. Type I alveolar cells possessed a nucleus-containing region and a thin cytoplasmic extension that spread as a delicate layer along the basal membrane, facilitating efficient gas exchange. The cytoplasm contained a small number of organelles and numerous pinocytic vesicles. The cytoplasm of alveolar type II cells was rich in synthetic organelles and mitochondria. A large number of lamellar bodies and a well-developed Golgi complex indicated active surfactant synthesis. The apical surface of alveolar type II cells was covered with numerous microvilli. In the alveolar lumen, solitary macrophages were noted, containing osmiophilic primary lysosomes in their cytoplasm. Therefore, the respiratory portion of rat lungs has a typical structure and can be extrapolated to the human body.

At the 1st week of the experiment, disturbances were observed in the blood vessels of the microcirculation [14], particularly in the capacitance section, which manifested as vascular spasm with erythrocyte stasis inside the vessels. This led to initial perfusion disorders in the vascular system and was reflected in the condition of the interalveolar connective tissue throughout the experiment, becoming evident by week 4 as interstitial edema and disorganization of stromal components. Local areas of electron-lucent substance were detected, filling the intercellular spaces and forming conglomerates. Thickening of the air-blood barrier was detected, with the basal membrane being uneven, widened, and having blurred edges. Previous studies [15] on the state of diffuse lymphoid tissue in the lungs indicated its hyperplasia, reflecting activation of compensatory reactions, which in turn led to stress in the nonspecific and humoral components of the immune system. This was confirmed by an increase in the number of intra-alveolar macrophages, as components of food additives, particularly colorants, can act as haptens and exhibit antigenic properties [7; 8; 9], thereby increasing their activity and promoting leukocyte migration, predominantly neutrophils. Edematous changes caused deformation of respiratory alveolar cells and endothelial cells, as confirmed by electron microscopic data, and also led to thickening of the air-blood barrier. This triggered hyperfunction of secretory alveolocytes and further disruption of gas exchange processes. By the 8th week, destructive and dystrophic changes in alveolar type II cells were observed, leading to disruption of the normal surfactant structure, destructive changes in alveolar type I cells, and damage to the hemocapillary wall. As the experiment progressed, alongside increasing destruction of the air-blood barrier components, compensatory-reparative reactions were also noted, leading to improvement in the condition of alveolar epithelial components. However, signs of humoral immunity activation were simultaneously observed, manifested by the presence of actively phagocytizing alveolar macrophages. Impaired gas exchange processes led to the formation of so-called emphysematous zones in the alveolar apparatus and further destruction of the alveolar epithelium. Consumption of the complex of food additives also activated nonspecific immune responses, resulting in active migration of eosinophils into the alveolar lumen [16].

CONCLUSIONS

Thus, the consumption of the complex of food additives leads to destructive-dystrophic changes in the structural components of the lungs in rats and a reorganization of the intercellular substance components. The alveoli exhibited both collapsed lumens and emphysematously dilated areas due to the destruction of synthesis organelles and disruption of gas exchange processes, with lamellar bodies being significantly altered. The prolonged action of the components of the food complex resulted in the activation of alveolar macrophages, which were in a state of increased activity and characterized by polymorphism in their structural organization, alongside the activation of the nonspecific arm of the immune response.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Investigating the impact of zinc oxide nanoparticles derived from the alcoholic extract of *Origanum majorana* leaves on the histological morphology of *Leishmania donovania* infected albino rats' livers

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ABSTRACT

Aim: The impacts of zinc oxide nano-extract from *Origanum majorana* leaves on the liver histological morphology of rats were investigated in the current study.
Materials and Methods: There were forty-two rats that are rats are divided into six groups of seven animals. Performing the experiment, 0.5 mg of normal saline was given to the first group, T1. Additionally, a 10 mg/kg nano-extract of *Origanum majorana* leaves was given to the second group, T2. A nano-extract solution containing 15 mg/kg of *Origanum majorana* leaves extract was injected to the third group, T3. A nano-extract derived from the seeds of *Origanum majorana* leaves of 10 mg/kg in combination with *L. donovania* was injected to the fourth group, T4. A nano-extract from *Origanum majorana* leaves at a concentration of 15 mg/kg in conjunction with *L. donovania* was injected to the fifth group, T5. Finally, *L. donovania* alone was injected for 29 days to the sixth group, T6.
Results: Considerable changes were noticed in the nucleus and fib. Moreover, the findings revealed that there are several changes in their liver's structure like sinusoidal dilatation, prescience of specific inflammatory cells surrounding the central vein, and prescience of simple necrosis and bleeding in *L. donovani*-infected tissue.
Conclusions: The histological changes on the liver treated with Nano-extract (zinc oxide) of the *Origanum majorana* leaves at different concentrations was employed for treating the histological shifts and reducing the damage caused by the parasite. Thus, effectiveness of the nano-extract is effective in reducing the influences and resisting the parasite.

KEY WORDS: zinc oxide, *Origanum majorana* leaves, *Leishmania donovania,* rats' livers

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INTRODUCTION

One of the large organ and gland in the human body is liver which held almost 2% of the adult's total weight. It occurs in the upper right quadrant of the abdomen exactly below the diaphragm. It is created of a larger right lobe and a smaller left lobe by the sickle ligament [1]. The gastrohepatic ligament connecting the stomach to the left hepatic lobe and the liver to the digestive system includes neurovascular components such the hepatic branch of the vagus nerve. The hepatoduodenal ligament and portal liver link the duodenum and portal structures, making the liver a major conduit for oxygenated and deoxygenated blood to the heart. In addition, the transverse colon may sometimes be seen in close proximity to or immediately contacting the right lobe of the intestinal tract [2, 3]. Presently, nanoparticles (NPs) are being employed in medical fields for the diagnosis and treatment of numerous diseases, including cancer and autoimmune disorders [4]. However, their application in medical fields is severely restricted due to the detrimental impacts they have on healthy cells and organs. Nanoparticle size, surface area, shape, dispersion, and protein corona effects also affect their safety and toxicity [5]. Interdisciplinary cancer nanobiotechnology, which combines engineering, science, and medicine, is an expanding field with numerous applications. The cancer treatment strategy offered is comprehensive and unique, including preventive measures, personalized therapy interventions, early diagnosis, prediction, and medication [6].

AIM

The impacts of zinc oxide nano-extract from *Origanum majorana* leaves on the liver histological morphology of rats were investigated in the current study.

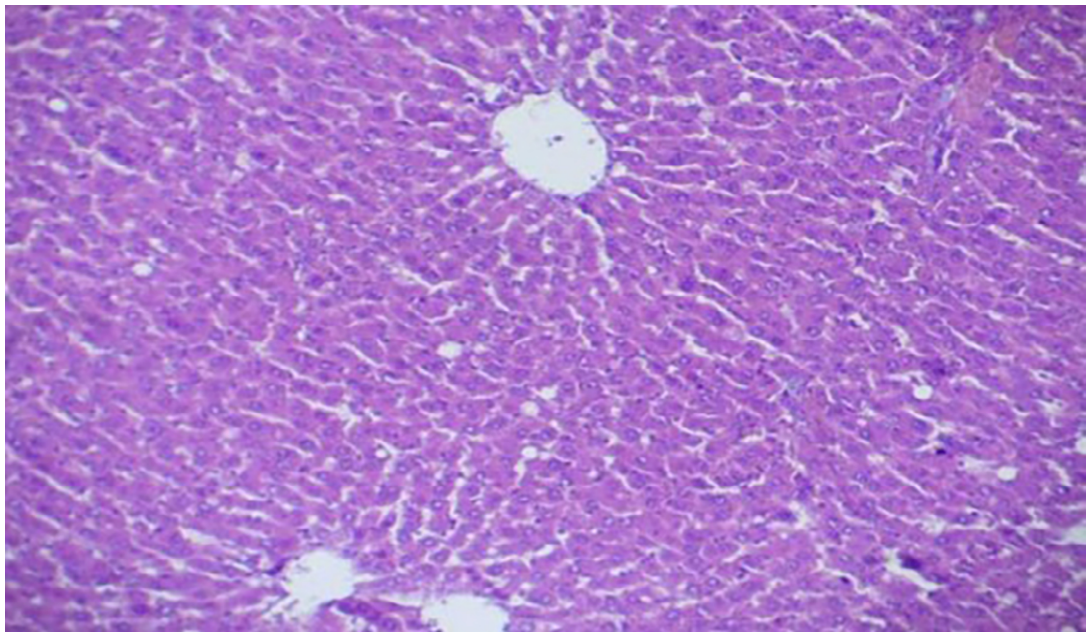

Fig. 1. A liver tissue cross-section in control group displaying the normal structure of hepatocytes and the central vein (100x) (H&E)
Source: Auhor's own study

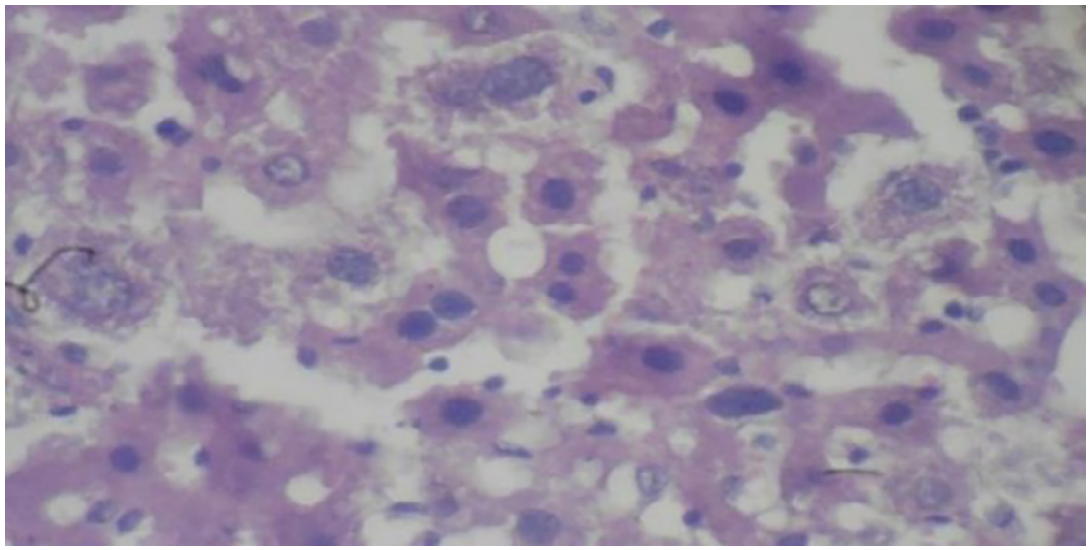

Fig. 2. A liver tissue cross-section of the rat in the experimental group that was treated with a nano-extract derived from the seeds of *Origanum majorana* at a concentration of 10 ml/kg. The hepatocytes exhibit normal appearance, the hepatic fibers demonstrate regularity, and histological changes are absent (400x H&E stain)
Source: Auhor's own study

MATERIALS AND METHODS

Methods for producing an alcoholic extract from powdered *Origanum majorana* leaves. The methanolic extract of the seeds obtained from the leaves of *Origanum majorana* was prepared, with certain modifications, in accordance with the micro-FTIR method [7]. The process was modified to produce nanoparticles (zinc oxide) from methanolic *Origanum majorana* leaves extract [7]. The research employed thirty adult male white Albino rats of the type Rattus, weighing between 250 and 300 g and aged between 6 and 10 weeks. Plastic boxes with iron clips on top that held water bottles were used to keep the animals. Cages are always being cleaned and have trash on top of them. A natural pellet meal is supplied, and the animals are kept in acceptable laboratory settings with 12 hours of light and 12 hours of darkness at 20-25°C. The animals were left for 14 days prior to the commencement of the experiment in order to facilitate adaptation. Throughout this time, they were supplied with water and a formulated diet [8]. The Institutional Animal Care's Central Ethics Committee Biology conducted the first evaluation, authorization, and acceptance of the procedures for the use of live animals in research. The study was conducted from January 2021 to March 2022. The rodents were categorized into the following six groups. The control group (T1) consists of 7 animals. The rats were given 0.5 mg of normal saline intravenously every time they were tested. The second group (T2) comprised 7 animals that were injected with a 10 mg/kg nano-extract of *Origanum majorana leaves*. Group T3, consisting of 7 animals, was administered a nano-extract solution containing 15 mg/kg of *Origanum majorana* leaf extract. Group T4, consisting of 7 animals, was injected with a nano-extract derived from the leaves

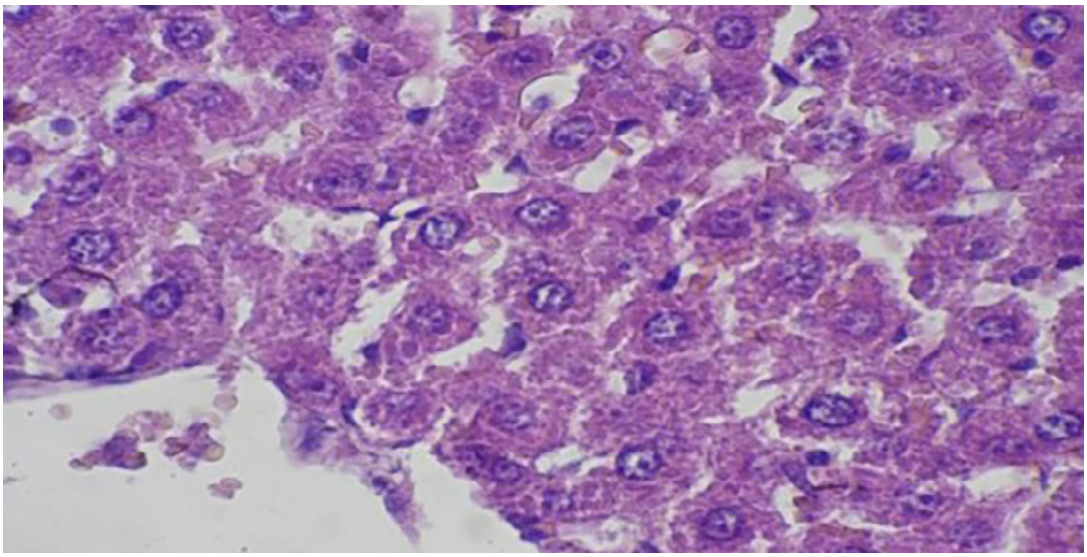

Fig. 3. A cut through the liver tissue of a rat in the group that was given a nano-extract made from *Origanum majorana* seeds at a 15 ml/kg dose showed the following: There are a few binuclear cells among the liver nerves and hepatocytes (400x H&E), which give them their unique shape and pattern
Source: Auhor's own study

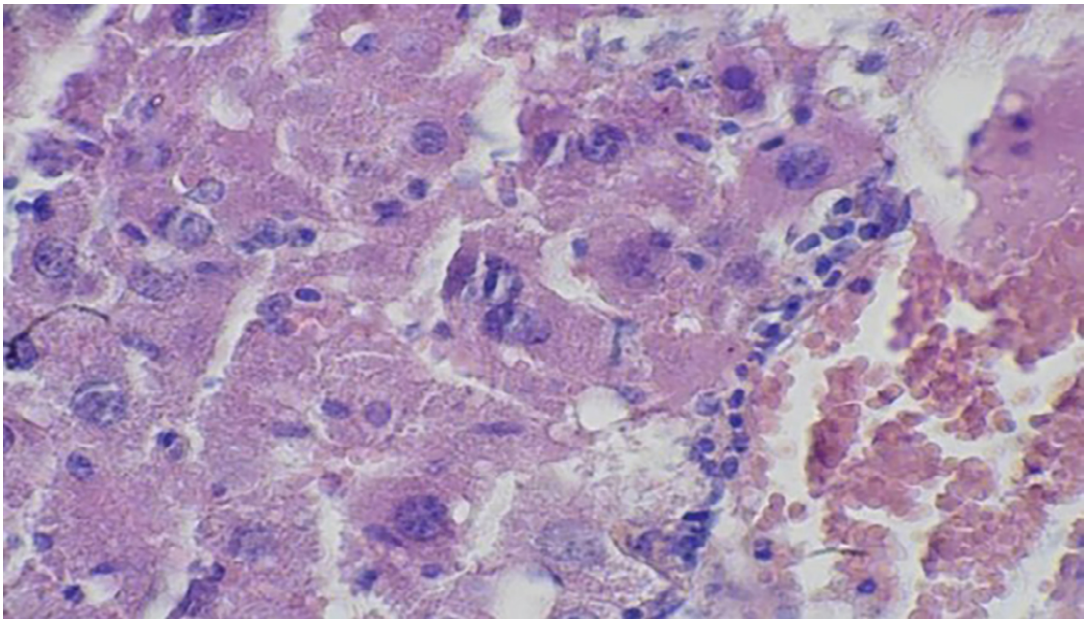

Fig. 4. A liver tissue cross-section from a rat in the *Origanum majorana* leaf treatment group (10 mg/kg plus *L. donovania*) demonstrates a central vein with noticeable hepatocyte necrosis (H&E X400)
Source: Auhor's own study

of *Origanum majorana* at a concentration of 10 mg/kg in conjunction with *L. donovania*. Group T5, consisting of 7 animals, was administered a nano-extract derived solely from the leaves of Origanum majorana at a concentration of 15 mg/kg in conjunction with *L. donovania*. Group T6, consisting of 7 animals, that were injected solely with *L. donovania* as the positive control group. All of the animals from the beginning of the experiment were slaughtered once the first trial ended. To perform an autopsy, the animals were fastened to a dissection plate constructed from cork and firmly fastened with staples. The purpose of the autopsy was to assess the impact of different doses 10 and 15 mg/kg of nano-zinc oxide derived from *Origanum majorana* leaves seed extract on the liver. The animals were rendered unconscious by injecting a mixture of 20 mg of xylazine and 10 mg of ketamine [9]. The promastigotes of the *L. donovani* parasite were cultured and activated in Novy-MacNeal-Nicolle (NNN) media. After that, it was put into RPMI-1640 medium together with 1% of the antibiotic (penicillin and streptomycin) and 10% FBS serum. Very sterile, and after 72 hours, put in a refrigerated incubator at 26°C, the right temperature for the parasite's flagellated stage of development [10]. In order to confirm that the parasite's promastigote stage was growing, the previously incubated culture medium was checked by taking a prepared slide with a 40x lens for microscopic details after a drop of the media was applied to it. When it was confirmed that the flagellar stage of the parasite had appeared, 0.5 ml of the isolate was transferred [11]. After collecting the promastigotes, they were centrifuged at 1500 rpm for 10 minutes to wash them in locks' solution. The pellet was then resuspended in approximately 5 ml of lock solution and the supernatant was removed using a Pasteur

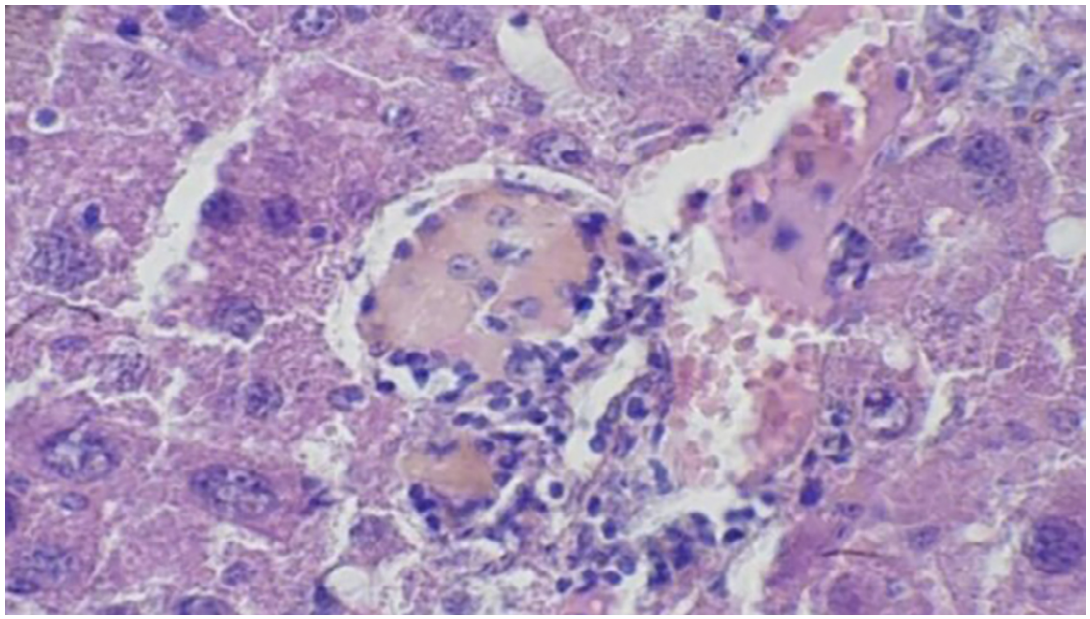

Fig. 5. A rat's liver tissue cross-section from the group that was given 15 mg/kg of *Origanum majorana* leaves along with *L. donovania* shows that inflammatory cells have started to appear (H&E X400)
Source: Auhor's own study

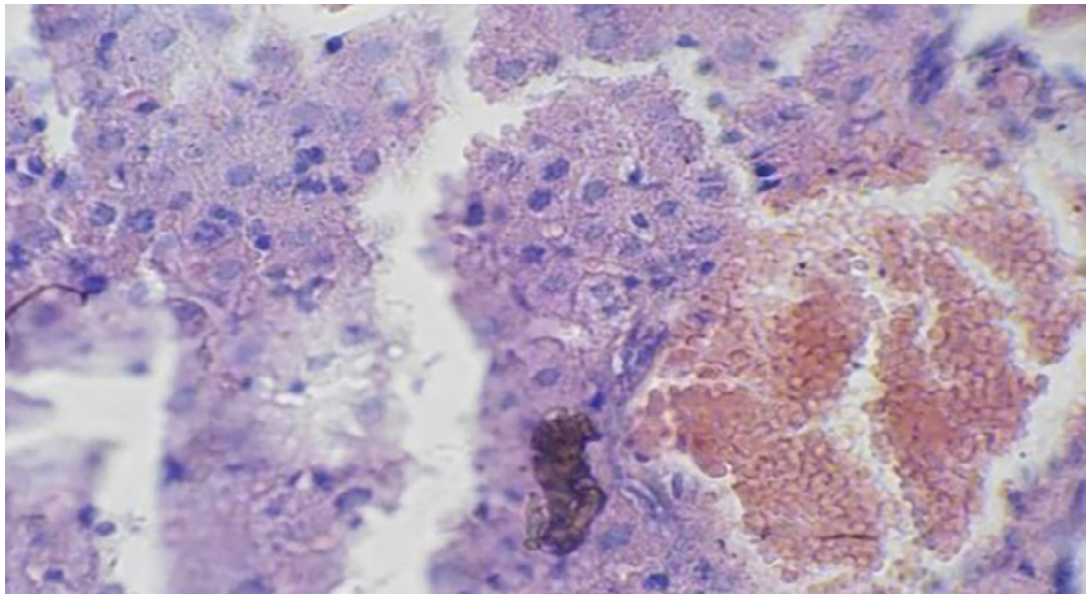

Fig. 6. A liver tissue cross-section from a rat infected with *L. donovania* that shows the presence of inflammatory cells and bleeding (H&E X400)
Source: Auhor's own study

pipette. Using a hemocytometer, the concentration was adjusted to 1.2106 parasite promastigote cells based on the number of promastigotes per ml. The following is a list of the animals found in each of the 16 little corner squares. The total number of cells per ml = N x 10 x 1000 x 20 where N = number of cells counted, 10 = number of cells in l mm^3, 1000 = number of cells in l ml, 20 is the dilution factor.

RESULTS

In figure 1, microscopic inspection of the control group's livers showed normal liver structure and no hepatocyte histological alterations. As can be seen in figure 2, when animals were given a nano-extract of *Origanum majorana* leaves at a dosage of 10 mg/kg, their liver cells had a normal structure, regular arrangement of liver tissue, and no histological changes. As seen in figure 3 show, that after receiving of a 15 mg/kg nano-extract of *Origanum majorana* leaves *via* injection, the livers of the animals exhibited typical hepatic cord morphology, hepatocytes with their characteristic configuration, and the development of certain binuclear cells. Figure 4 demonstrates that upon administering a nano-extract derived from *Origanum majorana* leaves at a dose of 10 mg/kg together with *L. donovani*, the livers of the mice had a central vein with significant hepatocyte necrosis. As seen in figure 5, inflammatory cells invaded the livers of mice that were administered a 15 mg/kg dosage of *Origanum majorana* leaf nano-extract together with *L. donovani*. Figure 6 shows that the livers of mice injected with *L. donovani* exhibited the presence of atypical cells, bleeding, and inflammatory cells.

DISCUSSION

Nanotechnology is an efficient treatment method because of its high efficacy and therapeutic index against germs. The use of novel biomaterials like nanoparticles to accomplish this accomplishment is generating curiosity all over the world. For the treatment of diseases that are resistant to medication, nanoparticles have the potential to become a very important viable alternative [12]. This is consistent with a close study on the effects of the inhibitory nano-extract. Nanotechnology is a brand-new, enabling technology that has the potential to lead to a wide range of innovative uses and better technologies for biological and biomedical applications. Nanotechnology is one of the factors contributing to the increased interest [13]. The liver, central veins, hepatic cords, and sinusoids are histologically normal. Animal models are also useful. Some studies show a toxicity concern after apricot and other fruit seed ingestion, as seen by increased liver chemistry tests. These findings corroborated a prior study [14, 15]. In contrast, Shaibah et al. [16] proposed amygdalin as a potential preventative measure against hepatic fibrosis. A higher concentration of serum ALT (alanine aminotransferase) than AST (aspartate aminotransferase) signifies liver injury with greater specificity [17]. Even though amygdalin's toxicity and effectiveness in animal models have been extensively studied, oral administration releases much cyanide [18]. The conversion of amygdalin to hydrocyanic acid can occur through the activity of emulsion complex enzymes [19], which include β-D-glucosidase, a compound present in foods and small intestine and colon microflora [20]. Amygdalin may undergo hydrolysis in the absence of enzyme catalysis [21]. Benzaldehyde, glucose, and hydrocyanic acid are the byproducts of its hydrolysis in water. Amygdalin, on the other hand, goes through epimerization when it's heated. Cyanide is a very toxic substance that may cause harm to essential organs such as the kidneys, liver, brain, and heart by producing reactive oxygen species (ROS). In addition, the failure to reduce free radical damage leads to oxidative stress [22]. Recent research has revealed that amygdalin is toxic when ingested orally but not when administered intravenously; however, its mechanism of action and potentially lethal concentrations remain unknown [23]. It is possible that an eclectic gut is connected with the toxic effects caused by many oral dosages of amygdalin [24]. Histopathological examination of particular tissues showed severe liver degeneration in rats given high-dose amygdalin. In contrast, the control and amygdalin-treated livers had typical morphology. In the current investigation, cytoplasmic vacuolization, Kupffer cell activation, and vascular congestion were indicative of liver injury. Similar histological damage was seen in the rats' livers after oral cyanide treatment [25]. Nonetheless, goats' exposure to cyanide chemicals resulted in minor hepatic degenerative alterations [26].

CONCLUSIONS

The extract of zinc oxide nanaoextract was more efficient in inhibiting the amastigote phase of *L. donovani* in rats and did not show any side effects on the histological structure of spleen. The current study was conducted to determine the effect of zinc oxide nanoparticles from *Origanum majorana* leaves extract at different concentrations (10-15 kg/g).

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Ethical approval
This study was approved by the Animal Care Committee at the University of Kufa, Iraq (2020/No.20660)

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ORIGINAL ARTICLE

CONTENTS

Optimizing the management of obese patients after bariatric interventions to prevent thromboembolic complications

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ABSTRACT

Aim: To optimize the management of obese patients in the perioperative period to prevent thromboembolic complications.

Materials and Methods: From 2011 to 2024, a total of 988 patients with obesity underwent laparoscopic bariatric surgery at the clinical base of the Department of General Surgery No. 2 of Bogomolets National Medical University. The retrospective group included 498 patients who received treatment between 2011 and 2020. 490 patients were enrolled in the prospective group for the period from 2020 to 2024.

Results: Retospective group had 1 episodes of postoperative thromboembolic complication, representing a rate of 0,2%, prospective group – 0 episodes of postoperative bleeding, representing a rate of 0% The stepwise inclusion/exclusion of variables (Stepwise) method was used to select the minimum set of factor characteristics associated with the occurrence of bleeding in patients with M0 after laparoscopic gastric bypass.

Conclusoins: Shortening the thromboembolic complications prophylaxis regimen from 14 to 7 days in combination with the use of elements of the ERAS protocol did not cause an increase in the level of venous thromboembolism in the prospective group – 0/490 (0%) compared to the retrospective group – 1/498 (0.2%). Intraoperative pneumocompression of the lower extremities as a method of thromboembolic complications prophylaxis is effective in combination with the use of LMWH for a short period (7 days). The use of tranexamic acid preparations together with low molecular weight heparins does not affect the level of thromboembolic complications.

KEY WORDS: obesity, thromboembolism, prophylaxis, gastric bypass, complication

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INTRODUCTION

Obese patients are at high risk of thromboembolic complications. Bariatric surgery increases this risk, so rational anticoagulant prophylaxis is an important element of the perioperative period.

Thromboembolic complications occur in 0.3-2.4% of patients after bariatric surgery [1-3]. Deep vein thrombosis occurs in 0-5.4%, pulmonary embolism (PE) – 0-6.4%. Mortality due to pulmonary embolism occurs in 0.22% of patients, and in the first 30 days – 40% of mortality from PE [1-7].

After laparoscopic gastric bypass, venous thromboembolism (VTE) occurs in 0-1.1%, after laparoscopic sleeve gastrectomy – 0-2.9%, after repeated bariatric surgeries – 0-6.4%. [8].

Risk factors for VTE are divided into those that depend on the patient and on the procedure itself. Male gender, age, weight and BMI before surgery, smoking, heart failure, arterial hypertension, hormonal therapy, sedentary lifestyle, hypercoagulable state, COPD, previous history of VTE are factors that depend on the patient. The length of surgery, the type of bariatric surgery and the presence of other postoperative complications are factors that depend on the procedure itself. [9].

The European guidelines for perioperative VTE prophylaxis recommend the use of LMWH rather than heparin, rivaroxaban, or apixaban in obese patients (evidence level 2C). An increase in the standard dose is recommended if the patient weighs more than 150 kg or has a BMI greater than 40 kg/m2 (evidence level 2B).

AIM

The aim of the study was to optimize the management of obese patients in the perioperative period to prevent thromboembolic complications.

MATERIALS AND METHODS

To improve the management of obese patients and optimize thromboprophylaxis, a retrospective and prospective analysis of obese patients undergoing laparoscopic gastric bypass was conducted.

RETROSPECTIVE GROUP

Preoperative assessment included: complete blood count, complete urinalysis, biochemical blood count (total protein, ALT, AST, total bilirubin with fractions, urea, creatinine), coagulogram, blood group and rhesus, electrocardiography, echocardiography, a chest X-ray, an abdominal ultrasound, cardiologist and pulmonologist consultation, spirometry, lower extremity vascular ultrasound, glycosylated haemoglobin (Hb1Ac), blood C-peptide, TSH blood test, ACTH blood test, cortisol blood test, acid-base blood test, and an electrolyte panel (K, Na, Cl, Ca).

In order to prevent rhabdomyolysis, if the operation lasted more than 2 hours, pneumoperitoneum was eliminated for 10 minutes. As a thromboprophylaxis, elastic compression of the lower extremities was performed intraoperatively. A nasogastric tube was installed for 3-4 days. Removal of the urinary catheter was performed 1 day after the operation. Drainage of the abdominal cavity was performed with two drains. The average duration of the surgical intervention was 179.43 minutes. Intraoperatively, all patients were administered an intravenous proton pump inhibitor 40 mg, ondansetron 4 mg.

In the postoperative period, elastic compression of the lower extremities was continued; the patient was verticalized in the ICU 6 hours after extubation; a small saline enema was performed the next day after surgery. Low-molecular-weight heparins (LMWH) were administered once daily subcutaneously at 0.4 for 14 days. The drinking regimen was resumed on the 6th day during gastrography with liquid contrast to assess the capacity of the gastroenteroanastomosis. All patients received PPIs for 30 days after surgery, according to the following scheme: PPI 20 mg 2 times a day.

PROSPECTIVE GROUP

In the prospective group, ERAS recommendations were applied. Intraoperatively, local infiltration anesthesia of the trocar sites was added; instead of elastic compression, intraoperatively pneumocompression of the lower extremities was performed to prevent thrombosis. For this purpose, LX size cuffs with additional inserts were used. Compression was performed along the entire length of the legs with a pressure of 40 mmHg throughout the entire period of surgery. After surgery, the system was removed and elastic compression was subsequently performed using bandages. Intraoperatively, all patients were administered tranexamic acid preparations at a dose of 1 g, and in the postoperative period after 12 and 24 hours.

After surgery, the urinary catheter was removed immediately; the nasogastric tube was removed within 1 day; the drainage was removed 2-3 days after surgery.

In the postoperative period, early activation of patients was carried out after 2 hours; the drinking regimen was started 6 hours after surgery with a stepwise increase in fluid volume and a decrease in infusion therapy. On the 3rd day, all patients without complications underwent contrast gastrography to assess the capacity of the gastroentero anastomosis. A course of proton pump inhibitors was prescribed for 6 months (20 mg 2 times a day).

Thromboprophylaxis was performed according to an abbreviated regimen, using low molecular weight heparins, which were administered subcutaneously once a day at 4000 anti-Xa IU for 7 days. Patients who had a high risk of thromboembolic complications (according to the Caprini scale >3) received thromboprophylaxis for 14 days and were not included in the prospective group. After surgery, elastic compression was used.

While preparing for surgery, one patient was diagnosed with thrombosis of the left great saphenous vein during Dopplerography of the vessels of the lower extremities. As a stage of preparation for gastric bypass surgery, a crossectomy operation was performed in 1 patient.

The study was conducted in accordance with modern principles of bioethics. Statistical analysis was performed using IBM SPSS Statistics Base software (version 26). Normality of distribution was checked using the Shapiro-Wilk W criterion. Under normal distribution, data are presented as the mean, standard deviation, and/or 95% confidence interval. To determine the relationship between complications and factorial features, we will use the method of constructing a univariate and multivariate logistic regression model with the stepwise inclusion of the most significant features (Stepwise). The value of the strength of the relationship between factorial features will be estimated by the odds ratio (OR) with its 95% confidence interval (CI).

RESULTS

During 2011-2024, 988 obese patients were treated with bariatric surgery at the Department of General Surgery No2 of the Bogomolets National Medical University.

The retrospective group included 498 patients treated during 2011-2019, 240 (48.2%) men and 258 (51.8%) women. The average body weight was 144.8 (95% CI: 142.7–146.9) kg, the average BMI was 45.44 (95% CI: 44.67–46.22) kg/m2. Laparoscopic gastric bypass was performed in 178 patients, laparoscopic sleeve resection in 154 patients, laparoscopic mini-gastric bypass in 69 patients, and two-stage treatment (intragastric balloon placement + laparoscopic gastric bypass) in 97.

The prospective study included 490 patients treated during 2020-2024, 233 (47.6%) men and 257 (52.4%)

Table 1. Comparison of the main indicators in the retrospective and prospective groups

Factor sign	Retrospective group	Prospective group	P, value
Preoperative			
Sex (1 – male, 2 – female)	1,51±0,5	1,61±0,48	0,232
Age, years	44,79±8,46	43,47±9,44	0,168
Height, sm	1,78±0,08	1,77±0,07	0,697
Weight, kg	144,8±13,93	145,1±14,99	0,834
BMI, kg/m^2	45,44±5,23	45,67±5,51	0,689
Comorbidity, n (%)	206 (41,5)	155 (31,7)	0,238
Arterial hypertension, n (%)	257 (51,6)	230 (47,1)	0,563
Diabetes mellitus, n (%)	142(28,6)	185(37,9)	0,004
Hyperlipidemia, n (%)	274(55,0)	316(64,6)	0,772
Sleep apnea syndrome, n (%)	106(21,3)	232 (47,5)	0,001
Chronic obstructive lung disease, n (%)	223(44.9)	223(45,6)	0,768
Intraoperative			
Time of operation, min	179,4±16,45	135,7±8,87	0,001
Postoperative			
Complication, n (%)	36(7,2)	12 (2,4)	<0,001
Revision operation, n (%)	17(3,41)	4(0,8)	<0,001
Re-hospitalization, n (%)	9(1,8)	2(0,4)	<0,001
Thromboembolic complication, n (%)	1(0,2)	0(0)	<0,001

Source: compiled by the authors of this study

women. The mean body weight was 145.1 (95% CI: 142.9–147.3) kg, and the mean BMI was 45.67 (95% CI: 44.85–46.49) kg/m2. The study groups are comparable in terms of the main indicators, except for type 2 diabetes, sleep apnea syndrome, and average operation time (table 1). Laparoscopic gastric bypass was performed in 278 patients, laparoscopic sleeve resection in 122 patients, and laparoscopic mini-gastric bypass in 90 patients.

In 1 patient (0.2%, 95% CI: 0.005-0.016) in the retrospective group, on the 30th day after surgery, we observed splenic vein thrombosis with the formation of splenic infarction. The patient was re-hospitalized and underwent laparoscopic splenectomy. In the prospective group, the VTE rate was 0/208 patients.

The total number of all possible complications in the prospective group decreased compared to the retrospective group.

DISCUSSION

Thromboembolic complications are the main cause of mortality after bariatric surgery. Due to the significant development of thromboprophylaxis over the past 20 years, there has been a clear decrease in the number of VTE after bariatric surgery from 30% to 0.5%, but they still remain a cause of mortality after bariatric surgery. Preoperative examination and prevention of VTE is an important element of the management of obese patients who are scheduled for laparoscopic gastric bypass.

A study of the use of elements of the ERAS protocol in combination with a reduction in the duration of thromboprophylaxis for obese patients after laparoscopic gastric bypass showed the safety of this approach.

The European guidelines on perioperative thromboprophylaxis clearly regulate the mandatory use of anticoagulants, but there is currently no consensus on the optimal timing. [12] Almarshad, (2020), used a 10-day period of THA, resulting in 0.5% VTE. Only medical interventions were used, without the use of the ERAS protocol and mechanical pneumocompression of the lower extremities [13]. The randomized trial Kröll D, (2023) found no difference in the short THA regimen of 7 days versus the long THA regimen of 28 days, with only one case of VTE in the long THA group, but the postoperative bleeding rate was 3 (short group) versus 7 (long) [14]. The study by Almalki, A. S. (2023) also found no difference between short (2-4 days) and long (14 days) thromboprophylaxis [15].

According to the ERAS protocol (2021) for bariatric patients, the use of the elements we used is evidence-based and safe. [10] In the study by Leeman (2020), a combination of short-term thromboprophylaxis and the ERAS protocol was proposed to reduce

the number of bleedings and the impact on the level of VTE [11]. In the study by Blanchet, M. C. (2018), the elements of the ERAS protocol were the basis of TP, and anticoagulants were additionally used only for patients at risk (Caprin >3), for a duration of 10 days. No difference in the number of VTEs was found [16].

One of the elements of the management of obese patients in the prospective group was mechanical prevention of VTE, namely pneumocompression of the lower extremities. The effectiveness of this technique is confirmed and approved by numerous recommendations, but there are no clear boundaries in the use of pharmacological thromboprophylaxis in parallel specifically for obese patients after laparoscopic gastric bypass, due to an increase in the level of bleeding and possible other complications [18]. The study by Calzada, M. G. (2021) confirmed the positive combined effect of the ERAS protocol + lower limb pneumocompression + pharmacological TP for 10 days on reducing the number of VTEs [17]. In the study by Abuoglu, H. H. (2019), there were no VTEs, a positive effect of the combination of pneumocompression and LMWH administration (administration period 15 days after surgery) [19].

In the prospective group, all patients were administered tranexamic acid preparations. It was important to determine the possibility of combining hemostatics with anticoagulants for a short period (7 days). The number of bleedings in the prospective group decreased from 8 to 2, and no cases of VTE were detected. The effect of tranexamic acid occurs due to the inhibition of plasminogen, blocking fibrinolysis occurs, and blood loss is reduced. But in the case of thrombus formation in the venous bed, this may lead to blocking its dissolution [20]. Due to the lack of direct interaction of tranexamic acid with LMWH and the effect on different links of hemostasis, such a combination is possible. In the study of Hossain, N. (2024) the use of TC (intraoperatively 1 g) contributed to a decrease in the amount of bleeding and did not affect the rate of VTE, but thromboprophylaxis was not taken into account here [21].

CONCLUSIONS

Shortening the thromboembolic complications prophylaxis regimen from 14 to 7 days in combination with the use of elements of the ERAS protocol did not cause an increase in the level of venous thromboembolism in the prospective group – 0/490 (0%) compared to the retrospective group – 1/498 (0.2%).

Intraoperative pneumocompression of the lower extremities as a method of thromboembolic complications prophylaxis is effective in combination with the use of LMWH for a short period (7 days).

The use of tranexamic acid preparations together with low molecular weight heparins does not affect the level of thromboembolic complications.

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ORIGINAL ARTICLE

CONTENTS

Health-preserving: Innovative technologies in the professional educational training of Ukrainian students during wartime

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ABSTRACT

Aim: To characterize innovative educational technologies of health-preserving in the professional training of higher education students in Ukraine in the conditions of war.

Materials and Methods: In the research process, a group of methods was used: theoretical (specific research) – analysis, comparison and generalization of scientific literature on the research problem to systematize and generalize facts, information, materials on the researched problem and determine the essence of the main concepts; in the research process, a group of methods was used: theoretical (specific research) – analysis, comparison and generalization of scientific literature on the research problem to systematize and generalize facts, information, materials on the researched problem and determine the essence of the main concepts.

Results: Amid russian aggression, Ukrainian students are facing challenges that impact not only the educational process but also their psycho-emotional well-being. The war has significantly increased stress levels, instability, and psychological pressure on students who are forced to study under constant threat. In this context, innovative health-preserving educational technologies are becoming increasingly vital for supporting students' physical and mental health, as well as ensuring the continuity of their professional training during wartime.

Conclusions: Post-traumatic stress disorder poses a significant threat to the mental health of students. The phenomenon of collective trauma has recently been intensified by the ongoing war. Supporting individuals' mental health is a key priority of public policy, particularly within the higher education system. Modern approaches to the educational process in universities, with an emphasis on health preservation, involve a variety of innovative methods and technologies that help students adapt to wartime conditions, care for their mental well-being, maintain resilience, and cope with stress. A distinctive feature of these efforts is large-scale educational outreach, not only among students and faculty but also among the wider public.

KEY WORDS: health-preserving, mental health, psychological support, psychoeducation, professional training of medical students, higher education institution, NGOs

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INTRODUCTION

In the context of modern challenges, russian aggression, especially since the full-scale invasion of 2022, education in Ukraine is facing problems that affect not only the educational process but also the psycho-emotional state of students, which has deteriorated significantly. Under such conditions, innovative educational health technologies are becoming more relevant, helping to maintain the physical and mental health of students, as well as ensuring their professional training in wartime.

Despite the fact that the problems of studying the state of mental health of students are the subject of analysis by scientists from various fields of knowledge: teachers, doctors, psychologists, sociologists, philosophers, etc., there are practically no studies in the Ukrainian scientific discourse that highlight the problem of using innovative educational technologies of health-preservingin the professional training of higher education students in Ukraine in wartime.

Certain aspects of the problem of mental health of people in war and crisis situations (issues of post-traumatic stress disorder as a medical and psychosocial problem, collective trauma and group identity, medical and psychological consequences of war distress in Ukraine, mental health of the individual during the war, directions of psychological support for

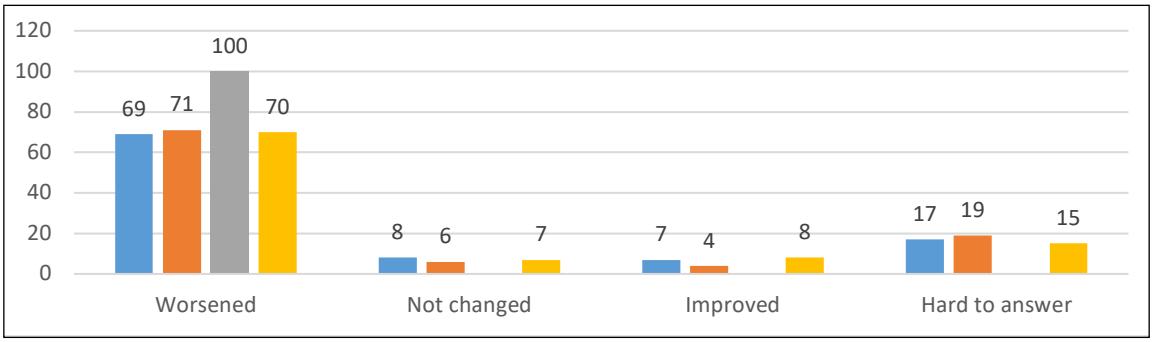

Fig. 1. Results of a survey on the impact of war on the mental health of young people, according to U-report
Picture taken by the authors

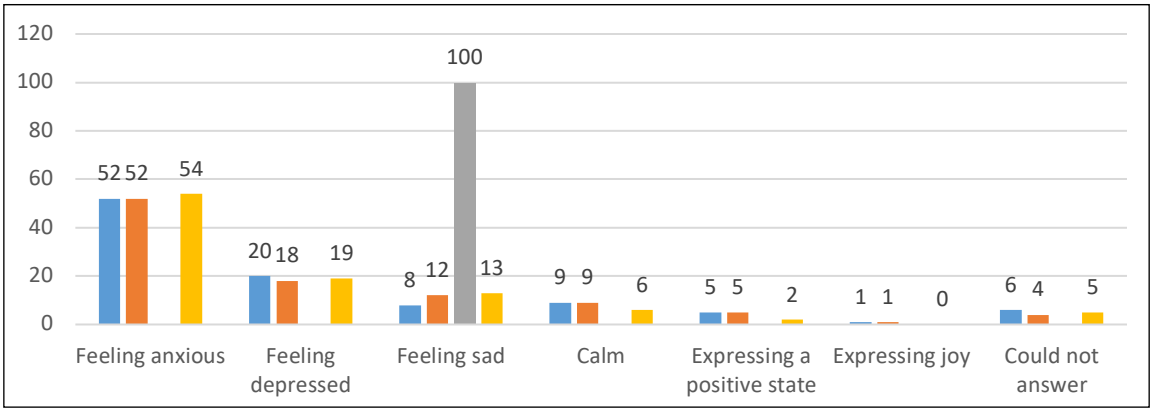

Fig. 2. Results of a survey on the emotional state of young people after the outbreak of war, according to U-report
Picture taken by the authors

Ukrainian students during the war, etc. The issues of emergency psychological assistance to victims in an emergency situation: theoretical and applied aspects, etc.) were raised by L. Karamushka [1], O. Lazurenko [2], N. Tertychna and N. Smila [3], N. Onishchenko [4], R. Romanenko and N. Koliadenko [5], S. Strozhuk, N. Kryvda [6], O. Chaban and O. Haustova [7], V. Chorna, M. Antomonov, etc. [8].

AIM

The aim of the article is to characterize innovative educational technologies of health-preserving in the professional training of higher education students in Ukraine in the conditions of war.

MATERIALS AND METHODS

Practical research methods were used: observation of higher education students regarding the state of their mental health during the war, response to stressful situations, questionnaires among students of the Vasyl Stefanyk Precarpathian National University (PNU) and the I. Horbachevsky Ternopil National Medical University (TNMU) (200 people) regarding their emotional state in the fourth year of the war, the impact of the war on mental health, conversations with students that were of a clarifying nature (as a supplement to the answers to the questionnaire questions), as well as methods of mathematical processing of the research results, etc.

RESULTS

Students, like all students, are a particularly vulnerable social group. According to official data, under the conditions of russian aggression, 40-50% of Ukrainians will need psychological assistance [9]. If we consider in more detail, the number of such people among different population groups will be: among the military and veterans – 1.8 million; about 4 million – children and adolescents; among older people – 7 million people. The projected need for mental health care in primary health-preservingis 27 million visits [9]. At the same time, about 3-4 million Ukrainians will have some kind of mental health disorder – moderate or severe [9]. However, among the above statistics, we did not find information about students.

According to a survey by U-report, a digital platform of UNICEF, published in early February 2023, out of 4,765 responses from 24624 respondents (young people) (the sample came from almost all regions of Ukraine, except for the temporarily occupied ones), 73% of young peo-

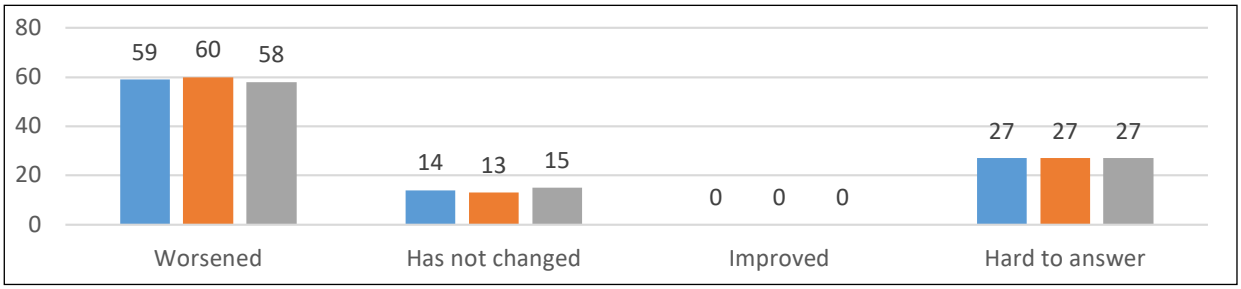

Fig. 3. Results of the survey of students of PNU and TNMU on the impact of the war on their mental health
Picture taken by the authors

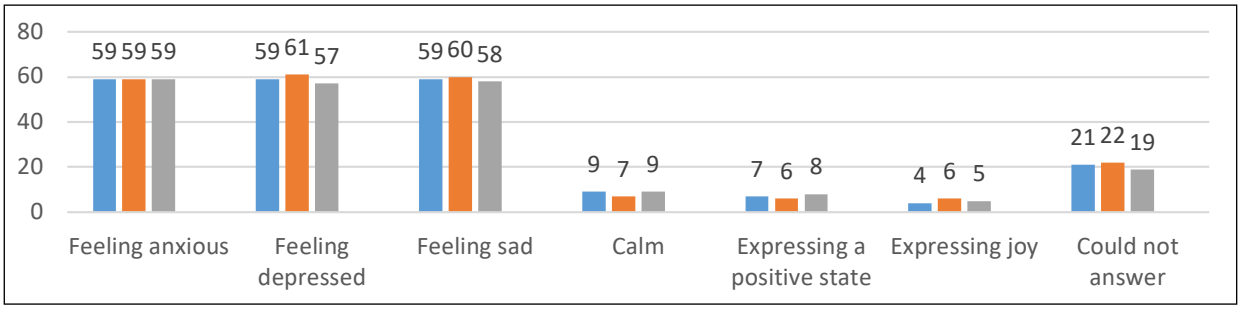

Fig. 4. Results of the survey of students of PNU and TNMU on their emotional state during the fourth year of the war
Picture taken by the authors

ple needed psychological support after the outbreak of war, but only 30% sought help. 56% of respondents learned how to improve their mental health during the war. When asked whether their emotional state had changed since 24 February 2022, 69% said it had worsened, 8% said it had not changed, 17% were not sure, and 7% said their emotional state had improved; the data is approximately the same (with a difference of two units) for young people from Ivano-Frankivsk region (this figure is only 4% vs. 7%). 100% of respondents from the Autonomous Republic of Crimea (ARC) reported a deterioration in their emotional state [10] (see Fig. 1).

Interestingly, to the question «What has been your emotional state since the beginning of the war?», the majority (4619 people out of 4803 respondents) answered that they felt anxious (52%), depressed (20%), sad (8%; 12% of young people in Ivano-Frankivsk region felt this way), calmness was expressed by 9% of respondents, joyful (1%) and positive (5%) emotional states were characteristic of a small group of young people, and 4 to 6% of respondents were unable to answer this question. A slightly higher degree of anxiety (54%) than the overall figure and sadness (13%) is demonstrated by young people from Ternopil region, while a smaller percentage of people reported feeling calm (6% against the overall figure of 9%), positive (2% against 5%), and not feeling happy at all. All respondents from the Autonomous Republic of Crimea reported a sad emotional state (Fig. 2).

In late March – early April 2025, we conducted a survey among students of Vasyl Stefanyk Precarpathian National University (PNU) and I. Horbachevsky Ternopil National Medical University (TNMU) (200 people) about their emotional state in the fourth year of the war and the impact of the war on their mental health. The questionnaire included the same questions as the U-report questionnaire, a digital platform of UNICEF, which was published in early February 2023. The results of the survey are shown in Fig. 3 and Fig.4.

Consequently, the results of the 2023 and 2025 surveys of students on the state of their mental health show that the results of the survey of students of PNU and TNMU in the fourth year of the war on the impact of the war on their mental health have changed. On the one hand, 60% of students at PNU and 58% at TNMU feel a deterioration in their emotional state (previously this figure was higher: 71%, 70%). But, on the other hand, not a single student said that their emotional state had improved (previously, these figures were 4% (Ivano-Frankivsk region) and 8% (Ternopil region), respectively). Students' anxiety has increased (59% feel it (52% before), the number of students who feel depressed has tripled (59% now, 20% before), even more respondents feel sad (60% of students at PNU and 58% at TNMU (previously this figure was much lower: 12%, 13%), and the percentage of students who express joy and describe their emotional state as positive has slightly decreased.

Supporting the mental health of individuals is one of the priorities of state policy, in particular in the higher education system. For more details, see our separate publications [11-14].

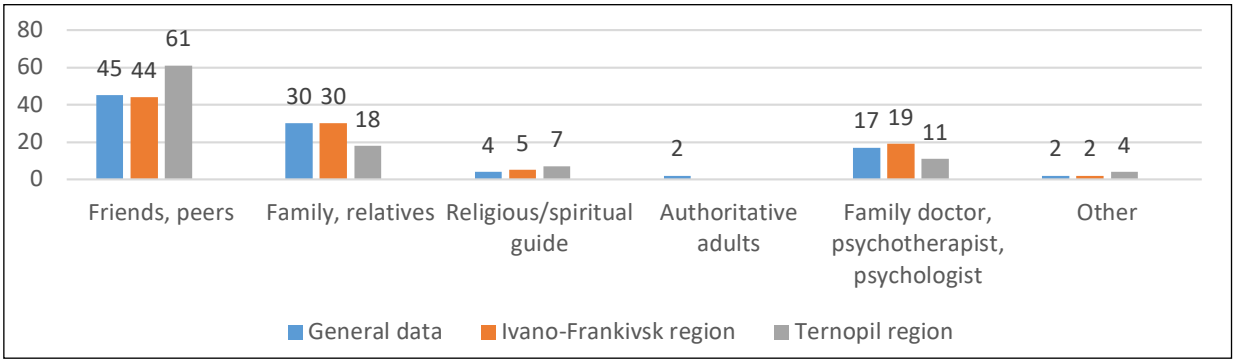

Fig. 5. Results of answers to the question «If you needed emotional support, who would you turn to for help and advice?», according to U-report
Picture taken by the authors

The war and the consequences caused by it pose a serious challenge to higher education students, society and the state as a whole.

According to the results of our study, there is a stereotype among students about psychotherapists, psychologists, i.e. specialists, students believe that they should only turn to them when absolutely necessary, because the «strong» do not seek help, emotions should be kept inside, not shown. As a result of this stereotypical view, students are more likely to seek help from their friends than from psychotherapists, or they turn to the latter when their mental health is at risk, the disease has gone beyond the initial stage, and its treatment will require more time and effort (Fig. 5). Thus, students' mental health is negatively affected not only by objective factors, but also by subjective ones – the so-called social stigma that applies to those with mental illness or emotional disorders.

Post-traumatic stress disorder (hereinafter referred to as PTSD) poses a great threat to the mental health of students, as people under the age of 22 or over 30 are the most vulnerable to it. PTSD is caused by a person's experience of losing relatives in war, being held in captivity, occupation, a traumatic event that threatened their life, health, physical integrity, or, for example, witnessing this in relation to other people, learning about a traumatic event that happened to their relatives (death or threat to life), etc.[5, 7, 8]. It is worth noting that, on the one hand, the level of PTSD at the time of an emergency is low: it usually manifests itself six months after the traumatic event. On the other hand, if the stressor has a powerful long-term effect (for example, a person worries about a relative in captivity, in the occupied territory, in the frontline zone of occupation, constant situations of shelling and air raids, etc.), the likelihood of rapid development of PTSD increases. According to official data, only 20% of people who have experienced traumatic events suffer from PTSD. Experts say that this depends not only on the person's characteristics (physical and mental health, etc.), but also on the help and support of loved ones. The nature of the traumatic event itself is of great importance. PTSD is distinguished by timeframe: acute (if it develops within 30-90 days), chronic – more than 90 days, with delayed onset – later than 6 months (quite rare) [9]. People with PTSD are characterised by constant thoughts about the traumatic event they have experienced, anxiety, panic attacks, often loss of trust in people, relationship problems, alcohol and drug abuse, and sometimes suicidal thoughts [5, 7, 8]. Scientists note that PTSD mostly coexists with other forms of psychopathology, and 90% of survivors have at least one comorbidity throughout their lives (depression, alcohol abuse or other addiction; anxiety disorders; and psychosomatic disorders). [9]. Thus, most manifestations of PTSD lead to social maladjustment, which causes significant problems not only for the person but also for the people around him or her.

Diagnosis of PTSD is very important given that, as our survey and U-Report data showed, 73% of young people felt the need for psychological support after the outbreak of war, but only 30% sought help, and 56% learned how to improve their mental health during the war. As a rule, young people most often (almost half of the respondents) (Fig. 5) sought emotional support from friends/peers (45% on average, and in Ternopil oblast it reaches 61%), 30% of respondents seek emotional support from family and friends (in Ternopil oblast the percentage is much lower – only 18%, 4-5 to 7% turn to spiritual/religious representatives, and authoritative adults (teachers, lecturers, supervisors) are not advisers for young people. Family doctors, psychotherapists, and psychologists are sought by 17% of respondents (19% in Ivano-Frankivsk region, and 11% in Ternopil region). Thus, the need for professional help from doctors, psychotherapists, and psychologists is becoming more urgent, primarily in order to diagnose PTSD in higher education students, if necessary [9].

This is important because PTSD treatment itself can take from one month to one and a half years, provided that the patient's situation is not complicated by other

acute problems, such as the situation at the frontline, legal, medical or social problems. At the same time, one of the symptoms of PTSD is avoidance, which prevents people from visiting a specialist: a psychologist, psychotherapist or psychiatrist. Under such conditions, the stress disorder will remain undetected. Accordingly, early diagnostic and treatment interventions can reduce the prevalence of PTSD among those who have experienced mental trauma. In addition to PTSD, another threat to the mental health of students is distress – disruption of adaptation and coping reactions, depression and various disorders caused by extreme war-related circumstances for the human psyche. All of this increases the risk of developing or exacerbating somatic diseases, primarily cardiovascular diseases and cancer.

Recently, the phenomenon of collective trauma has been exacerbated by the war. According to scholars (S. Storozhuk, N. Kryvda [6], O. Chaban, O. Haustova [7], etc.), this is a type of psychological trauma that a group of people (or even the whole society) has received due to a social, man-made or environmental disaster, criminal actions of political and other social actors. We would add that this is also the case in the context of russia's military aggression, and as a result of the aggressor state's military actions. It is this collective trauma that the Ukrainian people, including students, are experiencing today throughout the country, caused by the war, which provoked the ecocide of natural areas of the territories occupied by the enemy, the genocide of Ukrainians, as evidenced by victims of occupation, prisoners of war, killed civilians, children, abducted and taken to russia children and youth, deportations of Ukrainians, restrictions on the freedom of large groups of people (life in the TOT, imprisonment of Ukrainians, the Tatar population of Crimea); political, religious (UGCC, UOC) and other repressions; terrorist acts in numerous cities of Ukraine that caused a public outcry; public executions of Ukrainian prisoners, deaths of famous young Ukrainians, talented soldiers, musicians who were idols of youth, etc. The phenomenon of collective trauma is not limited either in time or space. It is characteristic of both direct and indirect participants in the events of traumatization, i.e. the entire Ukrainian student body, which is currently experiencing a stress disorder caused by the war, the phenomenon of collective trauma is united by a single territory, culture, mentality and inter-institutional interactions. This type of mental trauma is of great importance not only for the current generation of students who have experienced this trauma, but also for future generations [15]. The phenomenon of psychological trauma, as shown by the results of our survey, is not the same for different categories of students (for example, those who serve or have served in the Armed Forces, i.e. participated or are participating in hostilities, those who live in frontline areas, those who are internally displaced due to the loss of homes, students who live abroad, students who live in regions far from the combat zone (Chernivtsi and Zakarpattia regions), which have hardly been attacked by missiles and UAVs, foreign students studying at TNMU, etc. Even those students who have experienced the same or similar traumatic events, due to their temperament, character, and individual mental characteristics, react to them differently, with different consequences for their own mental health, so the approach to collective trauma and its consequences should be differentiated and specific to the individual.

In this regard, we would like to emphasise that today, in the professional training of Ukrainian students in the context of war, it is important to coordinate the actions of public authorities, specialised educational and research institutions, non-governmental organizations specialising in psychological assistance to the population; as well as to involve foreign (including international) organisations, representatives of the public sector, government and financial institutions. In our opinion, innovative educational health technologies can play an important role in this process.

Here are some examples of how health education technologies are used in the professional training of future specialists in wartime with the assistance of the state, public initiatives, and higher education institutions (HEIs). For example, back in June 2022, the creation of the National Programme for Mental Health and Psychosocial Support (hereinafter – the National Programme) was initiated, which aims to create its own Ukrainian model of «a system of mental health and psychosocial support that will implement the best international and domestic practices», «to build an effective system of quality and affordable mental health services so that everyone who needs them can use them» [9]. The establishment of the Interagency Coordination Council on Mental Health and Psychological Assistance to Persons Affected by the Armed Aggression of the russian Federation against Ukraine is an important step towards the implementation of this state programme towards the implementation of the national programme of mental health and psychosocial support. The tasks include building a system of training, certification, and quality monitoring of psychologists, psychotherapists, and psychiatrists working in the system of most ministries; training family doctors, psychologists, social workers, and educators in rapid psychological support techniques; creating a register of specialists and techniques, systematising data, de-

veloping a model for retraining and retraining staff, and a system for engaging them [9].

About 60,000 specialists have been trained under the National Programme. For example, the participants (representatives of the Ministry of Health, the Ministry of Social Policy, the Ministry of Education and Science, the Ministry of Veterans Affairs, the Ministry of Internal Affairs, the Ministry of Defence, the Ministry for Reintegration of the Temporarily Occupied Territories, as well as trainers from companies that are members of the «Business Without Barriers» community, NGOs and international organisations) acquired relevant skills as a result of a series of train-the-trainer sessions on the WHO «Self-Help Plus» stress management course. The training of mental health and psychosocial support professionals is carried out with the close support of Israeli NGOs: the «IsraelMedDay» online conference was attended by more than 1,000 professionals; about 3,000 professionals from the Ministry of Internal Affairs, education and social work sectors, Ukrzaliznytsia, Ukrposhta and «Oschadbank» were trained by the Israel Trauma Coalition. More than 2,000 professionals attended 6 webinars from the Israeli NATAL Centre for Trauma and Resilience. About 160 government hotline operators were also trained in first aid and stress management [9].The National Programme resulted in the creation of training materials (the «Basic Skills for Caring for Yourself and Others» handbook; a new section of the «Barrier-Free Handbook», «Ethics of Interaction in Times of Stress»; stress management in the «BetterMe»: «Mental Health»; videos for television «Tell me honestly, are you okay?», self-help kit from Ukrainian stars and TV presenters; a series of animated videos about the nature of stress, helping yourself and loved ones) that can be used in the system of professional training of future specialists in higher education institutions [10].

DISCUSSION

In Ukraine, a year after the start of the full-scale invasion, the state has taken many measures at the level of ministries (government agencies), and a number of public initiatives (non-governmental agencies) have been created to provide psychological support, and we emphasise: free of charge. Information about the activities of governmental and non-governmental structures to preserve the mental health of Ukrainians should be actively disseminated among students, pupils, and the general population, and health education should be updated.

Specialised non-governmental organisations make a significant contribution to supporting the mental health of citizens, in particular, we would like to highlight the activities of the National Psychological Association (NPA), which launched a free hotline in Ukraine in early June 2022, which operates in the format of audio and video calls, and soon afterwards, with the support of foreign partners, the NPA organised similar platforms in 20 European countries. These hotlines are staffed by professional psychologists who have relevant experience and have been trained to provide psychological assistance in crisis situations. Such assistance is very important for Ukrainian refugee students abroad, also because these hotlines help Ukrainian students maintain a mental connection with their homeland. Ukrainian students can take advantage of psychological support (including round-the-clock support) from the following public institutions: «Zaporuka», the «Resilience Hub», the «Lifeline Ukraine» National Professional Line for Suicide Prevention and Mental Health Support, the «ObiyMy» Psychological Support Centre, and the «Step Towards» Rehabilitation Centre for Free Psychological Assistance, «Open Doors» Psychological Counselling Centre, «Tell Me» Online Platform, «Razom» Psychological Support Group, «Psychological Support» Telegram Channel, «Victory» Telegram Channel addressed to students (for people aged 8 to 22), the online programme«Being a Parent of an Angel», etc. [8].

Today, scholars in Ukraine pay great attention to the problem of preserving and maintaining mental health during the war [1-4, 11, 12, 14].

The first in Ukraine Stress Resilience Centre, established in early April 2022, which employs 15 psychologists, is doing a great job of using educational health technologies in the training of future specialists. In addition to psychological support for demobilised soldiers and their families, various social and professional groups, they provide psychological support to employees of the educational, medical, social, and communal sectors, as well as professionally assist those who provide public and administrative services, and conduct counselling. The training of specialists of the Centre for Stress Resilience was organized in Israel under the programme of the Israel Trauma Coalition [13]. Subsequently, such psychological support platforms were established in other cities of Ukraine, and psychological rehabilitation centres operate throughout the country. At the beginning of June 2023, the «RAZOM with You» Psychological Support Centre was launched in Bucha.

Let's consider how the latest educational technologies of health-preservingare used in the professional training of future specialists by individual HEIs of different profiles, describing the content, key forms, and methods of work. For example, at the Faculty of

Psychology of the PNU, students have the opportunity to obtain a second (master's) level of education in such educational programmes as «Clinical and Rehabilitation Psychology» and «Psychology», and there is a psychological support centre«Razom with You», which provides counselling services (free of charge) (with the support of Razom for Ukraine (USA)) to adults and children who, for various reasons, are in a state of acute stress during the war, university specialists provide psychological support and assistance to all who need it, including internally displaced persons, families of military personnel and those affected by the war [16].

The students themselves, who received special training at the Centre for Supervision and Professional Development of Psychologists, became the organisers of the «Tutoring Academy» project, which was created as part of the UPSHIFT programme, implemented in Ivano-Frankivsk region by the NGO «AMONG OTHER THINGS» with the support of UNICEF and the Government of Japan, and aimed at increasing the psychological resilience of young people and improving their mental health. It lasted for three months, during which six students offered a wide range of educational, practical activities, taught young people about the importance of mental health and taught them self-help techniques. They also offered individual support, first aid counselling, and organised film clubs to watch and discuss films on psychological topics. Leading experts were invited to give lectures on sexology, forms of manifestation and impact of abusive relationships, the importance of knowing one's rights for emotional stability, etc. Group meetings were an integral part of the Tutoring Academy's activities to build an atmosphere of trust, develop communication skills, and provide psychological support. Innovative forms of work (film screenings, debates, quests, quizzes, and other active forms) contributed to the wider involvement of young people in the topic of psychological health in an interesting way to learn how to be psychologically resilient in the face of military challenges [16].

An important role in the professional training of future medical professionals is played by the Mental Health Centre established at the Ivano-Frankivsk National Medical University (IFNMU) [15], which aims to provide quality mental health care based on an integrative approach. The Mental Health Centre of the IFNMU is actually a city mental health hub for the general population, including those affected by the russian aggression in Ukraine, internally displaced persons, military personnel, veterans of the russian-Ukrainian war, and their families. The Mental Health Centre of the IFNMU promotes the professional development of medical personnel in the field of early detection and prevention of mental illness, among other activities – public education to destigmatise mental disorders and understand the consequences of war (group and individual psychotherapy, psychoeducation (creation of programmes to explain the most common mental disorders that occur in wartime: panic attacks, anxiety disorders, prolonged grief disorder), creation of self-help groups, intensive intervention for those who need it, organisation of coordinated work of municipal mental health services, development of trainings to overcome the crisis tension caused by unexpected events of war.

Established in January 2019 at Ternopil National Medical University, the Center for Psychological Counseling has, for six years, not only contributed to the professional training of future specialists in medicine, pharmacology, and dentistry, but also supported international students and those enhancing their professional competence at the Faculty of Postgraduate Education. The Center's main objective is to promote psychological culture among all participants in the educational process, humanize relationships within student and teaching communities, provide psychological assistance in crisis and stressful situations, prevent maladjustment processes, offer psychological support throughout the educational journey, and implement preventive, corrective, and educational initiatives. Specialists of the Psychological Counselling Centre of TNMU actively provide psychological support to the population, advise teachers and students. Created as a space for self-exploration, assistance, and support in difficult life situations, since 2022 the Center has been fulfilling a priority mission — providing emergency psychological support, almost around the clock, in both online and offline formats to all those in need. By consolidating the efforts of the Center's psychologists and leading specialists from the Department of Psychiatry, Narcology, and Medical Psychology, led by Professor Olena Venger, Doctor of Medical Sciences, the staff have conducted over 60 psychoeducational events and a series of training sessions for internally displaced persons (adults and children) in hospitals, shelters, and charitable organizations, including Caritas. They offer psychological diagnostics, counseling, education (thematic meetings, workshops, training sessions, and seminars), and run personal development groups as well as psychological support groups. The TNMU Psychological Counseling Center has also joined the Psychological Assistance Ecosystem in Education, established under the National Program for Mental Health Support of the Population of Ukraine.

CONCLUSIONS

In light of the results, after the full-scale invasion of the russian federation in 2022 into the territory of Ukraine, educational processes are faced with problems that affect not only the educational process, but also the psycho-emotional state of students. Under such conditions, innovative educational health-preserving technologies are being actualized, which contribute to maintaining the physical and mental health of students, as well as ensuring the irprofessional training in war time conditions. Maintaining the mental health of the individual is one of the priority tasks of state policy, in particular in the higher education system. War and the consequences caused by it pose a serious challenge both for students of higher education, and for society and the stateas a whole. In view of this, in the professional training of Ukrainian students in war time conditions, coordination of actions of state authorities, specialized educational and research institutions, andnon-governmental organizations specializing in psychological assistance to the population is important; as well as the involvement of foreign (in particular international) organizations, representatives of the public sector, government and financial institutions. In our opinion, innovative educational technologies of health preservation can play an important role in this process. Some examples of the use of educational technologies of health-preserving in the professional training of future specialists in war conditions with the assistance of the state, public institutions and higher education institutions are given. Typical forms of the use of innovative educational technologies of health preservation in the professional training of future specialists are highlighted.

Modern approaches to the educational process in higher education institutions with an emphasis on health involve various methods and technologies that allow students to adapt to wartime conditions, take care of their mental health, maintain well-being, be stress-resistant, etc. Higher education institutions are implementing educational programs related to mental health, and almost all institutions have created centers for psychological health, psychological support, psychological counseling, etc. A feature of the activity is broad educational work not only among students and teachers, but also among the general public. Such assistance is provided free of charge in online and offline formats, usually around the clock, emergency high-quality psychological assistance is provided to everyone who needs it, including those who have suffered from russian aggression in Ukraine, internally displaced persons, military personnel, veterans of the russian-Ukrainian war, and their families. These centers contribute to improving the qualifications of medical personnel in the field of early detection and prevention of mental illnesses, among the forms of activity – educational work among the population to destigmatize mental disorders and understand the consequences of war (group and individual psychotherapy, psychoeducation (creation of programs to explain the most common mental disorders that arise in wartime conditions: panic attacks, anxiety disorders, prolonged grief disorder)), creation of self-help groups, intensive intervention for those who feel such a need, organization of coordinated work of city mental health services, development of trainings to overcome crisis tension caused by unexpected events of war.Among the typical forms of using innovative educational health-preserving technologies in the professional training of future specialists are lectures, thematic meetings, master classes, conducting trainings and workshops, work in personal development groups and psychological support groups, stress management, group discussions, case methods, film screenings and further discussion, educational webinars, coaching programs, the use of interactive online platforms, virtual laboratories, hotlines, simulators for practical training, practical work in charitable organizations, extensive volunteer work, various physical activities (walks, yoga, fitness classes, sports, etc.), art therapy, etc. Innovative educational technologies of health preservation are an integral part of modern professional training of Ukrainian students in wartime conditions. Their implementation contributes to the preserving of the physical and mental health of young people, helps to adapt to new realities and ensures a high level of the educational process even under martial law. Increasing students' awareness of health-preserving, developing innovative programs and supporting state and international initiatives in this area will help ensure the effective functioning of the educational system of Ukraine. An important direction is broad education among students of the importance of acquiring knowledge and forming health preservation competencies.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Healthcare associated infections in patients with combat wounds and antimicrobial resistance of the responsible pathogens in Ukraine: results of a multicenter study (2022-2024)

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ABSTRACT

Aim: Aim this study was to estimate the prevalence and incidence of HAI in patients with combat wounds, and determine phenotypic and genotypic aspects of antimicrobial resistance of the responsible pathogens in Ukraine.

Materials and Methods: A multicenter observational cohort study based on HAIs and antimicrobial resistance surveillance data in Ukraine. Between June 21, 2022 and December 31, 2024, patients (aged 20-74 years) with combat wounds were admitted to civilian hospitals which are located in Kharkiv, Dnipro, Kherson, Zaporizhzhia, Odessa, and Kyiv, Ukraine. The criteria for HAIs were adapted from the CDC/NHSN. Antimicrobial susceptibility test used Kirby – Bauer disc diffusion antibiotic test according to the EUCAST.

Results: Among 7,324 patients with combat wound, 5,022 (68.6%) HAIs were observed. The most frequently reported HAI types were surgical site infections (27.3%), bone and joint infections (25.6%), skin and soft tissue infections (15.7%), bloodstream infections (9.7%), central nervous system infections (7.9%), and pneumonia (5.3%). In total, 88.9% isolates from patients with combat wounds were found to be MDROs. A significant number of the MDROs isolated from patients with HAIs had β-lactamase genes, including extended-spectrum β-lactamase (ESBL) (53.1%), OXA-type (32.9%), AmpC-type (35.7%), KPC-type (31.8%), and metallo-β-lactamases (51.4%) including IMP-type (18.5%), VIM-type (29.6%), and NDM-1 (34.7%).

Conclusions: This study found a high prevalence of HAI in patients with combat wounds caused by MDROs, varying depending on the bacterial species, and antimicrobial group. The majority of MDRO isolates from patients with HAI carried β-lactamase genes.

KEY WORDS: healthcare-associated infections, multidrug-resistant organisms, β-lactamase genes, combat wound, Eastern Ukraine military conflict, Ukraine

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INTRODUCTION

The ongiong military conflict in Ukraine has placed extraordinary pressure on medical infrastructure due to the increase in the number of hospitalized patients. This situation is observed primarily in the east of Ukraine, where active military actions continue. In addition, both soldiers and civilians also suffer combat injuries in other regions of Ukraine.

Combat wounds are considered contaminated. Infectious complications are a frequent occurrence associated with combat-related trauma. Therefore, most injured patients receive a prophylactic dose of antibi-

otics upon hospitalization. However, despite antibiotic prophylaxis, some in patients with war injuries after surgical treatment develop infections. According to the literature, approximately 34-57% of patients at hospitals developed a combat-related wound infection [1, 2]. Currently, there is no national network for prospective surveillance for combat- related infections in patients evacuated to civil Ukrainian hospitals.

It is reported that a significant morbidity of combat-related infections in Iraq, Afghanistan, and Vietnam were associated with multidrug-resistant organisms (MDROs) [1, 3]. There is also concern regarding potential adverse outcomes associated with MDROs of the combat-related infectious complications in Ukraine. The Eastern Ukraine military conflict has disrupted the normal functioning of healthcare and poses a potential risk for the increased spread of prevalence MDROs in Ukrainian hospitals. There are already numerous health issues regarding the spread of diseases associated with MDROs in Ukraine. Antimicrobial resistance (AMR) spread in Ukrainian hospitals is a national concern [4, 5] and may have implications for other country [6, 7]. It has been highlighted in recent studies that has increase in antibiotic-resistant pathogens since the start of the war [6, 8, 9].

Due to high morbidity a combat-related wound infection caused by MDROs, early diagnosis and treatment of these infections. Currently, in Ukrainian hospitals, efforts to improve infection control (IC) training and to begin local HAI and AMR surveillance have been implemented. However, finance and personnel resources are limited in Ukraine. These creating difficulties implementing surveillance and establishing effective IC measures for MDROs prevention. Previous reports of combat-related HAIs in Ukraine have been limited to AMR of the responsible pathogens these infections in military personnel admitted only to military hospitals [10, 11].

AIM

The aim of this study was to estimate the prevalence and incidence of HAI in patients with combat wounds, and determine phenotypic and genotypic aspects of antimicrobial resistance of the responsible pathogens in Ukraine.

MATERIALS AND METHODS

STUDY DESIGN, SETTING AND PATIENTS

A multicenter observational cohort study based on HAIs and antimicrobial resistance surveillance data in Ukraine. This study was initiated in June 2022 as combat operations were increasing in Ukraine. Between June 21, 2022 and December 31, 2024, 7,324 patients (aged 20-74 years) with combat wounds were admitted to hospitals which are located in the Eastern, Southern and Central regions (Kharkiv, Dnipro, Kherson, Zaporizhzhia, Odessa, and Kyiv) of Ukraine. Of which 6,782 (92.6%) were military personnel that has combat wound in military conflict and 542 (7.4%) were combat trauma or injured outside of the active war theaters. All wounded military personnel and civilians with war trauma or injuries was medevac'd to local hospitals.

DEFINITION

An HAI cases was defined as an infection arising >48 h after surgical or other medical procedures. In this study the criteria for specific HAI site were adapted from the Centers for Disease Control and Prevention's and National Healthcare Safety Network's (CDC/NHSN) definitions [12].

DATA COLLECTION

We developed a special questionnaire for collecting infection-related data from all patients with trauma or injuries, admitted to participating hospitals. We developed a special questionnaire for collecting infection-related data from all patients, admitted to participating hospitals. In this study was collected data from medical records, including gender, age (years), microbiological investigations, invasive procedures, procedure/treatment, day of admission to the ICU, surgical interventions, previous hospitalization, antibiotics usage, and culture and sensitivity of the clinical isolates. Specimens from all patients were also collected and retained in a microbiological isolate repository. All patients were given the opportunity to enroll in a prospective follow-up cohort study. Follow-up of each patient (besides the military personnel) with trauma or injuries after surgical treatment was continued for one month, and for some infections for up to 90 days.

MICROBIOLOGICAL ANALYSIS

In this study, species identification isolated strains and was performed antibiotic susceptibility testing was performed by using automated microbiology testing (Vitek-2; bioMe´rieux, France). Some antimicrobial susceptibility test used Kirby – Bauer disc diffusion antibiotic test according to the protocol of the European Committee on Antimicrobial Susceptibility Testing (EUCAST) (http://eucast.org). A bacterial isolate is considered resistant to antibiotics when tested and interpreted as resistant in accordance with the EUCAST clinical breakpoint criteria. All Multidrug resistance or-

Table 1. Distribution of healthcare-associated infections (HAI) detected in patients with combat wound in Ukraine, 2022-2024 (n=5,022)

Type of HAI	n	%	95% CI
Surgical site infections	1,372	27,3	26.8 – 27.8
Bone and joint infections	1,287	25,6	25.1 – 26.1
Skin and soft tissue infections	786	15,7	15.3 – 16.1
Bloodstream infections	487	9,7	9.4 – 10.1
Central nervous system infections	396	7,9	7.6 – 8.2
Pneumonia	267	5,3	5.1 – 5.6
Urinary tract infections	204	4,1	3.9 – 4.3
Eye, ear, nose, throat, or mouth infections	83	1,7	1.6 – 1.9
Lower respiratory infection, other than pneumonia	54	1,1	1.0 – 1.2
Cardiovascular system infections	52	1,0	0.9 – 1.1
Clinical sepsis	34	0,7	0.6 – 0.8

CI, Confidence Interval
Source: compiled by the authors of this study

ganisms (MDROs) identified in this study were collected for further molecular-based investigations.

MOLECULAR ANALYSIS

All phenotypically multidrug resistant (MDR) strains isolated from patients with trauma or injuries, were analysed for the presence of the b-lactamase genes using polymerase chain reaction (PCR). DNA was extracted from a single colony of each isolate using QIAmp® DNA Mini kit (Qiagen, Hilden, Germany) following the manufacturer's instructions. Confirmation of isolates as non-susceptible to β-lactamases was done by the Carba NP test, the EDTA double-disc synergy test (DDST), and PCR for bla_{VIM-}, bla_{IMP-} and bla_{NDM-}like genes [13-16]. Gram-negative isolates as ESBLs were detected by DDST with aztreonam and amoxicillin plus clavulanate discs [17]. In this study, selected β-lactamase genes, namely bla_{CTX-M-}, bla_{SHV-}, bla_{TEM-}, bla_{OXA-1-} and $bla_{OXA-48-}$like genes, and other genes were detected by PCR as described previously [18]. Cefoxitin-resistant *Staphylococcus aureus* (MRSA) was tested for the presence of the *mec*A gene using PCR, as previously described.

ETHICS

Ethical clearance for this study was obtained from the Ethics Board of the Ukrainian Association of Infection Control and Antimicrobial Resistance. Patients agreed to participate in this study. Participants' data were anonymised prior to the analysis.

STATISTICAL ANALYSIS

All the data entered into the electronic database and analyzed. IBM SPSS and Microsoft Excel (Microsoft Office 2016 Redmond, WA, USA) were used in the statistical analysis of the collected material. Statistical analysis presents descriptive statistics for the characteristics of units, patients, and types of HAI. A descriptive analysis was performed by calculating the number and percentage for each value. Pearson's chi-square test was performed to check the matching performance between the case and comparison groups and compare the differences between groups for categorical variables. In this study, the level of significance was $p < 0.05$.

RESULTS

PREVALENCE AND INCIDENCE OF HAI, AND PATIENT CHARACTERISTICS

During the study period (2022-2024), 5,022 (68.6%) of 7,324 patients with combat wound were found to have HAIs. HAIs cases in military personnel and civilians with combat wound were 68,7% (4657/6782) and 67,3 (365/542), respectively. Of the total cases of HAIs in patients with combat wound, 27.3% [95% confidence interval (CI), 26.8-27.8] were surgical site infections (SSI), 25.6% (95% CI, 25.1-26.1) bone and joint infections (BJ), 15.7% (95% CI, 15.3-16.1) skin and soft tissue infections (SST), 9.7% (95% CI, 9.4-10.1) bloodstream infections (BSI), 7.9% (95% CI, 7.6-8.2) central nervous system infections (CNS), 5.3% (95% CI, 5.1-5.6) pneumonia (PNEU), 4.1% (95% CI, 3.9-4.3) urinary tract infections (UTI), 1.7% (95% CI, 1.6-1.9) Eye, ear, nose, throat, or mouth infections (EENT), and 2.8% other infections (clinical sepsis, lower respiratory infection, other than pneumonia, and cardiovascular system infections) (Table 1).

Among patients with HAIs a mild combat injury was diagnosed in 15.5% of the wounded, severe – in 72.4%,

Table 2. Distribution of pathogens isolated from patients with combat wound infection in Ukraine, 2022-2024

Microorganism	Organisms reported, n (%)								
	All HAI (n=17,286)	SSI (n=1,895)	BJ (n=3,243)	SST (n=3,006)	BSI (n=2,091)	CNS (n=1,956)	PNEU (n=1,838)	UTI (n=2,311)	Other HAI (n=946)
Gram-positive cocci	4,039 (23.4)	531 (13.2)	827 (20.5)	583 (14.4)	666 (16.5)	441 (10.9)	275 (6.8)	532 (13.2)	184 (4.6)
Staphylococcus aureus	881 (21.8)	147 (16.7)	252 (28.6)	117 (13.3)	127 (14.4)	78 (8.9)	37 (4.2)	95 (10.8)	28 (3.2)
CoNS	751 (18.6)	17 (2.3)	39 (5.2)	19 (2.5)	289 (38.5)	118 (15.7)	9 (1.2)	211 (28.1)	49 (6.5)
Enterococcus faecalis	1,037 (25.7)	212 (20.4)	298 (28.7)	311 (30.0)	57 (5.5)	57 (5.5)	27 (2.6)	56 (5.4)	19 (1.8)
Enterococcus faecium	878 (21.7)	129 (14.7)	189 (21.5)	97 (11.0)	132 (15.0)	117 (13.3)	64 (7.3)	89 (10.1)	61 (6.9)
Streptococcus pneumoniae	356 (8.8)	9 (2.5)	27 (7.6)	18 (5.1)	39 (11.0)	58 (16.3)	127 (35.7)	69 (19.4)	9 (2.5)
Other Gram-positive cocci	136 (3.4)	17 (12.5)	22 (16.2)	21 (15.4)	22 (16.2)	13 (9.6)	11 (8.1)	12 (8.8)	18 (13.2)
Gram-negative bacilli	11,894 (68.8)	1,215 (10.2)	2,137 (18.0)	2,232 (18.8)	1,243 (10.5)	1,281 (10.8)	1,446 (12.2)	1,674 (14.1)	666 (5.6)
Enterobacteriales	7,395 (62.2)	757 (10.2)	1,324 (17.9)	1,583 (21.4)	669 (9.0)	648 (8.8)	748 (10.1)	1,227 (16.6)	439 (5.9)
Escherichia coli	2,239 (18.8)	327 (14.6)	578 (25.8)	757 (33.8)	112 (5.0)	94 (4.2)	77 (3.4)	197 (8.8)	97 (4.3)
Enterobacter cloacae	511 (4.3)	97 (19.0)	124 (24.3)	177 (34.6)	23 (4.5)	31 (6.1)	12 (2.3)	29 (5.7)	18 (3.5)
Enterobacter aerogenes	549 (4.6)	88 (16.0)	162 (29.5)	192 (35.0)	19 (3.5)	33 (6.0)	14 (2.6)	27 (4.9)	14 (2.6)
Citrobacter spp.	277 (2.3)	24 (8.7)	77 (27.8)	84 (30.3)	18 (6.5)	28 (10.1)	9 (3.2)	18 (6.5)	19 (6.9)
Klebsiella pneumonia	993 (8.3)	37 (3.7)	71 (7.2)	89 (9.0)	198 (19.9)	135 (13.0)	297 (29.9)	89 (9.0)	77 (7.8)
Klebsiella oxytoca	588 (4.9)	24 (4.1)	38 (6.5)	41 (7.0)	112 (19.0)	117 (19.9)	187 (31.8)	44 (7.5)	25 (4.3)
Proteus vulgaris	377 (3.2)	3 (0.8)	22 (5.8)	18 (4.8)	12 (3.2)	8 (2.1)	7 (1.9)	254 (67.4)	53 (14.1)
Proteus mirabilis	527 (4.4)	14 (2.7)	48 (9.1)	58 (11.0)	18 (3.4)	16 (3.0)	12 (2.3)	312 (59.2)	49 (9.3)
Proteus morganii	279 (2.3)	3 (1.1)	21 (7.5)	18 (6.5)	13 (4.7)	13 (4.7)	8 (2.9)	157 (56.3)	46 (16.5)
Providencia rettgeri	143 (1.2)	2 (1.4)	17 (11.9)	19 (13.3)	6 (4.2)	18 (12.6)	14 (9.8)	49 (34.3)	18 (12.6)
Serratia marcescens	849 (7.1)	137 (16.1)	159 (18.7)	122 (14.4)	127 (15.0)	141 (16.6)	108 (12.7)	41 (4.8)	14 (1.6)
Other Enterobacteriales	63 (0.5)	1 (1.6)	7 (11.1)	8 (12.7)	11 (17.5)	14 (22.2)	3 (4.8)	10 (15.9)	9 (14.3)
Non-fermenting Gram (-) bacteria	4,499 (37.8)	458 (10.2)	813 (18.1)	649 (14.4)	574 (12.8)	633 (14.1)	698 (15.5)	447 (9.9)	227 (5.0)
Acinetobacter lwoffii	512 (4.3)	18 (3.5)	42 (8.2)	29 (5.7)	106 (20.7)	98 (19.1)	139 (27.1)	41 (8.0)	39 (7.6)
Acinetobacter baumannii	987 (8.3)	29 (2.9)	127 (12.9)	84 (8.5)	174 (17.6)	179 (18.1)	202 (20.5)	105 (10.6)	87 (8.8)
Pseudomonas aeruginosa	1,988 (16.7)	299 (15.0)	438 (22.0)	397 (20.0)	148 (7.4)	238 (12.0)	205 (10.3)	197 (9.9)	66 (3.3)
Stenotrophomonas maltophilia	981 (8.2)	112 (11.4)	203 (20.7)	137 (14.0)	142 (14.5)	112 (11.4)	147 (15.0)	97 (9.9)	31 (3.2)

Table 2. Contt.

Other Pseudomonadaceae	31 (0.3)	0 (0)	3 (9.7)	2 (6.5)	4 (12.9)	6 (19.4)	5 (16.1)	7 (22.6)	4 (12.9)
Fungi	1,353 (7.8)	149 (11.0)	279 (20.6)	191 (14.1)	182 (13.5)	234 (17.3)	117 (8.6)	105 (7.8)	96 (7.1)
Candida spp.	1,158 (85.6)	132 (11.4)	211 (18.2)	137 (11.8)	175 (15.1)	212 (18.3)	112 (9.7)	92 (7.9)	87 (7.5)
Aspergillus spp.	164 (12.1)	16 (9.8)	61 (37.2)	49 (29.9)	1 (0.6)	18 (11.0)	2 (1.2)	9 (5.5)	8 (4.9)
Other fungi	31 (2.3)	1 (3.2)	7 (22.6)	5 (16.1)	6 (19.4)	4 (12.9)	3 (9.7)	4 (12.9)	1 (3.2)

HAI, Healthcare-associated infections; SSI, Surgical site infection; BJ, Bone and joint infection, SST, Skin and soft tissue; BSI, Bloodstream infection; CNS, Central nervous system; PNEU, Pneumonia; UTI, Urinary tract infection
Source: compiled by the authors of this study

extremely severe – in 12.1%. The most common combat wounds were shrapnel wounds (78.1%), bullet wounds (9.4%), explosive injury (8.4%), and burns (3.1%). Isolated combat wound was diagnosed in only 4.3% of observations. Most often, a combat injury was combined with injuries to the limbs (68.7%) and chest (51.4%). Head injuries and fractured among patients' bones were in 9.5% and 8.9%, respectively. Thoraco-abdominal wounds among patients with HAIs were found in 12.3% of the wounded. Most combat wounds (93.1%) in patients were classified as contaminated or considered to be dirty or infected. No combat wounds that belong to class 1 wounds were found. Combat wounds classified as class 2 wounds were found in 6.3% of patients. In this study, 22.9% of HAIs cases developed due as contaminated combat wound, and 77.1% from inadequate treatment of traumatic wounds, gross purulence, and evident infections, and MDROs found in combat wound in military personnel and civilians.

The incidence of HAIs was highest among patients with combat wounds admitted to intensive care units (ICUs). The most common HAI types in the ICU among patients with combat wound were respiratory infections and BSIs, while SSIs were the most common infection type in surgery and traumatology departments. In this study the strongest independent associations with HAIs were observed for intubation, urinary and vascular catheters. Most cases of pneumonia and UTI among patients with combat wounds were device-associated, and of BSIs were central-line-associated. During the study period, an increase in the incidence of HAI was observed ($P < 0.0012$), which was significantly associated with an increase in the incidence of ventilator-associated pneumonia (17.9%), catheter-associated bloodstream infections (15.3%), and SSI (11.4%). The prevalence of HAI in patients with combat wound varied widely within the Ukraine. An increase in the incidence of HAIs was observed in southern (Odesa, Dnipro) and eastern region (Kharkiv) of Ukraine.

ANTIMICROBIAL RESISTANCE OF RESPONSIBLE PATHOGENS

During study period in total, 17,286 organisms were isolated from 5,022 patients with HAIs (Table 2). Among 5,022 patients with HAIs, 874 (17.4%) had only monomicrobial infections and 4,148 (82.6%) had polymicrobial infections. A higher proportion of patients with monomicrobial HAIs had only one combat wound with an infected wound and associated microbiology data compared to polymicrobial patients with infections ($p<0.009$). Patients with polymicrobial HAIs had higher injury severity ($p<0.007$) and a greater number were admitted to the ICU ($p<0.012$). The most common bacterial isolates during study period were *Escherichia coli* (13%), *Pseudomonas aeruginosa* (11.5%), *Enterococcus faecalis* (6%), *Klebsiella pneumonia* (5.7%), *Acinetobacter baumannii* (5.7%), *Stenotrophomonas maltophilia* (5.7%), *Staphylococcus aureus* (5.1%), *Enterococcus faecium* (5.1%), and *Serratia marcescens* (4.9%). Gram-positive bacteria were the most common causes of BJ, SST, SSIs and BSIs, and Gram-negative bacteria were the most common causes of pneumonia, UTIs, and CNS infections. (Table 2).

In this study, antimicrobial susceptibility testing data were available for all pathogens causing HAI in patients with combat wound infections. Among the gram-positive bacteria, that 44.6% and 17.3% of coagulase-negative staphylococci (CoNS) isolates were b-lactam (oxacillin) – and glycopeptide (teicoplanin)-resistant, respectively. Meticillin resistance of *S. aureus* (MRSA) and vancomycin resistance of enterococci was found in 43.9% and in 18.1% strains, respectively. MRSA is based on cefoxitin. Data from molecular confirmation tests (detection of *mec*A gene by polymerase chain reaction or positive PBP2A-agglutination test) are prioritized over phenotypic antibiotic susceptibility-testing results. Third-generation cephalosporins (cefotaxime or ceftazidime) resistance was found in 81.6% of *K. pneumoniae*

Table 3. Distribution of pathogens isolated from patients with combat wound infection and antimicrobial resistance phenotype by bacterial species and antimicrobial group/agent, Ukraine, 2022-2024

Pathogen	Antimicrobial group/agent	AMR, n/%
Escherichia coli	Aminopenicillin (amoxicillin/ampicillin) resistance	1,721 (76.9)
	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	1,133 (51.6)
	Carbapenem (imipenem/meropenem) resistance	499 (22.3)
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	1,032 (46.1)
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance	636 (28.4)
	Combined resistance to third-generation cephalosporins, fluoroquinolones, and aminoglycosides	385 (17.2)
Klebsiella pneumoniae	Third-generation cephalosporin (cefotaxime/ceftriaxone/ceftazidime) resistance	810 (81.6)
	Carbapenem (imipenem/meropenem) resistance	594 (59.8)
	Fluoroquinolone (ciprofloxacin/levofloxacin/ofloxacin) resistance	787 (79.3)
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance	723 (72.8)
	Combined resistance to fluoroquinolones, third-generation cephalosporins, and aminoglycosides	642 (64.7)
Pseudomonas aeruginosa	Piperacillin-tazobactam resistance	1,068 (53.7)
	Ceftazidime resistance	1,019 (51.3)
	Carbapenem (imipenem/meropenem) resistance	1,440 (72.4)
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	1,388 (69.8)
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance	1,318 (66.3)
	Combined resistance to ≥3 antimicrobial groups (among piperacillin-tazobactam, ceftazidime, carbapenems, fluoroquinolones, and aminoglycosides)	1,215 (61.1)
Acinetobacter baumannii	Carbapenem (imipenem/meropenem) resistance	811 (81.2)
	Fluoroquinolone (ciprofloxacin/levofloxacin) resistance	915 (92.7)
	Aminoglycoside (gentamicin/netilmicin/tobramycin) resistance	887 (89.9)
	Combined resistance to carbapenems, fluoroquinolones, and aminoglycosidesc	748 (75.8)
Staphylococcus aureus	Meticillin-resistant S. aureus	387 (43.9)
Streptococcus pneumoniae	Penicillin non-wild-type	38 (10.7)
	Macrolide (azithromycin/clarithromycin/erythromycin) resistance	35 (9.8)
	Combined penicillin non-wild-type and resistance to macrolidesc	31 (8.7)
Enterococcus faecalis	High-level gentamicin resistance	659 (63.5)
Enterococcus faecium	Vancomycin resistance	159 (18.1)

Source: compiled by the authors of this study

and in 51.6% of *E coli* isolates. Carbapenem resistance was reported in 59.8% of *K. pneumoniae* and in 72.4% of *P aeruginosa*, and in 81.2% of *A. baumannii* isolates. Distribution of pathogens isolated from patients with combat wound infection and antimicrobial resistance phenotype by bacterial species and antimicrobial group/agent, are presented in Table 3.

MOLECULAR CHARACTERIZATION OF ANTIMICROBIAL RESISTANCE GENES

In present study, of the 17,286 strains isolated from patients with combat wound infection, 88.9% were found to be MDROs, predominantly, *A. baumannii* (75.8%), *K. pneumoniae* (64.7%), *P. aeruginosa* (61.1%), *S. aureus* (43.9%), *E. coli* (17.2%), *E. faecium* (18.1%), *S. maltophilia* (22.5%), *Enterobacter* spp. (17.9%), *S. marcescens* (19.3%), *P. mirabilis* (14.8%), CoNS (17.3%), *Citrobacter* spp. (11.8%), and other species (5.2%).

In this study, by PCR amplification, 43.7% of the MDROs showed the presence of β-lactamase genes, including AmpC, bla_{KPC}, bla_{NDM-1}, bla_{CTX-M}, bla_{OXA-1}, bla_{OXA-10}, bla_{OXA-20}, bla_{OXA-23}, bla_{OXA-24}, bla_{OXA-30}, bla_{OXA-40}, bla_{OXA-48}, bla_{OXA-51}, bla_{OXA-58}, $bla_{OXA-143}$, bla_{SHV}, bla_{SIM}, bla_{TEM}, bla_{IMP-1}, bla_{VIM-1}, and bla_{VIM-2}. Overall, a significant number of the MDROs isolated from patients with combat

Table 4. Distribution of β-lactamase genes among multidrug-resistant organisms (MDROs) isolated from patients with combat wound infection in Ukraine, 2022-2024

Pathogen	Antibiotic resistance genes carried by isolates
Klebsiella pneumoniae	AmpC, bla_{CTX-M}, bla_{KPC}, bla_{NDM-1}, bla_{OXA-1}, bla_{OXA-10}, bla_{OXA-20}, bla_{OXA-23}, bla_{OXA-24}, bla_{OXA-30}, bla_{OXA-40}, bla_{OXA-48}, bla_{OXA-51}, bla_{OXA-58}, $bla_{OXA-143}$, bla_{SHV-1}, bla_{TEM-1}, bla_{SIM-1}, bla_{VIM-2}
Escherichia coli	AmpC, bla_{CTX-M}, bla_{KPC}, bla_{NDM-1}, bla_{OXA-1}, bla_{OXA-10}, bla_{OXA-20}, bla_{OXA-23}, bla_{OXA-24}, bla_{OXA-30}, bla_{OXA-40}, bla_{OXA-48}, bla_{OXA-51}, bla_{OXA-58}, $bla_{OXA-143}$, bla_{SHV-1}, bla_{TEM-1}, bla_{SIM-1}, bla_{VIM-2}
Pseudomonas aeruginosa	AmpC, bla_{CTX-M}, bla_{KPC}, bla_{NDM-1}, bla_{OXA-1}, bla_{OXA-10}, bla_{OXA-20}, bla_{OXA-23}, bla_{OXA-24}, bla_{OXA-30}, bla_{OXA-40}, bla_{OXA-48}, bla_{OXA-51}, bla_{OXA-58}, $bla_{OXA-143}$, bla_{SHV-1}, bla_{TEM-1}, bla_{SIM-1}, bla_{IMP-1}, bla_{VIM-2}
Enterobacter aerogenes	AmpC, bla_{CTX-M}, bla_{KPC}, bla_{NDM-1}, bla_{OXA-1}, bla_{OXA-10}, bla_{OXA-20}, bla_{OXA-23}, bla_{OXA-24}, bla_{OXA-30}, bla_{OXA-40}, bla_{OXA-48}, bla_{OXA-51}, bla_{OXA-58}, $bla_{OXA-143}$, bla_{SHV-1}, bla_{TEM-1}, bla_{SIM-1}, bla_{VIM-2}
Enterobacter cloacae	AmpC, bla_{CTX-M}, bla_{KPC}, bla_{NDM-1}, bla_{OXA-1}, bla_{OXA-10}, bla_{OXA-20}, bla_{OXA-23}, bla_{OXA-24}, bla_{OXA-30}, bla_{OXA-40}, bla_{OXA-48}, bla_{OXA-51}, bla_{OXA-58}, $bla_{OXA-143}$, bla_{SHV-1}, bla_{TEM-1}, bla_{SIM-1}, bla_{VIM-1}
Serratia marcescens	AmpC, bla_{CTX-M}, bla_{KPC}, bla_{NDM-1}, bla_{OXA-1}, bla_{OXA-23}, bla_{OXA-48}, bla_{OXA-51}, bla_{OXA-58}, $bla_{OXA-143}$, bla_{SHV-1}, bla_{TEM-1}, bla_{SIM-1}, bla_{VIM-2}
Proteus mirabilis	AmpC, bla_{CTX-M}, bla_{KPC}, bla_{NDM-1}, bla_{OXA-1}, bla_{OXA-23}, bla_{OXA-48}, bla_{OXA-51}, bla_{OXA-58}, $bla_{OXA-143}$, bla_{SHV-1}, bla_{TEM-1}, bla_{SIM-1}, bla_{VIM-1}
Acinetobacter baumannii	AmpC, bla_{CTX-M}, bla_{KPC}, bla_{NDM-1}, bla_{OXA-1}, bla_{OXA-10}, bla_{OXA-20}, bla_{OXA-23}, bla_{OXA-24}, bla_{OXA-30}, bla_{OXA-40}, bla_{OXA-48}, bla_{OXA-51}, bla_{OXA-58}, $bla_{OXA-143}$, bla_{SHV-1}, bla_{TEM-1}, bla_{SIM-1}, bla_{VIM-2}

Source: compiled by the authors of this study

wound infections had β-lactamase genes, including extended-spectrum β-lactamase (ESBL) (53.1%), OXA-type (32.9%), AmpC-type (35.7%), KPC-type (31.8%), and metallo-β-lactamases (51.4%) including IMP-type (18.5%), VIM-type (29.6%), and NDM-1 (34.7%). Among ESBLs bla_{TEM} was the commonest genotype (43.6 %), followed by $bla S_{HV}$, and bla_{CTX-M}. Most ESBL genes were identified in *K. pneumoniae* (78.2%), *E. coli* (51.2%), *E. cloacae* (48.3%), *P. mirabilis* (46.8%), *S.marcescens* (47.9%), and *E. aerogenes* (35.7%). The OXA-type ESBLs were identified in *P.aeruginosa* (44.2%) and *A. baumannii* (35.1%). AmpC-type β-lactamases were isolated from extended-spectrum cephalosporin-resistant Gram-negative bacteria (36.8%), including *E. aerogenes*, *A. baumannii*, *E. cloacae*, *S. marcescens*, *P. mirabilis, K. pneumoniae, P. aeruginosa*, and *E. coli*. In this study, Verona integron-encoded metallo-β-lactamase (VIM) and KPC-type carbapenemases were detected in 29.3% and 36.7% of isolates, respectively. In this study, OXA type β-lactamases and New Delhi metallo-β-lactamase (NDM-1) were detected in 41.1% and 32.7% of isolates, respectively. Characteristics of β-lactamase genes among MDROs isolated from patients with combat wound infection is presented in Table 4.

DISCUSSION

This study is based on multicentre prospective surveillance data for HAI and AMR of responsible pathogens in Ukraine. The aims of this study were to estimate the prevalence and incidence of HAIs in patients with combat wounds, and to determine phenotypic and genotypic aspects of antimicrobial resistance of the responsible pathogens in Ukraine. Our study expands upon the previous reports on HAI [4,5, 19,20] and is the first study to publish of prevalence and incidence of HAIs, and frequent pathogens and/or characterization of the phenotypic and genotypic mechanisms of responsible pathogens of HAI isolated from patients with combat wound in Ukraine.

In this study, the most common combat wounds were shrapnel wounds, bullet wounds, explosive injury, and burns. Most often, a combat injury was combined with injuries to the limbs, head injuries and fractured among patients' bones. This survey identified a high prevalence of HAI (68.6%) in patients with combat wound infections. It is well known that combat wounds are often characterized by high contamination rates, significant soft tissue damage, and the potential for severe complications like infection. A previous study reported that approximately 34% of the patients with combat wound at US hospitals developed a trauma-related infection during their initial hospitalization with skin and soft-tissue infections being predominant. Among this study cohort, 38% developed a new trauma-related infection with the incident infection being diagnosed following hospital discharge [1, 21]. On an infection level in patients with wounds, the majority were SST (45%) followed by PNEU (14%) and BSI (14%) [1]. In our study, of the all cases of HAIs in patients with combat wound, 27.3% were SSI, 25.6% BJ, 15.7% SST, 9.7% BSI, 7.9% CNS, 5.3% PNEU, 4.1% UTI, 1.7% EENT, and 2.8% other infections (clinical

sepsis, lower respiratory infection, other than pneumonia, and cardiovascular system infections). This study showed that combat wounds are much more complex because of higher contamination, mostly resulting from the environment where the wound occurred. Therefore, rapid wound healing time or surgical closure is indicated because of risk of infection [22].

The surgical wound classification was created to represent the bacterial load in a surgical field [23]. According to this classification, each class has a postoperative risk of a SSI with scores of 1% to 5% (Class 1, wounds are categorized as clean wounds), 3% to 11% (Class 2, wounds are categorized as clean-contaminated), 10% to 17% (Class 3, classified as contaminated), and more than 27% (Class 4, considered to be dirty or infected), respectively [24]. In our study, most combat wounds (93.1%) in patients with HAI were classified as contaminated or considered to be dirty or infected. No combat wounds that belong to class 1 wounds were found. Combat wounds classified as class 2 wounds were found in 6.3% of patients. In this study, 22.9% of HAIs cases developed due as contaminated combat wound, and 77.1% from inadequate treatment of traumatic wounds, gross purulence, and evident infections, and MDROs found in combat wound in military personnel and civilians.

According to the literature, during wars in Iraq and Afghanistan, improved survivability in severe trauma corresponded with a rise in the proportion of trauma-related infections, including those associated with MDROs [1]. It has been highlighted in recent studies that there has been an increase in antibiotic-resistant pathogens since the start of the Eastern Ukraine military conflict [6]. This was also observed in conflicts in Iraq [25], Syria [26], Congo [27] and Gaza [28]. AMR is a problem with no borders, especially in a war context. Nevertheless, limited research was conducted on the potential impacts of the Eastern Ukraine military conflict on AMR problem (AMR formation in microorganisms and transmission). Migration indirectly contributes to AMR formation and spread worldwide. Several publications highlighted gaps in such services as infection control, caused by limited resources and personnel, are exacerbating the transmission of MDROs in Ukraine [4, 5, 19, 20]. Therefore, healthcare networks in Europe now consider prior hospitalization in Ukraine to be a critical risk factor for colonization of MDROs [6, 29,30]. Previous reports from Eastern Ukraine military conflict zone have noted the emergence of multidrug-resistant (MDR) *Acinetobacter baumanii*, *Pseudomonas aeruginosa*, and *Enterobacterales* infections during hospitalization in Ukraine [10]. Those strains encompassed a variety of clonal lineages, with many carrying carbapenemases, extended-spectrum β-lactamases (ESBLs) [10]. Mc Gann PT, et al [11] reported that blood and surveillance cultures from an injured service member from Ukraine grew *A. baumannii*, *K.pneumoniae*, *E.faecium*, and three distinct *Pseudomonas aeruginosa* strains. Isolates were non-susceptible to most antibiotics and carried an array of β-lactamase genes, including carbapenemases (bla_{IMP-1}, bla_{NDM-1}, bla_{OXA-23}, bla_{OXA-48}, bla_{OXA-72}) [11].

In our study, many combat wound infections are polymicrobial. Among military personnel and civilians with severe combat trauma who survived, there was a corresponding rise in infectious complications caused MDROs. Previous studies (2021) have shown that in 85.1% isolates from patients were found to be MDROs [4]. In present study, 88.9% strains isolated from patients with combat wound infection were found to be MDROs, predominantly, *A. baumannii* (75.8%), *K. pneumoniae* (64.7%), *P. aeruginosa* (61.1%), *S. aureus* (43.9%), *E. coli* (17.2%), *E. faecium* (18.1%), *S. maltophilia* (22.5%), *Enterobacter* spp. (17.9%), *S. marcescens* (19.3%), *P.mirabilis* (14.8%), CoNS (17.3%), *Citrobacter* spp. (11.8%), and other species (5.2%). By PCR amplification, 43.7% of the MDROs showed the presence of β-lactamase genes, including AmpC, bla_{KPC}, bla_{NDM-1}, bla_{CTX-M}, bla_{OXA-1}, bla_{OXA-10}, bla_{OXA-20}, bla_{OXA-23}, bla_{OXA-24}, bla_{OXA-30}, bla_{OXA-40}, bla_{OXA-48}, bla_{OXA-51}, bla_{OXA-58}, $bla_{OXA-143}$, bla_{SHV}, bla_{SIM}, bla_{TEM}, bla_{IMP-1}, bla_{VIM-1}, and bla_{VIM-2}. Overall, a significant number of the MDROs isolated from patients with combat wound infections had β-lactamase genes, including extended-spectrum β-lactamase (ESBL) (53.1%), OXA-type (32.9%), AmpC-type (35.7%), KPC-type (31.8%), and metallo-β-lactamases (51.4%) including IMP-type (18.5%), VIM-type (29.6%), and NDM-1 (34.7%). Previous studies have shown that in Ukrainian hospitals many hightouch surfaces in hospital wards and healthcare workers (HCWs) were contaminated with MDROs, including strains with similar AMR phenotypes and genotypes [4, 5]. Our results are consistent with those of previous studies on MDROs and presence of β-lactamase genes, including ESBL, OXA-type, AmpC-type, KPC-type, and metallo-β-lactamases including IMP-type, VIM-type, and NDM-1. This confirms that MDROs isolated from patients with combat wound infections in Ukrainian hospitals are spread principally by transmission between HCWs and patients, and between HCWs nd the hospital environment.

STRENGTH AND LIMITATIONS

One strength of our study was that it was a prospective multi-centre observational cohort study, based on HAI and AMR surveillance data for patients with combat wound. Also, this was the first study of phenotypic

and genotypic characterization of antibiotic resistance in MDROs isolated from patients with combat wound infection in Ukrainian civil hospitals. Limitations of the study included that it was conducted in civilian hospitals for adult patients with combat wound only, and the prevalence of HAI and dissemination of MDROs in Ukrainian children's hospitals was not investigated.

CONCLUSIONS

This study found a high prevalence of HAI in patients with combat wounds caused by MDROs, varying depending on the bacterial species, and antimicrobial group. The majority of MDRO isolates from patients with HAI carried β-lactamase genes. The prevalence of MDROs in Ukrainian hospitals continues to increase, while infection control gaps in healthcare settings facilitate their transmission between patients. Although military conflict in Ukraine is ongoing, analysis of infection-related data remains critical to optimizing current clinical practice guidelines with the overall goal of improving outcomes for combat-wounded military personnel and civilians. There is a need to sustain HAIs and MDROs isolated from patients with combat wounds research to improve care readiness (i.e., prevention and treatment of infections) for military conflicts.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Peculiarities of changes in the level of vitamins B in patients with gastroesophageal reflux disease metabolic-associated fatty liver disease

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ABSTRACT

Aim: To determine the peculiarities of changes in the levels of B vitamins and their dependence on body mass index (BMI) in patients with GERD and metabolic dysfunction-associated fatty liver disease (MDAFLD).

Materials and Methods: 112 patients with GERD were examined. Patients were divided into two groups. Group 1 included 50 patients with GERD, and group 2 consisted of 62 patients with GERD in combination with MDAFLD. The level of homocysteine and B vitamins in the blood serum was determined.

Results: At patients group 1 were diagnosed the decreased levels of B6 and B12 in blood serum against a background of a slight increase in homocysteine levels in blood serum (up to 17.9±0.7 umol/l – $p<0.05$). In patients in group 2, a significant decrease in all B vitamins examined in the blood serum was found, accompanied by a significant increase in homocysteine levels (2.4 times – $p<0.01$).

Conclusions: In the vast majority of patients with GERD and MDAFLD, an increase in BMI was found, namely, overweight in 25.8% ($p < 0.01$) of patients and grade I obesity (in 37.1% of patients – $p < 0.001$). In patients with GERD and MDAFLD, a significant decrease in serum levels of B vitamins (B1, B3, B6, B9, B12) was found, which correlates negatively with overweight and obesity in these patients.

KEY WORDS: metabolic dysfunction-associated fatty liver disease (non-alcoholic fatty liver disease), gastroesophageal reflux disease, obesity, B vitamins, homocysteine

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INTRODUCTION

Non-alcoholic fatty liver disease (NAFLD) is the most common liver pathology worldwide, affecting 20-30% of the global population [1, 2]. Non-alcoholic fatty liver disease is characterised by the accumulation of macrovacuolar fat in the liver in individuals with no history of other aetiological factors, including excessive alcohol consumption. In the context of the obesity pandemic, according to experts, NAFLD affects more than 64 million people in the United States [3]. It has been established that NAFLD can not only progress to cirrhosis and even liver cancer, but is also closely associated with an increased risk of serious extrahepatic diseases, such as cardiovascular disease (CVD) and metabolic syndrome (MS). People with NAFLD are twice as likely to die from CVD than from liver disease. In light of the above information, a new definition has recently been proposed, called metabolic dysfunction associated with fatty liver disease (MDAFLD). To diagnose MDAFLD, it is no longer necessary to rule out other liver diseases, such as excessive alcohol consumption, viral hepatitis infection, and autoimmune liver diseases. Metabolic dysfunction is necessary for the correct verification of the diagnosis of MDAFLD [4, 5].

Gastroesophageal reflux disease (GERD) is a disease of the upper gastrointestinal tract characterised by reflux of stomach contents into the oesophagus and manifested by symptoms such as heartburn, belching and dysphagia. GERD is more commonly diagnosed in Western countries with high economic development, where its prevalence is estimated at 20%, compared to <5% in Asian countries [3]. The prevalence of GERD is about 13%, and unsatisfactory treatment results negatively affect the quality of life of such patients. Metabolic syndrome has been shown to be both an independent risk factor for GERD and a well-known risk factor for fatty liver disease [1].

There are no specific drugs for the treatment of NAFLD. Lifestyle modification remains the most effective long-term method of correction, and dietary recommendations are widely considered to be its basis [6, 7]. Given the significant impact of vitamins on the immune

system and their potential to influence NAFLD, it is advisable to investigate the role and level of vitamin intake in the diet of such patients. Some studies have examined the role of vitamins D, C, and E in the treatment of NAFLD [8, 9], but there is a lack of research on B vitamins and NAFLD, especially in the context of comorbidities with GERD.

AIM

To determine the peculiarities of changes in the levels of B vitamins and their dependence on body mass index (BMI) in patients with GERD and metabolic dysfunction-associated fatty liver disease (MDAFLD).

MATERIALS AND METHODS

At the clinical base of the Department of Procedure of Internal Diseases, 112 patients with GERD were examined. The examined patients with GERD for the period 2020 to 2025 were treated in the gastroenterological and endocrinological departments of the Municipal Non-Profit Enterprise «Andriy Novak Transcarpathian Regional Clinical Hospital» of the Transcarpathian Regional Council.

Patients were divided into two groups. Group 1 included 50 patients with GERD, and group 2 consisted of 62 patients with GERD in combination with MDAFLD. Among the examined patients of group 1, there were 25 (50.0 %) men, with an average age of 42.9±4.5 years; there were 25 (50.0 %) women, with an average age of 39.9±6.1 years. Among the examined patients of group 2, there were 39 (62.9 %) men, with an average age of 30.7±4.9 years; there were 23 (37.1 %) women, with an average age of 28.9±5.6 years. The control group included 30 healthy individuals (19 (56.7 %) men and 11 (43.3 %) women). The average age was 35.5±4.7 years.

The studies were conducted with patient approval (written authorization for relevant diagnostic procedures and therapeutic interventions was secured from all participants and control group members) while implementing comprehensive measures to maintain confidentiality of the collected data. The research methodology complied with the 1975 Helsinki Declaration on Human Rights and its 1983 revision, the Council of Europe Convention on Human Rights and Biomedicine, as well as Ukrainian legal requirements.

GERD diagnosis was established based on the unified clinical protocol criteria (Ministry of Health of Ukraine order No. 943 dated 31.10.2013) incorporating patient symptoms, endoscopic findings, and other relevant data. For diagnostic confirmation, study participants underwent fibroesophagogastroduodenoscopy (FEGDS) utilizing Pentax ERM-3300 video processor endoscopy equipment and Pentax E-2430, GIF-K20 flexible fiber endoscopes. Additionally, 24-hour pH monitoring was conducted following Prof. V.N. Chernobrovy's methodology. Endoscopic evaluation of esophageal damage severity employed the Los Angeles (LA) classification system (1998): Grade A – single (or multiple) mucosal defect measuring 5 mm or less, not extending between mucosal fold summits; Grade B – single (or multiple) mucosal defect exceeding 5 mm in length, not extending between mucosal fold summits; Grade C – single (or multiple) mucosal defect bridging two or more mucosal fold summits while affecting less than 75% of the circumference; Grade D – single (or multiple) mucosal defect encompassing at least 75% of the esophageal circumference.

MDAFLD diagnosis was established following the criteria outlined in the unified clinical protocol (Ministry of Health of Ukraine Order No. 826 dated 06.11.2014) and the EASL-EASD-EASO clinical recommendations for managing and treating such patients. The extent of hepatic impairment was assessed utilizing web-based calculators including NAFLD fibrosis score (NFS), Fibrosis 4 calculator (FIB-4), fibrotest, FibroIndex, Forns, APRI, along with hepatic elastometry findings.

All study participants underwent comprehensive evaluation using general clinical, anthropometric, instrumental, and laboratory techniques. To confirm the diagnosis, detailed patient complaints and medical history were thoroughly documented. Anthropometric assessment included measurements of height, weight, and waist circumference, with subsequent BMI calculation. Following WHO guidelines, participants were categorized based on BMI values: 16.0 or below indicated severe underweight; 16.0-18.5 represented underweight; 18.0-24.9 denoted normal weight; 25.0-29.9 signified overweight; 30.0-34.9 corresponded to first-degree obesity; 35.0-39.9 indicated second-degree obesity; 40.0 and above represented third-degree obesity.

The exclusion criteria were as follows: age under 18 years and over 70 years, liver damage due to viral (hepatitis B, C, D viruses), alcohol etiology; haemochromatosis; Wilson-Conovalov disease; oesophageal adenocarcinoma; stomach or duodenal ulcer; systemic autoimmune diseases; oncological diseases; pulmonary tuberculosis; psychiatric diseases that do not allow adequate assessment of the patient's health status and signing an informed consent for diagnosis and treatment; pregnancy and lactation; acute myocardial infarction, stroke (in the history of up to 6 months).

Serum homocysteine levels were determined in all study participants using the Cobas 8000 testing

platform (Roche Diagnostics), alongside B vitamin assessments: vitamin B1 (thiamine), vitamin B3 (niacin) and vitamin B6 (pyridoxine) were analyzed through high-performance liquid chromatography utilizing test kits (Recipe Complete Kit, Germany); vitamin B9 (folic acid) was measured via immunochemical methodology with electrochemiluminescent detection employing the Roche Diagnostics testing platform (Switzerland), while vitamin B12 (cyanocobalamin) was quantified through immunochemical chemiluminescent detection using the Abbott Diagnostics testing platform (USA).

The analysis and processing of the results of the examined patients were performed with the help of the computer program STATISTICA 10.0 (StatSoft Inc, USA) using parametric and non-parametric methods of evaluation of the results.

RESULTS

Changes in body mass index in the examined patients were assessed – Table 1.

Analysis of the anthropometric data obtained indicates a predominance of individuals with grade I obesity among patients in group 2 (in 37.1% of those examined – $p < 0.001$), while in group 1, patients with excess body weight were more common (44.0% of patients – $p < 0.01$). It should be noted that no patients with grade III obesity were diagnosed in group 1, while 6.4% of patients in group 2 were diagnosed with grade III obesity. Only in group 1 were patients with body mass deficit and significant body weight deficiency. When analysing the anamnestic data, it was during the stage of weight loss (among patients in group 1) that the onset of clinical manifestations of GERD was diagnosed.

The levels of B vitamins and homocysteine in the blood serum of the examined patients were assessed – Table 2.

At patients group 1 with GERD were diagnosed the decreased levels of B6 and B12 in blood serum against a background of a slight increase in homocysteine levels in blood serum (up to 17.9±0.7 umol/l, compared to 11.8±0.9 umol/l in the control group – $p<0.05$). The levels of vitamins B1, B3 and B9 in the blood serum of patients in group 1 also tended to decrease compared to those in the control group, but did not exceed the reference values.

In patients in group 2 (GERD combined with MDAFLD), a significant decrease in all B vitamins examined in the blood serum was found, accompanied by a significant increase in homocysteine levels (2.4 times – $p<0.01$).

A statistical analysis was performed to assess the relationship between vitamin levels and BMI at the examined patients – Table 3, 4.

Correlation analysis indicates a relationship between changes in BMI and levels of B vitamins. At the same time, a decrease in B vitamin levels correlates negatively with excess body weight and obesity of varying severity, predominantly in patients in group 2. Homocysteine levels are directly dependent on BMI, which corresponds to overweight and grade I obesity (in patients in group 1), as well as on an increase in BMI (overweight and grades I-II obesity) in patients in group 2.

Thus, our data indicate a relationship between increased body weight and decreased levels of B vitamins in blood serum in GERD combined with NAFLD.

DISCUSSION

A lot of cohort and observational studies have displayed that people suffering from NAFLD had a higher susceptibility to GERD, and one clinical trial indicated that the risk of reflux esophagitis would increase 16% among people with NAFLD (OR 1.16 95% CI 1.13–1.20) as compared to those without NAFLD9,10,11,12. In addition, a meta-analysis showed that the incidence of NAFLD was higher in people with GERD compared with healthy individuals, with an amalgamated OR of 2.07 (OR 2.07 95% CI, 1.54–2.79) [10].

Catanzaro R. and colleagues (2014) show that the prevalence of typical GERD symptoms is higher in patients with NAFLD. GERD was associated with higher BMI and metabolic status, but not with age and type 2 diabetes. According to these results, MetS can be considered as a common background, but it cannot fully explain this correlation. The authors suggest that NAFLD is an independent risk factor for the development of GERD symptoms [11].

Diet plays a significant role in choosing treatment tactics for patients with NAFLD. However, clinical studies on the consumption of foods rich in B vitamins, particularly in cases of concomitant GERD, are insufficiently studied.

The following compounds belong to the water-soluble B vitamins: vitamin B1 (thiamine), vitamin B2 (riboflavin), vitamin B3 (niacin), vitamin B5 (pantothenic acid), vitamin B6 (pyridoxine), vitamin B7 (biotin), vitamin B9 (folic acid), vitamin B12 (cyanocobalamin). However, only the levels of individual B vitamins have been studied in patients with NAFLD. Vitamins B1 and B2 and their active coenzymes (thiamine pyrophosphate and flavin adenine dinucleotide) play an important role in the catabolism of carbohydrates and fatty acids. The study found that premenopausal women, compared to postmenopausal women, are unable to synthesise choline (vitamin B4) through the endogenous pathway catalysed by phosphatidyl ethanolamine N-methyltransferase due to the absence or reduction of oestrogen levels [12]. The authors associate more severe fibrosis in

Table 1. Distribution of examined patients depending on BMI

Indicator	Examined patients	
	Group 1 (n=50) Absolute number / %	Group 2 (n=62) Absolute number / %
Significant body weight deficiency (BMI: less than 16.0)	1 / 2.0 %	_
Body mass deficit (BMI: 16.0–18.5)	5 / 10.0 %	_
Normal weight (BMI: 18.5 – 24.9)	16 / 32.0 % *	7 / 11.3 %
Overweight (BMI: 25.0 – 29.9)	22 / 44.0 % *	16 / 25.8 %
Obesity, grade I (BMI: 30.0 – 34.9)	4 / 8.0 %	23 / 37.1 % **
Obesity, grade II (BMI: 35.0 – 39.9)	2 / 4.0 %	12 / 19.4 %
Obesity, grade III (BMI: more than 40.0)	_	4 / 6.4 %

Note: statistically significant difference between indicators in patients in groups 1 and 2: * – $p < 0.01$; ** - $p < 0.001$
Source: compiled by the authors of this study

Table 2. Levels of B vitamins and homocysteine in the blood serum of the examined patients

Indicator	Reference values	Examined subjectes		
		Control group (n=20)	Group 1 (n=50)	Group 2 (n=62)
Vitamin B1, nmol/l	40.0-80.0	65.3±1.7	46.5±0.7+	31.8±0.6++*
Vitamin B3, umol/l	4.7-8.34	7.2±0.8	5.5±0.3+	2.9±0.4++*
Vitamin B6, ug/ml	14.6-72.8	58.9±2.4	13.9±1.1++	9.3±0.3+++*
Vitamin B9, ng/ml	3.0-17.0	12.6±0.6	4.8±0.2++	2.2±0.3+++**
Vitamin B12, pg/ml	197.0-771.0	621.5±5.7	188.5±3.2+++	143.7±2.5+++*
Homocysteine, umol/l	5.0-15.0	11.8±0.9	17.9±0.7+	28.3±0.4++*

Note: differences between the control group and the examined patients are significant: + – $p<0.05$; ++ – $p<0.01$; +++ – $p<0.001$; the difference between the indicators in patients of groups 1 and 2 is statistically significant: * – $p<0.05$; ** – $p<0.01$
Source: compiled by the authors of this study

Table 3. Comparison of BMI with levels of B vitamins and homocysteine in examined patients of group 1

Indicator	Examined patients of group 1		
	Normal weight	Overweight	Obesity, grade I
Vitamin B1	_	_	r= -0,70; p<0,05
Vitamin B3	_	_	r= -0,76; p<0,05
Vitamin B6	r= 0,66; p<0,05	r= -0,68; p<0,05	r= -0,80; p<0,01
Vitamin B9	_	r= -0,70; p<0,05	r= -0,74; p<0,05
Vitamin B12	r= 0,70; p<0,05	r= -0,74; p<0,05	r= -0,78; p<0,01
Homocysteine	r= -0,78; p<0,01	r= 0,70; p<0,05	r= 0,76; p<0,01

Source: compiled by the authors of this study

postmenopausal women with low choline intake. Vitamin B3 (niacin) is a precursor of the coenzyme nicotinamide adenine dinucleotide and nicotinamide adenine dinucleotide phosphate and is considered a possible option for the treatment of NAFLD. However, the relationship between vitamin B12, vitamin B9 and NAFLD is currently under debate due to the lack of clinical evidence of their possible positive effects in NAFLD [13-15].

A study conducted by Dr. Tripathi and his colleagues investigated the effects of vitamin B12 and folates in dietary models of mice and Cbs knockout mice, as well as in 36 patients and primates. After adding folates and vitamin

Table 4. Comparison of BMI with levels of B vitamins and homocysteine in examined patients of group 2

Indicator	Examined patients of group 2			
	Normal weight	Overweight	Obesity, grade I	Obesity, grade II
Vitamin B1	_	r= -0,54; p<0,05	r= -0,74; p<0,05	r= -0,78; p<0,01
Vitamin B3	_	r= -0,68; p<0,05	r= -0,82; p<0,01	r= -0,86; p<0,01
Vitamin B6	r= 0,74; p<0,05	r= -0,72; p<0,05	r= -0,86; p<0,01	r= -0,84; p<0,01
Vitamin B9	r= 0,68; p<0,05	r= -0,68; p<0,05	r= -0,90; p<0,01	r= -0,82; p<0,01
Vitamin B12	r= 0,76; p<0,01	r= -0,70; p<0,05	r= -0,92; p<0,01	r= -0,86; p<0,01
Homocysteine	r= -0,80; p<0,01	r= 0,68; p<0,05	r= 0,80; p<0,01	r= 0,86; p<0,01

Source: compiled by the authors of this study

B12 to drinking water from 0 to 16 weeks, the authors found histological improvement in liver cell infiltration by inflammatory cells and fibrosis in mice (except for steatosis). These data open up new possibilities for the use of dietary supplements containing vitamin B12 and folates for the prevention or treatment of NAFLD [16].

The role of B vitamins in patients with GERD is also not unambiguous. Sharp L and al. (2013) indicate that riboflavin intake is inversely related to reflux oesophagitis, and vitamin B-12 intake is positively related to esophageal adenocarcinoma (EAC). According to the authors, folate and other dietary factors containing methyl groups are involved in the etiology of EAC and its precursors [17].

On the contrary, another study investigated the role of a dietary supplement containing melatonin, l-tryptophan, vitamin B6, B9, B12, methionine and betaine on clinical symptoms of GERD. A blinded, randomised study was conducted in which 176 patients were treated with the above supplement (group A) and 175 were treated with omeprazole at a dose of 20 mg (group B). All subjects in group A (100%) reported complete regression of symptoms after 40 days of the proposed treatment. Only 115 patients (65.7%) taking omeprazole reported regression of symptoms over the same period ($p < 0.05$). The authors concluded that the drug they tested promotes regression of GERD symptoms without significant side effects [18].

Our data also indicate a marked decrease in the levels of all B vitamins (B1, B3, B6, B9, B12) in the blood serum of patients with GERD combined with MDAFLD. A correlation was established between BMI and a decrease in the levels of the corresponding vitamins, which requires correction. Further research is needed to clarify the relationship between B vitamins and obesity of varying severity in GERD combined with MDAFLD.

CONCLUSIONS

1. In the vast majority of patients with GERD and MDAFLD, an increase in BMI was found, namely, overweight in 25.8% ($p < 0.01$) of patients and grade I obesity (in 37.1% of patients – $p < 0.001$).
2. In patients with GERD and MDAFLD, a significant decrease in serum levels of B vitamins (B1, B3, B6, B9, B12) was found, which correlates negatively with overweight and obesity in these patients.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Assessment of mental health indicators in security sector employees during the war

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ABSTRACT

Aim: To compare mental health indicators in security sector employees who complied (Group A) and did not comply (Group B) with the motor activity regimen during their training and combat activities.

Materials and Methods: The research, which was conducted in 2024-2025, involved 450 security sector employees – cadets (n = 276), officer trainees (n = 71) and commissioned officers (n = 103) of the National Academy of Internal Affairs (Kyiv, Ukraine) who complied (Group A, n = 115) and did not comply (Group B, n = 335) with the motor activity regimen during their training and combat activities. Research methods: analysis and generalization of literature sources, methods of psychodiagnostic, biostatistical methods.

Results: It was found that in the course of training and combat activities, mental health indicators (stress level, propensity to develop stress, stress resilience, nervous and emotional tension, stress resistance, reactive anxiety, emotional state) of security sector employees of both groups deteriorated. Still, in Group A, the changes are unreliable ($p > 0.05$), and in Group B, reliable ($p \leq 0.01$-0.001). It was found that at the end of the research, cadets, officer trainees, and commissioned officers of Group A had all the studied indicators significantly ($p \leq 0.01$-0.001) better than those of Group B.

Conclusions: The effectiveness of motor activity (physical exercises) in overcoming stress and strengthening mental health in security sector employees during their training and combat activities under martial law has been proven.

KEY WORDS: mental health, stress, motor activity, security sector employees, war

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INTRODUCTION

The security sector is a set of state bodies and organizations designed to ensure the security of the individual, society, and the state [1]. Following the types of security that are widespread in our country, the most priority elements of the security sector are: personal security of citizens, public order – provided by law enforcement agencies; state security – provided by special services; economic, social, environmental, political security – provided by the relevant law enforcement agencies. Each type of security has its specifics and certain requirements for employees in their service (training and combat, law enforcement) activities. Still, all of them are characterized by a high stress level, especially under martial law [2-4].

The requirements of training and combat activities under martial law not only inevitably actualize the personal potential of a specialist, but also set them the task of their constant development and updating [5]. The substantive specificity of current social changes, which is manifested in the increased social mobility of large groups of people, in the network principles of communication and collective organization, in numerous movements of people, determine the need for law enforcement officers to constantly "complete" the trajectories of realization of their professional and individual status. Therefore, the functional responsibilities of security sector employees during the war, in addition to the traditional ones (preventive activities, combating crime, ensuring public safety and order, etc.), have been expanded to include checkpoints measures and filtration activities, assistance in evacuating citizens, participation in hostilities within the armed conflict zone and stabilization activities in the de-occupied territories, etc. [6].

Being exposed to extreme conditions and various stressful situations, every security sector employee experiences heavy and sometimes extreme loads [7]. Stressful situations in the context of military operations are associated with the dynamic nature of unfolding events (enemy occupation of territory or de-occupation measures), the need for quick decision-making, especially in cases of

increased responsibility for the legal consequences of the decision, the regime and nature of the activity, which in aggregate can be aggravated by active confrontation of the criminal element, subversive actions of representatives of sabotage and reconnaissance groups and collaborators [8]. The consequences of professional stress can be quite diverse. The most pronounced symptoms can include the following: psychological – anger, irritability, mood swings, difficulty concentrating, anxiety, fear, etc.; physical – insomnia or nightmares, fright for no reason, strong heartbeat, pain, fatigue, nervousness, muscle tension, etc.; social – separation from other members of the workforce, proneness to conflict, etc. [9, 10].

With a further increase in the intensity of mental stress under the influence of negative psychological phenomena, mistakes begin to appear even in worked-out (typical) situations, their number gradually increases, and the effectiveness of law enforcement (combat) activities decreases rapidly. When excessive tension arises, fatal mistakes occur (for example, the use of firearms at the slightest suspicion); the acquired knowledge and instructions on response and interaction tactics "fly out of one's head"; there are manifestations of outright cowardice, refusal to perform risky assignments, deception, dishonesty, etc. [11].

The above actualizes the search for effective ways to prevent stress and maintain the mental health of security sector employees during their training and combat activities under martial law. The analysis of the works of many scientists [12-14] has shown that one of the simple, affordable, and, at the same time, effective means of preventing stress in law enforcement officers during their training and combat activities in wartime is motor activity (exercise). Regular exercise helps reduce stress and anxiety symptoms, as physical activity produces endorphins, natural calming substances. In addition, physical training helps to increase self-esteem and self-respect, which is important for security sector personnel who often face situations that require self-confidence. Motor activity also plays a key role in regulating overall well-being, which in turn has a positive impact on psychological status. Systematic physical activity contributes to stress resilience by teaching the body to respond adequately to high loads and difficult situations. Therefore, according to many scientists [15-17], motor activity is not just a means of maintaining physical fitness, but also an effective tool for psychological self-regulation, which is extremely important for the effective work of security sector employees in wartime.

AIM

The aim is to compare mental health indicators in security sector employees who complied (Group A) and did not comply (Group B) with the motor activity regimen during their training and combat activities.

MATERIALS AND METHODS

PARTICIPANTS

The research, which was conducted in 2024-2025, involved 450 security sector employees – cadets (n = 276), officer trainees (n = 71) and commissioned officers (n = 103) of the National Academy of Internal Affairs (Kyiv, Ukraine). The group of cadets included higher education students (cadets) of the 1st-3rd training years, whose training and combat activities lasted 1 month and took place in the form of practical exercises at training grounds and training centers that maximally simulate the real conditions of service in practical police units. The group of officer trainees included the 4th training year cadets, whose training and combat activities lasted 3 months. It was carried out during their utilization tours in practical police units, involving public safety and order, organizing pass control at checkpoints at the entrance to settlements and sectors of the state border, participating in search and prevention activities, etc. The group of commissioned officers included officers who had been performing special and combat missions as part of consolidated units in the combat zone for 6 months and participated in stabilization activities in the de-occupied territories. All research participants were male.

To study the impact of motor activity during martial law training and combat missions on the mental health indicators of security sector employees, we conducted a survey among cadets, officer trainees, and commissioned officers to determine whether they engaged in physical activity during their training and combat missions to overcome stress and improve mental health. Based on the survey results, two groups were formed: Group A (n = 115) – participants of which systematically (2-3 times a week) were engaged in physical exercises at training grounds, during utilization tours and rotations (cadets – 78 people (28.3 %), officer trainees – 18 people (25.4 %), commissioned officers – 19 people (18.5 %)); Group B (n = 335) – participants who did not exercise for various reasons or did not exercise systematically (cadets – 198 people (71.7 %), officer trainees – 53 people (74.6 %), commissioned officers – 84 people (81.5 %)).

The main criteria for inclusion of the research participants in the experiment were participation in training and combat activities (cadets – in practical training at training grounds, officer trainees – in utilization tours in practical units, commissioned officers – in special and combat missions to repel the russian aggressor)

and compliance or non-compliance with the regime of motor activity in the course of their training and combat activities. In addition, all participants were informed about the aim of the research and provided voluntary written consent to participate. The issue of participants' compliance or non-compliance with the motor activity regimen was revealed by interviewing them using a specially designed questionnaire containing 5 questions: bibliographic data, duration of participation in training and combat activities, whether or not they were or were not engaged in physical exercises to prevent stress, restore psycho-emotional state, how many times a week, by what means. Age, education, marital status, financial well-being, and physical health were not considered. The exclusion criterion was the desire of participants to withdraw from the research at any time.

Research methods: analysis and generalization of literature sources, methods of psychodiagnostic, biostatistical methods. Analysis and generalization of literature sources was used to conduct an analytical review of scientific sources on the outlined range of issues (24 sources (2018-2025) from MedLine, Scopus, Web of Science, and Index Copernicus were analyzed).

The mental health of security sector employees was assessed using psycho-diagnostic methods (stress level test, PSM-25 psychological stress scale, methodology for determining the propensity to develop stress, stress resilience self-assessment test, methodology for assessing nervous and emotional stress, "Stress Resistance" methodology, reactive anxiety scale, methodology for self-assessment of emotional state) [18].

The stress level test allows for assessing the symptoms of stress and its overall level. The questionnaire contains 4 sets of 12 symptoms each. For the presence of one of the intellectual and behavioral symptoms, the respondents scored 1 point; emotional symptoms – 1.5 points, and physiological symptoms – 2 points. The stress level was assessed by the sum of the points and was considered moderate at 6-12 points, significant at 13-24 points, severe at 25-40 points, and excessive at more than 40 points. The PSM-25 psychological stress scale is designed to measure the structure of stress. It contains 25 statements, answering which the respondents chose the frequency of their manifestation and rated in points from 1 to 8, where 1 is never, and 8 is constantly. After that, the sum of points for all statements was determined. Stress was assessed as follows: 99 or less points – low stress, 100-124 – average stress, 125 or more points – high stress. The methodology for determining the propensity to develop stress contains 50 statements and allows for assessing the level of anxiety and the person's tendency to develop stress. The respondents were offered a form with statements opposite which they had to put "+" if the proposed answer "No" or "Yes" coincided with the respondent's opinion, or "–" if it did not. The propensity to develop stress was assessed as follows: 15 points or less – no stress, 16-24 points – moderate stress, 25-39 – average stress, 49-50 – high stress. The test of self-assessment of stress resistance contains 10 questions, answering which the cadets had to choose one of the proposed answers. The answers for questions 1, 2, 3, 7, 9, and 10 were evaluated as follows: never – 0, rarely – 1, sometimes – 2, quite often – 3, frequently – 4; for questions 4, 5, 6, and 8 – never – 4, rarely – 3, sometimes – 2, quite often – 1, usually – 0. If the sum was 6.8 points or less, the level of stress resistance was considered excellent; 6.9-14.2 – good; 14.3-24.2 – satisfactory; 24.3-34.2 – poor; 34.3 and more – very poor. The method for assessing nervous and emotional stress includes 30 signs of this condition, divided into three degrees of severity (a – low degree (complete absence), b – average degree, and c – high degree). The data were processed by summing the points: for answers a – 1 point, b – 2 points, and c – 3 points. The nervous and emotional stress level was considered low if the cadets scored 30-50 points, average – 51-70 points, and high – 71-90 points. The reactive anxiety scale contains 20 statements with response options, depending on how the respondents felt during testing: no, it is not true; probably true; true; quite true. The points were calculated using the formula: $RA = \Sigma 1 - \Sigma 2 + 50$, where RA is reactive anxiety, Σ1 is the sum of the numbers on scale items 3, 4, 6, 7, 9, 12, 13, 14, 17, and 18; Σ2 is the sum of the numbers on scale items 1, 2, 5, 8, 10, 11, 15, 16, 19, and 20. The level of anxiety was assessed as low with 30 points or less, moderate with 31-45 points, and high with 46 points or more. The emotional state self-assessment method includes four sets of 10 statements each ("Calm – Anxiety," "Energy – Fatigue," "Elevation – Depression," "Self-confidence – Helplessness"), among which in each set, it was necessary to choose the one that reflected the respondent's emotional state at the time of testing. The formula determined the emotional state: $ES = (I1 + I2 + I3 + I4) / 4$, where ES is an integral indicator of the emotional state; I1, I2, I3, and I4 are individual indicators on the respective scales. The emotional state was assessed as very good at 8-10 points, good – 6-7 points, poor – 4-5 points, bad – 1-3 points.

BIOSTATISTICAL METHODS

The biostatistical methods were used to process the data obtained. The compliance of the sample data distribution with the Gauss' law was assessed using the Shapiro-Wilk W test. All the data had a normal distribution,

Table 1. Dynamics of mental health indicators before and after training and combat activities in cadets (n = 276), officer trainees (n = 71) and commissioned officers (n = 103) who adhered (Group A) and did not adhere (Group B) to the motor activity regimen (Mean ± SE), points

Research participants	Group A		Group B		t_{AB}	
	Before	After	Before	After	Before	After
Stress level						
Cadets	7.6±0.59	8.2±0.61	7.9±0.47	10.5±0.49**	0.40	2.94
Officer trainees	6.6±1.19	7.4±1.22	6.8±0.69	10.7±0.78***	0.15	2.28
Commis. officers	8.1±1.21	10.3±1.25	8.4±0.61	14.3±0.65***	0.22	2.83
Psychological stress level						
Cadets	97.6±2.04	99.1±2.07	98.5±1.59	104.7±1.73*	0.35	2.08
Officer trainees	96.8±2.46	99.5±2.48	97.4±2.11	108.1±2.16**	0.19	2.61
Commis. officers	99.8±2.59	104.2±2.63	100.2±1.89	114.4±1.97***	0.12	3.10
Propensity to develop stress						
Cadets	18.7±1.28	19.6±1.31	18.8±1.07	23.2±1.09*	0.06	2.11
Officer trainees	18.9±1.68	20.7±1.72	18.5±1.39	24.1±1.42*	0.18	1.52
Commis. officers	20.2±1.79	22.6±1.83	20.6±1.13	27.5±1.18***	0.94	2.25
Stress resistance						
Cadets	16.2±0.95	17.3±0.97	16.0±0.76	19.9±0.80**	0.16	2.07
Officer trainees	15.7±1.59	17.8±1.61	15.8±1.06	22.1±1.11***	0.05	2.20
Commis. officers	16.0±1.63	18.9±1.65	16.3±0.92	23.2±0.98***	0.16	2.24
Nervous and emotional stress						
Cadets	53.1±1.15	54.8±1.17	52.9±0.75	58.2±0.81***	0.15	2.39
Officer trainees	52.3±2.16	55.1±2.19	52.7±1.24	60.6±1.28***	0.16	2.17
Commis. officers	57.1±2.27	62.5±2.31	57.4±1.13	68.6±1.15***	0.12	2.36
Stress resistance						
Cadets	14.9±1.28	16.2±1.30	15.1±0.84	19.5±0.89**	0.13	2.09
Officer trainees	14.1±2.09	17.0±2.13	14.3±1.45	22.1±1.51**	0.08	1.95
Commis. officers	17.3±2.14	20.5±2.17	17.9±1.18	25.9±1.23***	0.25	2.16
Reactive anxiety						
Cadets	40.7±0.92	41.1±0.95	40.6±0.73	43.6±0.77*	0.09	2.04
Officer trainees	40.1±2.17	42.3±2.21	40.8±1.08	48.2±1.14***	0.29	2.37
Commis. officers	42.5±2.07	44.9±2.12	43.1±0.96	52.8±0.99***	0.26	3.38
Emotional state						
Cadets	6.4±0.20	6.1±0.21	6.3±0.13	5.4±0.15***	0.42	2.71
Officer trainees	7.0±0.39	6.3±0.40	6.8±0.26	5.1±0.29***	0.43	2.43
Commis. officers	5.7±0.36	4.8±0.38	5.5±0.19	3.4±0.22***	0.74	3.29

Legend: n – sample size; Mean – arithmetic mean; SE – standard error; tAB – Student's t-test value between the indicators of groups A and B; p – p-value; *, **, *** – statistically significant differences between the indicators of group before and after training and combat activities at the level of $p \leq 0.05$; $p \leq 0.01$; $p \leq 0.001$

Source: compiled by the authors of this study

and therefore a Student's t-test was chosen to check the reliability of the difference in the comparison groups. The reliability of the difference was set at $p<0.05$. The results were presented as Mean ± SE, where Mean is the arithmetic mean and SE is the standard error of the arithmetic mean. All statistical analyses were performed using SPSS software, version 10.0, adapted for medical and biological research.

ETHICS

The procedure for organizing the study and the topic of the article were previously agreed with the Committee on compliance with Academic Integrity and Ethics of the NAIA. Also this study followed the regulations of the World Medical Association Declaration of Helsinki. Informed consent was received from all participants who took part in this study.

RESULTS

The results of the study of mental health indicators in security sector employees who complied (Group A) and did not comply (Group B) with the motor activity regimen during their training and combat activities are presented in Table 1.

The analysis of the dynamics of stress levels in the participants showed that before the beginning of the research period, there were no statistically significant differences between the participants of groups A and B ($p > 0.05$). After the end of the training and combat activities, the stress level of participants in both groups worsened. Still, in Group A, the changes were not statistically significant ($p > 0.05$) for all participants. In Group B, the indicators worsened with statistical significance: for cadets by 2.6 points ($p \leq 0.01$), for officer trainees by 3.9 points ($p \leq 0.001$), for commissioned officers by 5.9 points ($p \leq 0.001$). At the same time, the comparative analysis of the level of stress in groups A and B at the end of the research period showed that all participants in Group A had significantly ($p \leq 0.05$) better indicators than in Group B, by 2.3 points for cadets, by 3.3 points for officer trainees and by 4.0 points for commissioned officers.

The study of the dynamics of psychological stress (according to the PSM-25 scale) shows that before performing the training and combat tasks, the indicators of the participants in groups A and B did not differ statistically ($p > 0.05$). During the practical training period at the training grounds, utilization tours, and rotations, the level of psychological stress in cadets, officer trainees, and commissioned officers of both groups worsened; however, in Group A, no statistically significant changes were found ($p > 0.05$). In Group B, a statistically significant deterioration was recorded by 6.2 points in cadets ($p \leq 0.05$), by 10.7 points in officer trainees ($p \leq 0.01$), and by 14.2 points in commissioned officers ($p \leq 0.001$). After completing the training and combat activities tasks, the psychological stress level in all participants of Group A was significantly ($p \leq 0.05$-0.01) better than in Group B, by 5.6 points for cadets, 8.6 points for officer trainees, and 10.2 points for commissioned officers. This indicates the positive impact of motor activity on preventing stress in security sector employees during their training and combat missions under martial law.

The study of indicators of propensity to develop stress shows that in the training and combat activities, the participants of both groups showed a deterioration in their indicators. At the same time, in Group A, the difference between the indicators before and after the training and combat tasks is not statistically significant ($p > 0.05$). In Group B, the indicators deteriorated with statistical significance ($p \leq 0.05$-0.001) by 4.4, 5.6, and 6.9 points for cadets, officers trainees, and commissioned officers, respectively. Moreover, after the training and combat activities, all participants in Group B showed worse indicators of stress susceptibility than in Group A, by 3.6, 3.4, and 4.9 points, respectively. The study of the stress resilience level shows that during the training and combat activities, there is a deterioration in the stress resilience level in both groups. Still, in Group A, there were no statistically significant differences ($p > 0.05$). In Group B, the deterioration was 3.9, 6.3, and 6.9 points, respectively, for cadets, officer trainees, and commissioned officers, and was statistically significant ($p \leq 0.001$) for all participants in the research. At the end of the research period, the level of stress resilience in the participants of Group A was significantly better ($p \leq 0.05$) than in Group B, by 2.6-4.3 points, which confirms the positive effect of physical exercises during training and combat activities to counteract stress, as well as to maintain and restore the mental and physical health of security sector employees under martial law.

The study of nervous and emotional stress indicators shows that negative changes occurred in both groups during the training and combat activities. However, in Group A, no statistically significant changes were found ($p > 0.05$), and in Group B, statistically significant ($p \leq 0.001$) negative changes in the indicators of all research participants were noted: the deterioration in cadets was 5.3 points, in officer trainees – 7.9 points, and commissioned officers – 11.2 points. The comparative analysis of the indicators at the end of the research period showed significantly ($p \leq 0.05$) better results in Group A than in Group B, by 3.4, 5.5, and 6.1 points, respectively. The study of the dynamics of stress resistance indicators shows that during the performance of the training and combat tasks, the stress resistance level in all participants of groups A and B deteriorated. Still, in Group A, there were no statistically significant differences ($p > 0.05$). Group B had significant ($p \leq 0.01$-0.001) changes, amounting to 4.4 points for cadets, 7.8 points for officer trainees, and 8.0 points for commissioned officers. After the training and combat tasks, Group A showed better indicators of stress resistance than Group B, by 3.3, 5.1, and 5.4 points, respectively. This confirms the effectiveness of motor activity as a means of counteracting the stressful effects of extreme activities under martial law.

The study of the dynamics of reactive anxiety indicators shows that during the training and combat activities the level of anxiety in participants of both groups A and B worsened, but significant ($p \leq 0.05$-0.001) changes occurred only in Group B: the deterioration in cadets was 3.0 points, in officer trainees – 7.4 points, in commissioned officers – 9.7 points. At the end of the research period, all participants in Group A had a significantly lower level of anxiety than in Group B: 2.5 points for cadets, 5.9 points for officer trainees,

and 7.9 points for commissioned officers. The results suggest a positive impact of motor activity on reducing anxiety in security sector employees under martial law.

The analysis of the emotional state showed that during the period of performing the training and combat tasks in both groups, there was a deterioration in the emotional state. Still, in Group A, the differences were not significant ($p > 0.05$), and in Group B, significant ($p \leq 0.001$): in cadets by 0.9 points, in officer trainees – 1.7 points, in commissioned officers – 2.1 points. After completing the tasks of the training and combat activities, the level of emotional state of participants in Group A was significantly ($p \leq 0.05$) better than in Group B, by 0.7, 1.2, and 1.4 points for cadets, officer trainees, and commissioned officers, respectively. The research shows that adherence to the motor activity regimen (regular exercise) during the performance of training and combat activities under martial law has a positive effect on overcoming stress, its prevention, reducing anxiety and nervous and emotional stress, and restoring the psycho-emotional state of security sector employees.

DISCUSSION

War is an extraordinary psychological stimulus for every person, which is why any person, no matter how prepared, is still exposed to the negative effects of stress [19]. Law enforcement (training and combat) activities under martial law place rather high demands on the personal potential of law enforcement officers. Therefore, modern medical and psychological attention should focus on the psychological stability of a law enforcement officer's personality [6, 9]. Scientists [4] emphasize that the professional adaptation of a modern law enforcement officer to extreme situations of war is based primarily on the leading mechanisms of social and psychological adaptation. Thus, the studies of O. D. Volianiuk, I. V. Klymenko, O. A. Rivchachenko, et al. found that not every law enforcement officer is fully prepared to effectively perform their duties under martial law [20]. Our research complements this standpoint with the idea that law enforcement service in wartime radically changes their usual way of life and work, making significant adjustments to the psycho-emotional background and other personal indicators.

Scientists [1, 14] also emphasize the problem and risks of post-stress psychological trauma of modern law enforcement officers. While acute stress disorders, as an immediate response to a traumatic stressful event, are a demonstrative phenomenon, post-traumatic stress disorders are latent. Due to their latency, they become even more dangerous because, after prolonged containment, they accumulate, reaching a critical point. When the police officer's psyche is finally exhausted, even a minor event can act as a catalyst for a neuropsychiatric breakdown [4].

By studying the impact of motor activity on stress prevention and the restoration (maintenance) of mental health indicators of security sector employees, we found that this impact is positive, as it helps to reduce anxiety and nervous and emotional tension, and restore the psycho-emotional state of this category of employees. This confirms the effectiveness of motor activity as a means of counteracting the stressful effects of extreme activities under martial law, which coincides with the results of some scientific studies by researchers [21, 22].

At the same time, our data confirm the standpoint of scientists [23, 24] that the rational use of motor activity means for security sector employees will not only help to restore their emotional state, maintain mental health, but also improve the indicators of their service activities under martial law.

CONCLUSIONS

It was found that in the course of training and combat activities, mental health indicators (stress level, propensity to develop stress, stress resilience, nervous and emotional tension, stress resistance, reactive anxiety, emotional state) of security sector employees of both groups deteriorated. Still, in Group A, the changes are unreliable ($p > 0.05$), and in Group B, reliable ($p \leq 0.01$-0.001).

It was found that at the end of the research, cadets, officer trainees, and commissioned officers of Group A had all the studied indicators significantly ($p \leq 0.01$-0.001) better than those of Group B. Thus, the indicators of stress level in Group A are better than in Group B by 2.3, 3.3 and 4.0 points for cadets, officer trainees and commissioned officers, respectively; the indicators of psychological stress – by 5.6, 8.6 and 10.2 points; the indicators of stress propensity – by 3.6, 3.4 and 4.9 points; the indicators of stress resilience – by 2.6, 4.3 and 4.3 points; the indicators of nervous and emotional tension – by 3.4, 5.5 and 6.1 points; the indicators of stress resistance – by 3.3, 5.1 and 5.4 points; the indicators of reactive anxiety – by 2.5, 5.9 and 7.9 points; the indicators of emotional state – by 0.7, 1.2 and 1.4 points.

The effectiveness of motor activity (physical exercises) in overcoming stress and strengthening mental health in security sector employees during their training and combat activities under martial law has been proven.

PROSPECTS FOR FURTHER RESEARCH

It is planned to investigate the impact of physical exercises of different orientations and intensities on the level of stress symptoms manifestation in security sector employees during their assigned tasks.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Complex diagnostics and prognostication of temporomandibular joints diseases using condylography

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ABSTRACT

Aim: To increase the efficiency of diagnosing diseases of the temporomandibular joint by assessing a set of condylographic indicators and developing prognostic algorithms for the course and an optimized program of dental care for patients.

Materials and Methods: A clinical retrospective cross-sectional comparative study was conducted with the participation of 470 patients with temporomandibular joint pathology aged 18–76 (33 ± 12.9) years. The comprehensive examination included palpation of the masticatory muscles and temporomandibular joint, condylography, computed tomography, teleradiography, occlusiography, analysis of mandibular mobility, modeling of the jaws in the articulator, as well as logical and statistical data processing using standard methods ($p<0.05$).

Results: The analysis of diagnostic and therapeutic approaches to patients with temporomandibular joint diseases allowed us to develop mathematical prognostic models and propose an examination program that takes into account the specifics of the development and course of the pathology. The algorithms for predicting the course of temporomandibular joint diseases based on complex clinical, condylographic and articulation methods were substantiated, which allowed to improve the dental care of patients.

Conclusions: A modified program for diagnosing patients with the use of mathematical modeling (Wald's method of sequential analysis) was proposed to assess the probability of progression of temporomandibular joint diseases. Further research will focus on expanding the primary data base, improving mathematical models, testing individualized prognostic algorithms and evaluating their clinical effectiveness.

KEY WORDS: temporomandibular joint disorders, condylography, dentition defects, pain, splint, dentures

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INTRODUCTION

The temporomandibular joint (TMJ) is one of the most complex joints in the human body, prone to the development of various pathological conditions that can cause pain, discomfort and significantly reduce the quality of life of patients [1–4].

Disorders of TMJ have been an urgent problem of modern dentistry for several decades [2, 5, 6]. The urgency of the problem is due to the increasing prevalence of the pathology (5–12 % of the population) and its significant impact on the daily life of patients, comorbidity with other diseases, the risk of serious anatomical deformities and functional disorders, chronic pain syndrome, difficulties in therapy, etc. [3, 4, 7–9].

Among the modern diagnostic methods, axiography (condylography) is becoming increasingly widely used both in clinical practice and in scientific research, allowing an objective assessment of the motor activity and functional state of the TMJ [10–15]. With the help of condylography, it is possible to obtain accurate information about the characteristics of movement and the structural condition of the joint, which is important for predicting the development of pathological changes [13, 16–18]. The method allows detecting even minimal deviations in motor function, which can be a harbinger of serious disorders. In addition, condylography helps to objectively monitor the effectiveness of treatment measures and plan individualized therapy for each patient [18–27]. However, in order to achieve maximum diagnostic accuracy, condylography should be combined with other examination methods to provide a comprehensive approach to assessing the patient's condition.

AIM

The aims of the study was to increase the efficiency of diagnosing diseases of the temporomandibular joint by assessing a set of condylographic indicators and developing prognostic algorithms for the course and an optimized program of dental care for patients.

MATERIALS AND METHODS

A clinical retrospective cohort comparative cross-sectional study was conducted.

Diagnosis and treatment were performed and the medical records of patients aged 18 to 75 (33±12.9) years, who were examined and treated in 2017-2025 at various medical institutions, were analyzed. The study involved 470 patients (150 men, 320 women) with TMJ diseases.

The comprehensive examination examined clinical, anamnestic and physical symptoms (in particular, with palpation of the masticatory muscles and temporomandibular joints, range of motion of the mandible, etc.), axiography (condylography), occlusiography, analysis of jaw models in the articulator, computed tomography, teleradiography, mathematical prognostic modeling, etc.

The results of condylographic studies in the first cross-sectional examination were analyzed in 100 patients (35 men, 65 women), in the second cross-sectional examination for 1 year – in 11 patients (5 men, 6 women).

The qualitative parameters were presented in the form of absolute values and relative indicators (in percent). For paired intergroup comparison, the Fisher angular transformation method was used.

Quantitative indicators were evaluated by analyzing the central tendency, variability, probability of paired intergroup differences and correlations, taking into account the nature of the data distribution. In the case of a normal distribution, the arithmetic mean, standard deviation, Student's test, and Pearson's correlation coefficient were determined. In the case of a distribution that deviates significantly from the normal distribution, the median, upper and lower quartiles, Mann-Whitney U test, and Spearman correlation coefficient were used.

A comparative analysis of the distribution of individual clinical criteria in the groups was performed using the Wald sequential analysis [28]. This made it possible to determine the diagnostic value, prognostic value, the strength of the influence of factors on intergroup differences in indicators and prognostic coefficients. The main criteria for assessing the prognostic significance of clinical signs were the strength of the factor's influence (η^2, %) and its informativeness (P, bits), which were calculated according to the standard method [29].

To assess the clinical effectiveness (practical applicability) of the developed algorithms for predicting the progression of TMJ diseases, the following indicators of predictive power were used sensitivity (ratio of true positive (TP) to the sum of true positive and false negative (FN) results), specificity (ratio of true negative (TN) to the sum of true negative and false positive (FP) results), positive predictive potential (PPP, ratio of true positive (TP) to the sum of true positive and FP results), negative predictive potential (NP) – ratio of TP to the sum of TN and FP.

For all statistical calculations, results with $p < 0.05$ were considered significant. In the case of multiple comparisons, the Bonferroni correction was used, according to which the critical value of the p level was determined as the product of the threshold value ($p = 0.05$) and the number of comparisons.

The study database, calculation of derived indicators, analysis of frequency characteristics, and diagramming were performed using Microsoft Excel software from the Microsoft 365 package (https://www.office.com/, corporate license). StatSoft Statistica 8 software (http://statsoft.com/, license STA862D175437Q) was used for statistical calculations [29].

The dissertation research is an integral part of the complex research work on the topic: "Clinical and experimental substantiation of diagnostics and orthopedic treatment of patients with diseases of the maxillofacial area".

RESULTS

In order to use the results of the study for risk stratification based on clinical (anamnestic, physical), psychosocial, and condylographic indicators, the parameters of their prognostic value and strength of influence were calculated (Table 1).

Based on the analysis of the frequency of individual factors and the prognostic value of each of the criteria, a method (algorithm) for assessing the likelihood of progression of TMJ disease was developed.

For each studied indicator, its presence or absence is determined, after which the corresponding values of informativeness are summarized (Fig. 1).

The threshold amount for choosing one of the two hypotheses was 19.8, which was determined by the formula $1-\alpha/\beta$, α is a first-order error (omission of the development of an undesirable outcome, chosen with greater rigor at the level of 0.01), and β is a second-order error (false prediction of an undesirable outcome, chosen with less rigor at the level of 0.05).

Reaching the threshold sum of prognostic coefficients allows the scale to determine the risk group:

- if the sum of prognostic coefficients is -19.8 or less, the risk of progression of TMJ disorders is high;
- if the sum of the prognostic coefficients exceeds -19.8 but is less than 19.8, the risk of progression of TMJ disorders is considered uncertain;
- if the sum of prognostic coefficients is equal to or greater than 19.8, the risk of progression of TMJ disorders is low.

The actual prognostic power of the proposed method (algorithm) for assessing the likelihood of progression of TMJ diseases was determined by the results of a one-year follow-up. During the observation period, a high prognostic risk was detected in a statistically significant number of cases ($p=0.01$). In cases of actual development and progression of disorders, the risk was assessed as high in most observations, with no cases of erroneous assessment of the risk as minimal (Table 2).

Among those who were not predicted to progress and did not actually progress, the percentage of concordance in risk assessment was 50% (50% vs. 0%, $\varphi = 2.5$; $p < 0.01$). False high-risk diagnosis was recorded in 25% of cases (25% vs. 86%, $\varphi = 2.1$; $p < 0.05$).

For the purpose of practical clinical testing and implementation of the developed method, a computer program was created – a web application with a data entry form and functionality for automatic calculation of prognostic values. For ease of integration into clinical practice, the program was implemented on the WordPress platform as a plugin:

- data entry form – the interface for data entry is built using HTML and JavaScript, all indicators indicated in the table are presented in the form of drop-down lists and checkboxes, which avoids input errors;
- prognostic values calculation – implements the function of calculating the sum of prognostic coefficients based on the entered data, comparing the entered indicators with prognostic coefficients according to the ranking table

(riskSum += coefficients["pain_snshs"][form["pain_snshs"].value]);

- output of results – based on the calculated amount, the program automatically determines the risk group and displays the output in a convenient format on the user's screen;
- integration into WordPress – the program is developed as a plugin for WordPress, which allows it to be used on the websites of medical institutions; the form and data processing logic are integrated through the shortcode [risk_assessment_form], which can be placed on any page of the site.

The structure of the plugin includes PHP scripts (for form processing and data transfer), JavaScript (for real-time calculations), CSS (for interface design).

The developed program allows to standardize the process of stratifying the risk of progression of TMJ diseases. Its advantages are automation (and reducing the likelihood of errors in calculations), convenience (intuitive interface provides quick data entry), and accessibility (integration into WordPress allows you to use the program without the need for additional training or installation of specialized software).

The calculation of prognostic coefficients and risk determination using the program demonstrated full compliance of the results with the findings obtained during clinical observation.

DISCUSSION

Early diagnosis and prevention of TMJ diseases are important for the timely selection of effective treatment tactics (conservative or surgical), improvement of prognosis and prevention of complications [10, 11]. The problem of TMJ is multidisciplinary, covering dental and interdisciplinary aspects [12–14].

Despite significant progress in the study of TMJ pathologies, the problem of predicting their progression remains difficult due to the lack of universal risk assessment methods. Studies aimed at identifying criteria and parameters that allow determining the likelihood of development and progression of TMJ diseases are relevant. The novelty of this problem is the search for more accurate and reliable methods of diagnosis and prognosis, which allow timely and effective measures to prevent complications [21–23].

A promising area is the use of machine learning technologies and clinical decision support systems, as artificial intelligence can significantly improve the accuracy of diagnosis and optimize the choice of therapeutic tactics [24, 25].

Assessment of the probability of progression of TMJ pathology opens up new opportunities for its understanding and effective management. Although a number of studies, including ours [26, 27] have contributed to the development of appropriate methods, many issues remain unresolved. This emphasizes the importance of further research to improve the efficiency of diagnosis of TMJ diseases.

Combining quantitative condylography with comprehensive clinical, radiographic and psychosocial assessment yields a diagnostically richer picture of TMJ disorders than any single modality. The sequential Wald-based algorithm reliably separates high-, indeterminate- and low-risk trajectories, reaching sensitivity

Table 1. Prognostic indicators of clinical, psychosocial, condylographic indicators in patients with diseases of the temporomandibular joints (TMJ)

Factor rank	Clinical indicators, units of measurement	Gradations	p	Predictive value (pat)	Strength of impact (%)
	Pain in the TMJ area	Yes	<0.01	-9.1	18
		No		+4.6	
	Quality of movement according to condylography	Bad	<0.05	-3.6	17
		Moderate		+1.7	
		Good		+4.6	
	Pain during wide mouth opening	Yes	<0.01	-4.5	16
		No		+2.7	
	Average speed outside the normal range	Yes	<0.05	-4.5	15
		No		+4.3	
	Noises in the TMJ area	Yes	<0.01	-4.2	12
		No		+2.2	
	The desire to find the most comfortable position of the jaws when closing the teeth	Yes	<0.05	-5.7	10
		No		+1.5	
	Impaired chewing, diction	Yes	<0.05	-2.1	9
		No		+3.7	
	Asymmetry of movements of the lower jaw in the horizontal plane	Yes	<0.05	-2.2	9
		No		+1.8	
	Treatment with the use of a corrective mouthguard in history	Yes	<0.05	-2.8	9
		No		+2.2	
	Intersection of graphs of a condylogram (axiogram)	Yes	<0.05	-2.3	8
		No		+3.5	
	Bifurcation of condylogram (axiogram) graphs	Yes	<0.05	-2.5	7
		No		+3.1	
	Teeth grinding or clenching	Yes	<0.05	-2.3	7
		No		+2.9	
	Chronic pain in the temporal region	Yes	<0.05	-2.2	6
		No		+5.7	
	Severe sensitivity in the dental area	Yes	<0.05	-2.2	5
		No		+1.9	
	The angle of the sagittal articular path is outside the normal range	Yes	<0.05	-2.2	5
		No		+2.1	
	The angle of the transverse articular pathway is outside the normal range	Yes	<0.05	-2.1	5
		No		+2.0	
	Cramps in the head, neck, and throat	Yes	<0.05	-4.6	4
		No		+1.4	
	History of orthodontic treatment or selective teeth grinding	Yes	<0.05	-4.5	4
		No		+1.3	
	Serious accidents, history of intubation	Yes	<0.05	-4.3	4
		No		+1.2	
	Disorders of the masticatory muscles	Yes	<0.05	-4.0	4
		No		+1.1	

Table 1. Cont.

Factor rank	Clinical indicators, units of measurement	Gradations	p	Predictive value (pat)	Strength of impact (%)
	Previous dental treatment	Yes	<0.05	-5.1	3
		No		+3.6	
	Pathology of hard tissues of the teeth	Yes	<0.05	-2.9	3
		No		+3.2	
	Misalignment of the centers of the dentition	Yes	<0.05	-2.8	3
		No		+3.0	
	Misalignment of the centers behind the lip frenulum	Yes	<0.05	-2.6	3
		No		+2.8	
	Patient's perception of the seriousness of the condition	Yes	<0.05	-1.2	3
		No		+2.4	
	Posture disorders	Yes	<0.05	-0.9	3
		No		+0.6	
	No need for treatment in the patient's perception	Yes	<0.05	-0.8	3
		No		+0.4	
	Features of the psychological state	Yes	<0.05	-0.6	2
		No		+0.6	
	Presence of comorbid pathology	Yes	<0.05	-0.3	2
		No		+0.2	
	The length of the articular pathway is outside the normal range	Yes	<0.05	-0.2	2
		No		+0.2	
	Gamma outside the norm	Yes	<0.05	-0.1	1
		No		+0.1	
	Peak excess of the average speed	Yes	<0.05	-0.1	1
		No		+0.1	
	Travel time outside the normal range	Yes	<0.05	-0.1	1
		No		+0.1	

Source: compiled by the authors of this study

and specificity values comparable to or exceeding those reported for isolated kinematic or imaging markers in recent literature. Embedding this algorithm into a WordPress-based application transformes statistically dense insights into a pragmatic tool that can be deployed in general dental practice with minimal training.

The clinical implications are substantial. Early identification of high-risk patients enables clinicians to intensify conservative care, expedite imaging or refer for surgical consultation before irreversible remodelling develops. Conversely, confidently categorising low-risk cases may prevent overtreatment and reduce healthcare costs. The indeterminate category – often overlooked in binary models – encourages evidence-guided watchful waiting and targeted re-evaluation, aligning diagnostic reasoning with real-world uncertainty. Notably, the web tool's automated calculations mitigate human error and facilitate multicentre data sharing, fostering a learning-health-system approach to TMJ care.

Several limitations temper these conclusions. The retrospective, single-country design raises concerns about referral bias and ethnic or behavioural heterogeneity. Follow-up was limited to one year, precluding appraisal of long-term joint adaptation and treatment durability. Moreover, psychosocial factors, although included, were assessed through broad proxies; finer-grained measures of stress, sleep, or nociplastic pain could sharpen prognostication. Lastly, machine-learning classifiers might capture non-linear interactions that sequential analysis overlooks.

Future research should test the algorithm prospectively across diverse populations, extend observation windows beyond five years, and compare performance against neural-network or Bayesian approaches. Inte-

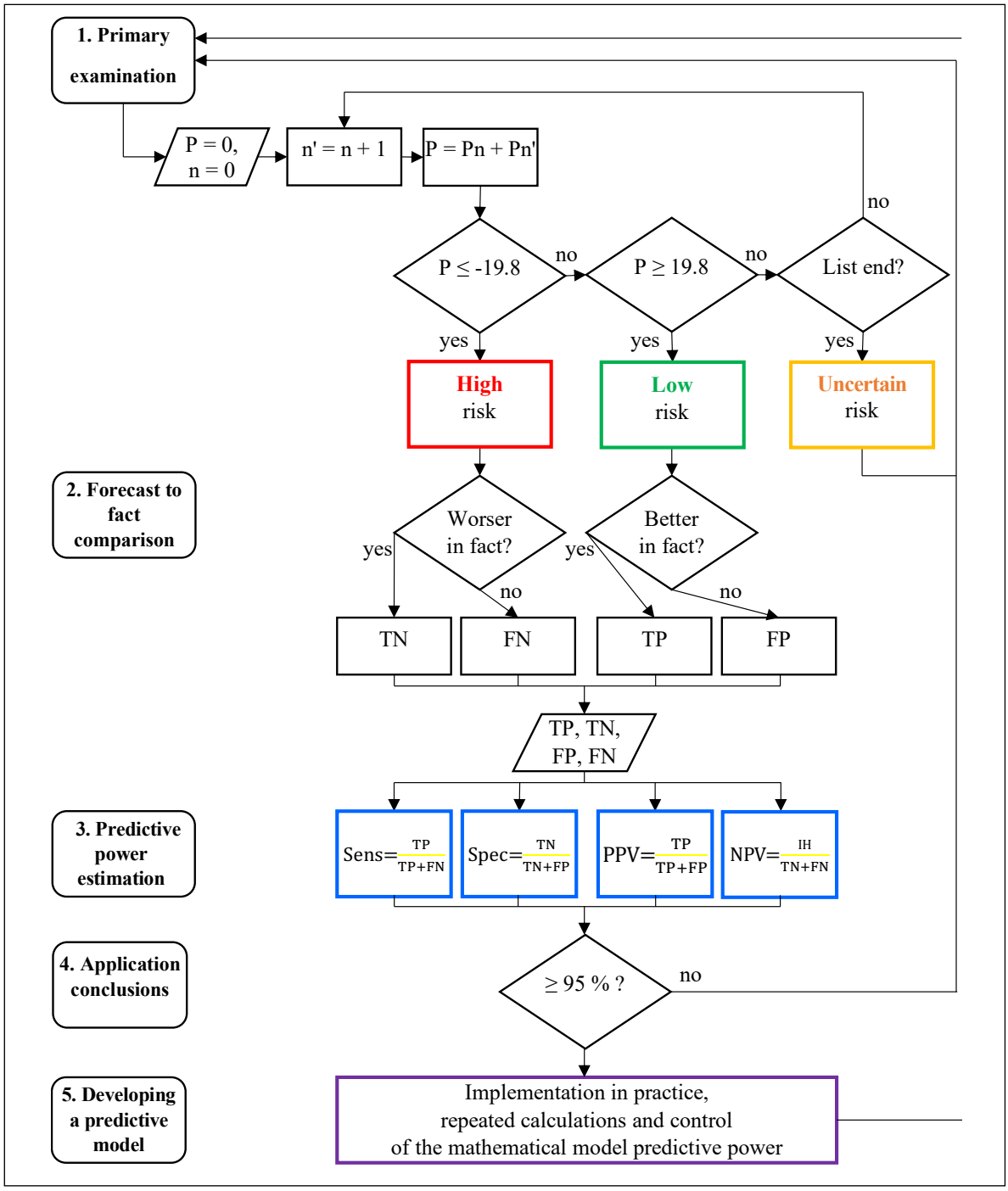

Fig. 1. Method (algorithm) for assessing the probability of progression of temporomandibular joints diseases and its prognostic power

Notes:

1. P is the predictive value of the indicator (pat);
2. n – rank of the factor;
3. TP – true positive results (positive both forecast and reality);
4. TN – true negative results (negative both forecast and reality);
3. FP – false positive results (positive forecast, negative reality);
4. FN – false negative results (negative forecast, positive realities);
5. Sens – sensitivity;
6. Spec – specificity;
7. PPV – positive predictive value;
8. NPV – negative predictive value

Source: compiled by the authors of this study

Table 2. Results of calculations by the method (algorithm) for assessing the probability of progression of temporomandibular joints diseases and its prognostic power in comparison with the data of actual patient observation

Progression in fact	Predictive risk assessment						TOTAL	
	Minimal		Uncertain		High			
	Abs.	%	Abs.	%	Abs.	%	Abs.	%
Yes	–	–	1	14	6	86	7	100
No	2	50	1	25	1	25	4	100
TOTAL	2	18	2	18	7	64	11	100

Source: compiled by the authors of this study

gration with wearable jaw-motion sensors and electronic health-record platforms could further personalise risk estimates. By iteratively refining both the mathematical core and its digital interface, we anticipate a new standard of precision-guided, patient-centred management for TMJ disorders.

Thus, in the theory and practice of clinical dentistry, prognostic algorithms expand the arsenal of tools and increase the effectiveness of predicting the risk of developing and progressing TMJ disorders, which makes it advisable to use them in practice in such patients.

CONCLUSIONS

1. Supplementation of clinical (anamnestic, physical) data with psychosocial and condylographic indicators allows to individualize the approach and increase the clinical effectiveness of the prognostic model of TMJ disease progression;
2. The algorithm for assessing the probability of progression of TMJ diseases and its prognostic power (applied by the method of sequential Wald analysis) is acceptable and clinically relevant. It takes into account not only binary conclusions, such as "high risk" or "low risk", but also intermediate values when the risk remains "undetermined". This approach is closer to real-world clinical thinking, where, in the absence of sufficient certainty, a physician can reasonably order additional tests or follow-up to clarify diagnostic or prognostic conclusions;
3. To evaluate the clinical effectiveness of the algorithm for assessing the likelihood of progression of TMJ diseases, it is appropriate and sufficient to calculate such indicators as sensitivity, specificity, as well as positive and negative predictive potentials using a standard method. This provides the possibility of objective control of the entire spectrum of clinically important aspects at both the individual and cohort levels;
4. It is recommended to apply the developed modified program of patient examination, which, along with standard methods, includes the use of clinical, condylographic and articulation diagnostic methods, as well as mathematical prognostic modeling using an algorithm for assessing the probability of progression of TMJ diseases.

Prospects for further research include replenishment of the primary data base, improvement of mathematical models, testing and implementation of individualized prognostic algorithms for assessing the progression of TMJ diseases with further determination of their clinical effectiveness.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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ORIGINAL ARTICLE

CONTENTS

Attitude of medical university students towards the need for knowledge about the organization of prevention and treatment of glaucoma

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ABSTRACT

Aim: To investigate the need among future doctors of various specialties (medical university students) to study the fundamentals of the organization of diagnosis, treatment and prevention of glaucoma.

Materials and Methods: A custom-designed questionnaire was used as the research tool. The study materials consisted of data obtained from a survey of senior students at three medical universities in Ukraine. Bibliographic, statistical, and analytical methods were employed in the study.

Results: Overall, 80% of medical students believe that knowledge of the discipline "Ophthalmology" is necessary for future physicians of all specialties. 75% of respondents rated the scope and quality of ophthalmology knowledge received during the pre-graduation stage at 3–5 points on a 5-point scale. One-third of students rated their knowledge of the organization of ophthalmologic care and the prevention of eye diseases at 3 points. More than 80% of students highly valued the importance of future physicians of all specialties being knowledgeable about modern approaches to glaucoma prevention and the factors influencing its development. However, while there is general understanding among future physicians about the need to know the current algorithm of actions when glaucoma or pseudoexfoliation syndrome is suspected, knowledge of modern treatment approaches for glaucoma patients is not deemed necessary by all. 75% of students plan to apply their knowledge of glaucoma prevention in their future practice, but they do not intend to carry out preventive activities aimed at preventing the development of glaucoma.

Conclusions: Overall, 70–80% of the surveyed medical students recognize the importance of ophthalmology knowledge. However, their assessment of the volume and quality of their own knowledge was not sufficiently high. Future physicians understand the importance of being informed about risk factors for glaucoma and its prevention. Evaluations of the need for in-depth knowledge of modern treatment approaches for glaucoma patients or the organization of glaucoma prevention were more reserved. Sixth-year students and medical interns feel uncertain about their theoretical and practical knowledge of ophthalmology. Educators teaching the "Ophthalmology" discipline should clearly demonstrate the relevance and value of ophthalmological knowledge for various medical specialties, especially for family physicians.

KEY WORDS: glaucoma, ophthalmology, medical education, knowledge needs assessment, organization of ophthalmologic care

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INTRODUCTION

One of the priorities of public health is the health of human eyes, as visual impairment and blindness have a negative impact on all aspects of human life, sustainable development and economies. At the same time, many people in the world continue to suffer from the consequences of poor access to high quality and affordable health care, including eye care. In 2020, approximately 596 million people worldwide had distance vision impairment, of whom 43 million were blind. According to the forecast, by 2050, their numbers may increase by 50.2% and 41.8%, respectively, including due to population aging. However, more than 90% of these cases have a preventable or treatable cause. The thirty-year dynamics (1990-2020) of a 28.5% decrease in the age-standardized prevalence of blindness worldwide as a result of timely diagnosis and effective treatment of eye diseases looks encouraging [1].

Glaucoma is the second leading cause of blindness in the world, and it is irreversible. Late diagnosis of the disease is often caused by its asymptomatic course in the early stages, which is why about half of the cases remain undiagnosed and untreated. The main prognostic risk factors for glaucoma are known: family and genetic history, ethnicity, myopia, and diabetes mellitus. However, the most important factor is elevated intraocular pressure, which is practically the only factor that can be effectively influenced [2].

This year's International Glaucoma Day is being held under the slogan «Unite for a Glaucoma-Free World» and is designed to help raise awareness of glaucoma among people around the world. Medical students, as future doctors, can make a significant impact on public awareness of glaucoma by emphasizing the importance of prevention, especially in cases of high risk.

The experience of involving medical students in glaucoma screening among low-income populations using portable tonometers (Student Sight Savers Program, an initiative launched at Johns Hopkins University, USA) in underserved areas not only raises public awareness of glaucoma, but also disseminates knowledge of future doctors, improves their practical skills, and encourages them to master the profession of ophthalmology [3].

In addition, the careful attitude of doctors of various specialties, especially family doctors, to patients with glaucoma will facilitate their early referral to an ophthalmologist and encourage continuous treatment, which can reduce the progression of the disease. Currently, there are many studies on the awareness of the public and medical students about glaucoma, but the motivational component of ophthalmology education for future doctors of various specialties is not sufficiently studied.

AIM

To investigate the need of future doctors of different specialties (students of medical universities) to learn the basics of organization of diagnosis, treatment and prevention of glaucoma.

MATERIALS AND METHODS

The research tool was a self-developed questionnaire containing 11 questions. The study materials were based on a questionnaire survey of 963 senior students of three medical universities in Kyiv, Chernivtsi and Poltava who had already completed the course «Ophthalmology» in the fourth year of study. The sample of medical students was dominated by women (68%), with men accounting for 32%. The average age of the students was 22.4 years. The study used bibliographic, medical and statistical, and analytical methods. The study was conducted in compliance with the standards and principles of the World Medical Association's Declaration of Helsinki «Ethical Conduct for Research Involving Human Subjects» (2014). The questionnaire used in the study was approved by the Ethics Committee of the A.A.Bogomolets National Medical University, Protocol No. 190, dated 12/23/24.

RESULTS

In Ukraine, medical students study the discipline «Ophthalmology» in the 4th year of study and a separate practical lesson is devoted to glaucoma. 75% of respondents rated the amount and quality of knowledge gained in this discipline at the undergraduate stage at 3-5 points (Table 1). The average score of answers to these questions did not differ significantly ($p>0.05$). It is noteworthy that one third of students rated their knowledge of the organization of ophthalmic care and prevention of ophthalmic diseases at 3 points. In general, 80% of medical students believe that knowledge of the discipline «Ophthalmology» is necessary for future doctors of all specialties.

More than 80% of students highly appreciated the importance of future doctors of all specializations' knowledge of modern approaches to the organization of glaucoma prevention and factors influencing the development of glaucoma (Table 2). However, if there is an understanding among future doctors that it is necessary to know the modern algorithm of actions in case of suspected glaucoma or pseudoexfoliation syndrome (mean score was 3.63±1.13 and 3.33±1.21, respectively), not all of them need to know modern approaches to the treatment of patients with glaucoma (mean score was significantly lower and amounted to 2.77±1.25, $p=0.00$, $t=15.38$).

Medical students in the vast majority plan to use knowledge about glaucoma prevention in their future activities (Table 3). In total, almost 75 of students rated these intentions at 3-5 points (mean score was 3.31±1.31), but the rest of the students do not see such a need, especially do not plan to carry out preventive activities to prevent the development of glaucoma (almost half of the students rated this possibility at 1-2 points). The mean score of this answer was significantly lower ($p=0.00$, $t=9.19$) and amounted to 2.79±1.25.

Perhaps this is related to the choice of future specialty by medical students, since only 9.35±0.94 of respondents had previously chosen ophthalmology. Despite the fact that 19.83±1.28 of respondents have not yet decided on their choice, 12.15±1.05 chose family medicine, 17.76±1.23 – therapeutic specialties, 19.42±1.27 – surgical specialties, the rest of the respondents (21.48±1.36) want to connect their future with other medical specialties (pediatrics, laboratory diagnostics, forensic medicine, psychology, radiology, etc.). Therefore, they believe that knowledge of ophthalmology, in particular glaucoma, is not as important for all specialties as it is for ophthalmologists. This is a serious challenge for ophthalmology teachers, who must convincingly demonstrate the importance of ophthalmology knowledge for various specialists, especially family doctors.

Table 1. Medical students' assessment of some aspects of mastering the discipline «Ophthalmology» (n=963)

№	Score on a scale from 1 to 5 (1 - the lowest degree, 5 - the highest degree), abs., (%±SE)					Average score (M±SD)
	1	2	3	4	5	
1	Do future doctors of all specializations need knowledge of the discipline "Ophthalmology"?					
	55 (5,71±0,75)	118 (12,25±1,06)	246 (25,55±1,41)	264 (27,41±1,44)	280 (29,2±1,46)	3,61±1,18
2	Do you consider the amount of knowledge gained in the discipline "Ophthalmology" at the pre-graduation stage sufficient for your future work as a doctor?					
	92 (9,55±0,95)	149 (15,47±1,17)	239 (24,82±1,39)	254 (26,38±1,42)	229 (23,78±1,37)	3,39±1,26
3	Could you please assess the quality of your knowledge on the organization of eye care and prevention of eye diseases?					
	74 (7,68±0,86)	158 (16,41±1,19)	287 (29,8±1,47)	247 (26,65±1,41)	197 (20,46±1,3)	3,34±1,19

Source: compiled by the authors of this study

Table 2. Medical students' assessment of the need to acquire knowledge about glaucoma: answer to the question «Do future doctors of all specializations need to know:» (n=963)

№	Score on a scale from 1 to 5 (1 - the lowest degree, 5 - the highest degree), abs., (%±SE)					Average score (M±SD)
	1	2	3	4	5	
1	modern approaches to the organization of glaucoma prevention?					
	52 (5,04±0,73)	140 (14,54±1,14)	262 (27,21±1,43)	271 (28,14±1,45)	239 (24,82±1,39)	3,52±1,16
2	factors that influence the development of glaucoma?					
	44 (4,57±0,67)	98 (10,18±0,97)	262 (27,21±1,43)	271 (28,14±1,45)	239 (24,82±1,39)	3,68±1,12
3	modern algorithm of actions in case of suspected glaucoma?					
	39 (4,05±0,64)	124 (12,88±1,08)	248 (25,75±1,41)	286 (29,7±1,47)	266 (27,62±1,44)	3,63±1,13
4	a modern algorithm of actions in case of suspected pseudoexfoliative syndrome?					
	84 (8,72±0,91)	154 (15,99±1,18)	276 (28,66±1,46)	250 (25,96±1,41)	199 (20,66±1,30)	3,33±1,21
5	modern approaches to the treatment of glaucoma patients?					
	170 (17,65±1,23)	268 (27,83±1,44)	246 (25,55±1,41)	167 (17,34±1,22)	112 (11,63±1,03)	2,77±1,25

Source: compiled by the authors of this study

Table 3. Assessment of medical students' intentions to use the acquired knowledge on glaucoma in future medical practice (, n=963)

№	Score on a scale from 1 to 5 (1 - the lowest degree, 5 - the highest degree), abs., (±SE)					Average score (M±SD)
	1	2	3	4	5	
1	Do you plan to use knowledge about glaucoma prevention in your future activities?					
	117 (12,15±1,05)	145 (15,06±1,15)	242 (25,13±1,4)	232 (24,09±1,38)	227 (23,57±1,37)	3,31±1,31
2	Do you plan to carry out preventive activities to prevent the development of glaucoma in your future activities?					
	167 (24,1±1,62)	245 (25,44±1,4)	228 (23,68±1,37)	214 (22,22±1,34)	199 (20,66±1,30)	2,79±1,25

Source: compiled by the authors of this study

DISCUSSION

The data obtained in this study on students' self-assessment of their knowledge of ophthalmology were considered low, which is consistent with the results of other studies. Gaps in knowledge were identified during a survey of senior medical students at the University of Punjab: only 45 of students know that glaucoma is the second cause of blindness in the world after cataracts, and 30 know that glaucoma is asymptomatic. The vast majority of students are familiar with the basic methods of diagnosis and treatment of glaucoma, but half of the respondents consider their level of knowledge insufficient [4]. A survey of students of the last two years of study at the Faculty of Medicine of the Federal University of Juiz de Fora (Brazil), which was aimed at finding out the level of knowledge about primary open-angle glaucoma, revealed that only one third of them mentioned fundoscopy and perimetry as important tools for assessing glaucoma. 95.1 of students recognized their knowledge as insufficient [5]. In another study,

where a survey of medical students from three colleges in India was structured as a glaucoma test, it was found that only 11 of students had good knowledge, 50 had satisfactory knowledge, but awareness of symptoms and risk factors such as family history of glaucoma, diabetes, hypertension, obesity, steroid use were low [6].

It should be noted that the study of ophthalmology is based on fundamental knowledge of normal and pathological anatomy and physiology of the eye. A study among Indian undergraduate college students who had not yet studied ophthalmology but were aware of the presence of glaucoma revealed an insufficient level of knowledge of pathophysiology and risk factors for its occurrence [7]. In addition, there is a certain time and semantic gap in the knowledge gained at the fundamental departments (2-3 years of study), then at the Department of Ophthalmology in the 4th year. In the 6th year, eye diseases are included as a separate topic in the family medicine cycle. Therefore, interdisciplinary collaboration can help to place ophthalmology knowledge in the contexts of different disciplines to build a more holistic view of ophthalmic pathology. It is also advisable to include the requirements of ophthalmic diagnostics in the OSCE exams using simulation models. This proposal was the result of an analysis of the state of ophthalmic education in the United States and Canada. When developing curricula, it is necessary to take into account the theory of cognitive load for better memorization of complex material in ophthalmology [8].

Regarding the choice of ophthalmology as a postgraduate specialization, it is known that students have a prevalent opinion that the discipline is difficult to master, as evidenced by the results of a survey of graduate students of an Indian medical university. However, their negative opinion can be changed by clinical experience [9]. A study of doctors in Brazilian clinics demonstrated the main reasons for choosing ophthalmology as a career. It turned out that they are common to doctors of different generations: flexible working hours, satisfaction from the opportunity to help people improve their vision, and the ability to perform surgical procedures. It has been found that younger generations in ophthalmology value short procedures and relatively quick results, while older generations value having a «family» ophthalmologist [10].

Leading ophthalmologists from Australian and New Zealand medical schools complain about the short duration of ophthalmology cycles, while pointing to the need for autonomous motivation in their students [11]. Thus, the results of a study of students' knowledge at the Medical School of the University of Split (Croatia) showed that, in general, the level of knowledge of students about glaucoma is characterized as low, even after completing the course of this discipline, possibly due to the fact that a short course in ophthalmology includes the study of a significant number of eye diseases. It has been suggested that elective courses on glaucoma should be created for students or for practicing medical professionals as part of their continuing education [12].

An even more significant lack of ophthalmology hours is observed at the postgraduate level of education. However, despite the fact that the number of hours of ophthalmic training received by family medicine interns at the University of Western Ontario was in line with the recommendations of the International Council of Ophthalmology Working Group, 80 of future family physicians were not entirely confident in their ability to treat common eye diseases, namely eye emergencies (acute angle-closure glaucoma, chemical eye burn). Therefore, it was reasonable to propose to increase the number of hours of ophthalmology in family medicine residency training [13].

Given that a significant number of medical higher education institutions have pharmaceutical faculties, the experience of involving pharmacists in disseminating information about eye diseases and their prevention among patients on the example of Saudi Arabia is relevant [14]. Pharmacists are the most accessible health care professionals, they have a unique opportunity to raise awareness of glaucoma among patients, improve patient compliance with the use of eye drops [15]. Therefore, it is advisable to support the idea of introducing ophthalmology into the educational training of pharmacists.

The survey of medical students at Jazan University provided insight into the compliance of the university's ophthalmology program with the International Council of Ophthalmology (ICO) recommendations, which included visual examination skills, emergency recognition, and more. It was found that almost half of the students reported insufficient practical experience, and only 20 had an average grade in ophthalmology of 4.76-5.00. Only 30 of survey participants expressed interest in ophthalmology. It was noted that medical education can be improved by increasing practical clinical experience, small group training, etc. Better quality of education can be achieved by improving the effectiveness of curricula for students to become qualified in ophthalmology [16].

Innovative practices of teaching ophthalmology and new international educational strategies can improve teaching and learning in a limited time. The «marginalization» of ophthalmology education (reducing it to determining visual acuity and prescribing glasses) can

be overcome by introducing innovations in the content of ophthalmology curricula, teaching methods, instructional design, learning objectives, and assessment methods [17].

A survey of students who underwent clinical practice in ophthalmology gave an idea of the motivation of medical students studying ophthalmology. It was found that, according to the theory of self-determination, the perception and awareness of the three basic psychological needs – autonomy, competence and belonging – are influenced by five main factors: leadership, growth mindset, evaluation, curriculum pressure and extracurricular pressure. This understanding should be taken into account by ophthalmology educators when developing curricula and using teaching methods to develop intrinsic motivation in students [18]. A study of factors that promoted or hindered the learning and motivation of 4th year medical students at the University of California identified the main areas of motivation support: teaching at the appropriate level; integration into the team and workflow; independent learning and career search [19].

CONCLUSIONS

The conducted survey of future doctors gave an idea of the level of formation of their motivational and value criteria regarding the need to acquire knowledge of early diagnosis, prevention and treatment of glaucoma in the process of undergraduate education. In general, medical students (70-80% of respondents) are aware of the importance of this knowledge, as well as mastering the discipline «Ophthalmology» in general. However, their own score on a 5-point scale was not high enough, as it did not reach 4 points for any question, and therefore students were not unanimous in assessing the importance of each aspect of glaucoma. 15-20% of respondents rated each question at 1-2 points. We can agree with this assessment regarding the need for in-depth knowledge of modern approaches to the treatment of patients with glaucoma or the organization of glaucoma prevention, which is required by doctors of not all specialties. Students of the 6th year of study or internship may be unsure of their knowledge of the theory and practice of ophthalmology. Only ophthalmologists who have undergone the appropriate specialization can be expected to have in-depth knowledge of the accurate diagnosis or complex treatment of glaucoma. It is important for doctors of other specialties to know the risk factors for glaucoma, methods of early diagnosis and basic preventive measures. Developing competency-based curricula, increasing practical clinical experience, and teaching in small groups will increase students' self-confidence, provide them with the necessary skills, and generally improve the quality of education.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest

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REVIEW ARTICLE

CONTENTS

Exploring the Neurological Impacts of the Ketogenic Diet: A Comprehensive Review

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ABSTRACT

Aim: This review aims to conduct an analysis of potential therapeutic effects, mechanisms of action, and consequences of the ketogenic diet in the context of the mentioned neurological disorders.

Materials and Methods: A review of scientific literature available in the PubMed and Google Scholar databases was conducted, utilizing key terms.

Conclusions: The presented work provides an integrated compilation of currently available studies analyzing the impact of the ketogenic diet and underscores the importance of continuing research to achieve a fuller understanding of the mechanisms of action of this diet and its potential therapeutic benefits.

KEY WORDS: Ketogenic diet, neurological disorders, epilepsy, Alzheimer's disease, migraine, depression, Parkinson's disease

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INTRODUCTION

In the human body, the main energy source is glucose. After a meal is consumed, glucose goes through numerous chemical processes. Part of the ingested carbohydrate is used as an energy substrate, part is stored as glycogen in the liver and muscles, part is converted to fat and stored as adipose tissue. Glycogen acts as an energy reserve and is converted back into glucose when needed. When glycogen stores are depleted and the body is unable to cover the resulting energy gap, it begins to produce glucose on its own from protein (through the breakdown of its own muscles), fats and lactate (which is formed during the anaerobic burning of glucose in the muscles). After a few days of the starvation period, the body adapts and ketones become the main source of energy.

Therapy based on dietary restrictions dates back to the time of Hippocrates, when fasting was the only known treatment for epilepsy. Also in the Bible, passages can be found where a boy is cured of epileptic seizures by means of 'prayer and fasting'. The first modern description of fasting as a treatment method appears in 1911, when a pair of French doctors, Guelpa and Marie, undertook the treatment of 20 children and adults, suffering from epilepsy, with food restriction and documented a milder course of epileptic seizures. In the early 1920s, Drs Cobb and Lennox of Harvard Medical School also began to study the effect of starvation on epileptic seizures. They were the first to discover that epileptic seizures were relieved about 3-4 days after the introduction of food restriction [1]. However, it was in 1921 that two key observations were made. Dr Rollin Woodyatt observed that acetone and beta-hydroxybutyric acid appear in a healthy patient not only as a result of starvation, but can also occur as a result of a diet containing too little carbohydrate and/or too much fat [1]. At the same time, Dr Russell Wilder described that the therapeutic benefits of introducing fasting can also be achieved by other means – the so-called 'ketogenic diet'.

AIM

This review aims to conduct an analysis of potential therapeutic effects, mechanisms of action, and consequences of the ketogenic diet in the context of the mentioned neurological disorders.

MATERIALS AND METHODS

A review of scientific literature available in the PubMed and Google Scholar databases was conducted, utilizing key terms.

REVIEW AND DISCUSSION

THE KETOGENIC DIET, THE ROLE OF KETONES

The oxidation of ketone bodies becomes an important factor affecting the overall energy metabolism of humans in numerous physiological states, such as fasting, starvation, the post-exercise state, pregnancy, the neonatal period, or just the use of low-carbohydrate diets [2]. The classic ketogenic diet is characterised by a high dietary fat content, the reduction of carbohydrate intake to the minimum necessary and the consumption of an adequate amount of protein. The aim of the ketogenic diet is to induce a state of ketosis in the body, which is characterised by increased lipolysis (breakdown of fatty acids) and ketogenesis, i.e. precisely the formation of ketone bodies. During a ketogenic diet, as with starvation, there is an increased production of ketone bodies (i.e. β-hydroxybutyrate), acetoacetate and acetone [3]. Studies show that ketone bodies not only function as energy fuel for tissues such as the brain, heart and skeletal muscle, but also play an important role as mediators or catalysts of various chemical processes in the body [2]. The brain is the most energy-intensive organ in the human body, for which the main source of energy is glucose. However, when the need arises, this main energy source can also be provided by ketone bodies, which can meet up to 60% of the brain's energy requirements [4].

With an increasing number of studies dedicated to the effects of the ketogenic diet on the human body, we are slowly learning more about the positive effects of ketone bodies on overall brain health and the potential therapeutic benefits against various neurogenic conditions.

EPILEPSY

Epilepsy is a chronic brain disease involving recurrent epileptic seizures. The pathogenesis of epilepsy is based on the predisposition of brain tissue to generate electrical impulses that lead to neuronal hyperstimulation and induce hyperactivity of different brain areas. An epileptic seizure is not synonymous with epilepsy. Epilepsy affects people of different sexes, ages and races. However, it is one of the most common childhood neurological diseases. The incidence is influenced by genetic, environmental and physiological factors. In one third of cases, drug treatment does not lead to seizure relief. There have been a number of studies that have shown the possible efficacy of the ketogenic diet in drug-resistant epilepsy. The ketogenic diet stabilises the body's glucose and insulin levels. Ketone bodies cause regeneration of nerve cells, mitigate inflammatory reactions and neutralise oxidative stress. Following a ketogenic diet, ATP production increases, which stimulates potassium channels and thus reduces neuronal activity. By decreasing aspartate, the synthesis of GABA, an inhibitory neurotransmitter, is increased. Medium chain triglycerides (MCTs) also have a positive effect. They increase the plasma concentration of decanoic acid, which in turn inhibits the α-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid (AMPA) receptor and thus has an even better anticonvulsant effect than ketones.

A 2020 publication described how adding MCTs to the diet (twice daily for three months) reduced the frequency of epileptic seizures in 42% of adult patients. The study showed that a diet with MCTs has a beneficial effect in people who do not classify for a classical ketogenic diet [5]. Some experts recommend the implementation of a ketogenic diet in people with epilepsy when two anti-epileptic drugs have failed. In some diseases such as GLUT-1 deficiency syndromes or pyruvate dehydrogenase deficiency, experts recommend including the diet earlier.

A study involving 160 children with drug-resistant epilepsy was conducted in 2022. They were put on a ketogenic diet and the effects were monitored for 24 months. In this study, absence of seizures was observed in 13.7 % of the children after 3 months, in 12.5 % of the children after 6 months, in 14.4 % after 12 months and in 10.6 % after 24 months. A 50% reduction in seizure intensity was also observed in 41.9% of children after 3 months, in 37.5% after 6 months, in 28.7% after 12 months and in 16.2% after 24 months. A reduction in the number of seizures along with a complete absence of seizures was shown in up to 48.31% of children [6].

ALZHEIMER'S DISEASE

Alzheimer's disease is the most common cause of dementia in older people. It is a heterogeneous and multifactorial disease characterised by cognitive impairment, confusion, progressive memory loss and personality changes. Alzheimer's disease develops over many years, often without showing specific symptoms in its early stages. The aetiopathogenesis of Alzheimer's disease is not fully understood. It is suggested that both environmental and genetic factors influence its development. The aetiopathogenesis of this disease has been linked to hypometabolism, mitochondrial dysfunction, inflammation, oxidative stress, blood-brain barrier disruption and cerebral atherosclerosis. In addition, genome-wide studies (GWAS) have shown that up to about 20 genetic sites may be associated with the risk of developing the disease [7]. Brain deposits

laden with amyloid β (Aβ) and intrinsic neurofibrillary tangles consisting of tau protein are important hallmarks of Alzheimer's disease. Studies report that Aβ directly affects the impairment of the glycolytic pathway and the tricarboxylic acid cycle. It can be said that patients with Alzheimer's disease show features of insulin resistance in the brain. Three pathologies have been suspected: reduced insulin transport to the brain, reduced insulin levels in the brain and faulty insulin receptors in the brain [8]. Dr Weinstein et al. observed a reduction in the volume of the grey matter in young people with hyperglycaemia. At the same time, Dr Kerti et al. observed a reduction in hippocampal volume. Thus, it can be concluded that hyperglycaemia leads to changes in the brain, causing memory impairment [4]. A randomised study of 26 patients diagnosed with Alzhaimer's Disease who were put on a ketogenic diet for 12 months showed an increase of an average of 5 points on the ACE III (Addenbrooke's Cognitive Functioning Scale) and an average of 2 points on the ADCS-AD (Everyday Functioning Scale) in tests performed at the end of therapy compared to tests performed before the introduction of the ketogenic diet [9]. While in one study by Mélanie Fortier et al. in which Alzhaimer's patients were given a ketogenic drink for 6 months, it was observed that improved scores on tests of cognitive function were directly and significantly correlated with increased levels of ketones in the blood and with increased uptake of ketones by the brain.

MIGRAINE

The Global Burden of Disease, Injury and Risk Factors Study continues to identify migraine as the leading cause of disability worldwide, particularly in people under 50 years of age. It is worth noting that disorders often co-occurring with migraine, such as neck pain, depression and anxiety, are also among the top ten causes of disability worldwide. This condition affects about 12% of the world's population, and its chronic form occurs in 1-2% of people worldwide. Of those struggling with episodic migraine, 2.5% of patients develop the chronic form [10]. Migraine manifests as frequent paroxysmal, very severe headaches, which may be accompanied by vegetative symptoms such as headache that worsens with movement, nausea, vomiting and hypersensitivity to environmental stimuli. It is a condition that significantly affects patients' quality of life and daily functioning. People with migraine also have a higher risk of developing comorbidities such as depression, anxiety, bipolar affective disorder, fibromyalgia, sleep disorders or cardiovascular disease. Although the exact causes of migraine are not yet fully understood, there is speculation that mitochondrial dysfunction and associated difficulties in ATP production may be one potential mechanism for this ailment. Several studies have confirmed the presence of a deficiency in energy production with an increase in energy consumption in migraine patients. It was discovered that an increase in energy demand beyond a certain threshold creates metabolic and biochemical conditions for the onset of a migraine attack, and that the hypoglycaemic state prolongs the occurrence of depression of electrical impulse propagation in the cerebral cortex [11]. In 2022, Carlo Lovati et al. conducted a study on 21 patients diagnosed with drug-resistant migraine. The subjects were divided into two groups: the first followed the guidelines of a ketogenic diet, the second a low-carbohydrate diet. Patients treated with the ketogenic diet showed a significant reduction in migraine attack frequency, headache intensity and medication intake. No significant benefit was observed in the low-carbohydrate diet group. In the same year, an identical study was conducted on 31 patients diagnosed with drug-resistant migraine, who were also changed to a ketogenic and low-carbohydrate diet. The results were comparable to those of the first study [12].

PARKINSON'S DISEASE

Parkinson's disease is a neurodegenerative disease whose likelihood of occurrence increases with age. It is predisposed by genetic factors, toxins, environmental factors and certain medications. The symptoms of Parkinson's disease include: muscle rigidity, resting tremor and motor retardation. The pathogenesis of Parkinson's disease is thought to be neuronal atrophy in the black matter, responsible for dopaminergic transmission in the striatum and basal nuclei. An additional role in the pathogenesis of the above disease is played by Lewy bodies – abnormal protein aggregates made up of the wrong form of alpha-synuclein.

The primary drug in this disease is levodopa. There have been studies showing that a ketogenic diet increases the bioavailability of levodopa [13]. At the same time, it has been observed that the ketogenic diet affects the activation of KATP channels located on GABAergic neurons, contributing to an increase in alpha synuclein synthesis [14].

The gut microbiota is also altered in Parkinson's disease. The ketogenic diet modifies the gut microbiota by increasing the number of Prevotella family bacteria and decreasing the number of Enterobacteriaceae family bacteria, contributing to an increased anti-inflammatory effect by reducing the occurrence of oxygenic stress in the gastrointestinal tract. There are also stud-

ies showing that the ketogenic diet alone reduces the mortality of dopaminergic neurons. In some studies, improvements in mood and balance, improved motor function and a reduction in tremor were observed in just 28 days after the ketogenic diet [15]. In others, improvements in speech and short-term memory were observed in study participants [16].

DEPRESSION

Depression is the fourth most serious illness globally, according to data from the World Health Organization (WHO), with approximately one-third of patients exhibiting resistance to pharmacological treatment. This condition affects individuals of all genders, races, and age groups. Stressful life events such as the death of a loved one, loss of employment, or the end of a relationship can contribute to its onset.

The pathogenesis of depression is primarily associated with disturbances in serotonin secretion, which in turn results from abnormalities in the metabolism of tryptophan, the amino acid precursor of serotonin. Deficiencies in other neurotransmitters are also implicated in the development of depressive disorders. These include gamma-aminobutyric acid (GABA), substance P, and brain-derived neurotrophic factor (BDNF).

The ketogenic diet includes a variety of foods rich in tryptophan. It has been observed that adherence to this dietary regimen increases the production of GABA, a neurotransmitter with calming effects that also enhances the efficacy of medications such as benzodiazepines [17]. However, studies have also shown that the ketogenic diet may reduce the abundance of gut bacteria such as *Bifidobacterium* and *Lactobacillus*, which are capable of synthesizing neurotransmitters; their depletion may contribute to the development of depressive symptoms [18].

MULTIPLE SCLEROSIS

Multiple sclerosis (MS) is an autoimmune disorder and one of the leading causes of disability among young adults. The incidence of this disease is steadily increasing, with a growing number of cases reported each year. In MS, the myelin sheath surrounding neurons becomes damaged, leading to disturbances in motor and sensory functions.

The ketogenic diet has shown promise in supporting the regeneration of myelin. The ketone body β-hydroxybutyrate crosses the blood-brain barrier and enhances the synthesis of brain-derived neurotrophic factor (BDNF), a key agent in promoting myelin growth. It has also been demonstrated that serum glucose levels are inversely correlated with BDNF concentrations[19]. The most significant effects were observed with the Mediterranean variant of the ketogenic diet, which was associated with increased activation of the CREB transcription factor, thereby boosting BDNF production [20] .

Another observed effect of the ketogenic diet was its impact on serum neurofilament light chain (sNfL), a biomarker used in MS diagnosis. After six months of adherence to the ketogenic diet, a decrease in sNfL levels was noted, indicating a neuroprotective effect [21]. Furthermore, reductions in cyclooxygenase enzymes (COX-1 and COX-2) and proinflammatory cytokines were observed following dietary intervention [22]. Improvements were recorded in both physical and mental health, including enhanced well-being and alleviation of depressive symptoms.

LIMITATIONS AND POTENTIAL ADVERSE EFFECTS OF THE KETOGENIC DIET

A primary limitation of this study is the limited number of available scientific investigations addressing the effects of the ketogenic diet in the context of MS. The most extensively studied neurological condition in relation to the ketogenic diet remains epilepsy. This disparity arises from the relatively recent expansion of research into neurological disorders beyond epilepsy. Nevertheless, despite the small body of research, the effects observed to date are compelling enough to justify further exploration in this domain.

The ketogenic diet also presents practical challenges. Clinical trials have reported difficulties in patient adherence, which can compromise its long-term effectiveness. In a multi-year study on the impact of the ketogenic diet on seizure severity, the most common reasons for early discontinuation were lack of motivation, poor compliance, and worsening of seizure symptoms [23].

Although rare, the ketogenic diet can also result in side effects such as nausea, vomiting, and hypoglycemia. These adverse effects are well-documented in a 2020 meta-analysis involving 932 participants (711 children and 221 adults) with diagnosed epilepsy [24]. Gastrointestinal symptoms—including diarrhea, nausea, and vomiting—were the most frequently reported. Among children, additional side effects included weight loss, recurrent infections, and increased drowsiness, while adults most commonly reported headaches, abdominal pain, and an elevated risk of kidney stone formation. In women, irregular menstruation was also noted.

Another 2020 study involving 158 children—126 of whom had epilepsy with an average age of 4.6 years—found that the most frequent adverse effect was vomiting, reported in 80% of cases. Hypoglycemia below 40 mg/dL occurred in 44 patients, while six experienced

excessive ketosis with urinary ketone levels reaching 160 mg/dL [25].

In patients with Parkinson's disease, some reported increased irritability, hunger, and thirst. However, it is important to emphasize that the so-called "keto flu" is a temporary and self-limiting condition that does not pose a serious health threat [26].

CONCLUSIONS

The presented work provides an integrated compilation of currently available studies analyzing the impact of the ketogenic diet and underscores the importance of continuing research to achieve a fuller understanding of the mechanisms of action of this diet and its potential therapeutic benefits.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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REVIEW ARTICLE

CONTENTS

Insurance services in the healthcare sector of Ukraine: Legal aspect

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ABSTRACT

Aim: The purpose of the study is to analyse the scientific approaches and legislative provisions reflecting the peculiarities of insurance services in the healthcare sector of Ukraine, and to formulate conclusions and proposals for improving the legal regulation of insurance relations in the field of healthcare services. This goal was achieved by solving the following tasks: to clarify the peculiarities of insurance services in the healthcare sector, to define the concept of health insurance, and to study the peculiarities of mandatory health insurance and the features of its voluntary forms.

Materials and Methods: The main provisions and results presented in this paper were obtained in the course of scientific research using general scientific and special methods of cognition of legal phenomena. The systematic approach was used to study the mechanism of legal regulation of insurance relations in the field of healthcare services in Ukraine, and to clarify the specifics of healthcare insurance services. The formal legal method allowed the author to study certain functions, tasks, and objectives of health insurance. The induction method was used to study the insurance relations arising in the course of medical care provision, and on their basis, conclusions were formulated regarding the need to amend legislation.

Conclusions: The absence of a legally established concept of «medical insurance» and its broad interpretation by both theorists and practitioners is an urgent problem. Mandatory state medical insurance in Ukraine covers only some occupational risks related to health within the framework of mandatory state social insurance and is provided for mainly by the norms of social security law contained in special laws.

KEY WORDS: services, health insurance, occupational disease insurance, voluntary health insurance contract, liability insurance for healthcare professionals

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INTRODUCTION

A person has the right to health care, which is an important element in the system of values of civil society and the state. This right is directly enshrined in Article 49 of the Constitution of Ukraine [1], the Civil Code [2] of Ukraine and the Law of Ukraine «Fundamentals of Legislation of Ukraine on Health Care» [3]. The current stage of development of the healthcare sector in Ukraine is characterized by the intensive use of insurance opportunities by participants in legal relations to protect their property interests related to life, health and ability to work. The introduction of market mechanisms in the organization of health care allows the use of insurance in the provision of medical services, which is the beginning of the formation of the medical insurance market. The effective realization of the constitutional right to medical care and medical insurance, as enshrined in the Constitution of Ukraine [1], constitutes a fundamental objective of national healthcare policy. Globally, health insurance is recognized as one of the most efficient instruments for structuring access to medical services and mitigating the consequences of health-related risks. In the Ukrainian context, there is an urgent need to enhance the legal framework governing insurance services in the healthcare sector. Key priorities include the introduction of a mandatory medical insurance system, the standardization and regulation of occupational disease insurance, and the further development of voluntary insurance models.

The foregoing necessitates a study of the peculiarities of health insurance as the main instrument for ensuring the right to health care.

AIM

The purpose of the study is to analyse the scientific approaches and legislative provisions reflecting the peculiarities of insurance services in the healthcare sector of Ukraine, and to formulate conclusions and proposals for improving the legal regulation of insurance relations in the field of healthcare services. This goal was achieved by solving the following tasks: to clarify the peculiarities of insurance services in the healthcare sector, to define the concept of health insurance, and to study the peculiarities of mandatory health insurance and the features of its voluntary forms.

MATERIALS AND METHODS

The main provisions and results presented in this paper were obtained in the course of scientific research using general scientific and special methods of cognition of legal phenomena. The systematic approach was used to study the mechanism of legal regulation of insurance relations in the field of healthcare services in Ukraine, and to clarify the specifics of healthcare insurance services. The formal legal method allowed the author to study certain functions, tasks, and objectives of health insurance. The induction method was used to study the insurance relations arising in the course of medical care provision, and on their basis, conclusions were formulated regarding the need to amend legislation.

REVIEW AND DISCUSSION

Article 177 of the Civil Code of Ukraine (Ukraine's CC) states that a service is «one of the objects of civil rights» [2]. The Law of Ukraine «On Consumer Rights Protection» in clause 17, part 1, Article 1 defines a service as the activity of a contractor to provide (transfer) to a consumer a certain tangible or intangible good specified by a contract, which is carried out on an individual order of a consumer to meet his personal needs [4]. The absence of a legislative definition of the concept of service gives rise to different approaches to its understanding among scholars, linking the service to an action, activity or result. From the point of view of the law, it seems that a service has no result and exists in an indefinite status of an action or activity In the legal literature, it is generally accepted that a service is a type of civil legal relationship expressed in the form of a certain legal transaction, i.e. in the form of a series of expedient actions of the contractor or in the activity that is the object of the obligation, which has an intangible effect, an unstable material result or a materialized result associated with other contractual relations, and is characterized by the properties of feasibility, inseparability from the source, instant consumption, and informalized quality. Among the features that are inherent in all services are: its intangible result, synchronization of receipt and provision, impossibility of preservation, lack of guaranteed result. As an object of civil rights, services, in turn, are divided into types according to their content. The Civil Code of Ukraine does not establish an exhaustive list of types of services. Milash names the following features of a service, some of them: «1) the service is the activity of the person who provides it; 2) the provision of services does not create an embodied (objectified) result; 3) the useful effect of the service is consumed in the process of its provision, and the consumer value disappears; 4) impossibility of its storage; 5) inexhaustibility (no matter how much the service is provided, its quantitative characteristics do not decrease); 6) the subject of the service is the relevant actions, not their final result (since the result of labour does not receive a material form, it always exists in the form of the activity itself)» [5].

In the legal literature, insurance services are considered as «a contractual service under certain conditions, which is concluded to compensate for material losses incurred by a person who is a party to a contractual relationship» [6].

Insurance services, in addition to the general features inherent in services as objects of civil law, also have special features: the insurer's activities are related to financial assets, as this type of service is a financial service; actions performed in favour of third parties; the insured's will be manifested depending on the type of insurance (mandatory or voluntary).

In the healthcare sector, a set of insurance services to provide guarantees for the provision of medical care creates a system of medical (health) insurance. As the experience of foreign countries shows, the main goal of health insurance is to maximize the availability of medical services for a wide range of people and the tendency to fully compensate the insured's expenses. According to global standards, health insurance covers two groups of risks arising from health conditions: – the cost of medical services for health restoration, rehabilitation and care; – loss of income from unfulfilled labour activity caused by a health condition (both during the disease and after it in case of disability) [7].

Modern legal scholars provide different definitions of the concept of «medical insurance. All types of insurance related to reimbursement of the insured's expenses in connection with the disease and the need for treatment [6]. Some authors suggest that health insurance should be considered as a form of protection of the interests of an individual in case of loss of health for any reason [8]. Insurance in case of loss of health for any reason, including illness and accident [9]. The nature of health insurance is expressed in the provision of insurance coverage in the form of medical care. According to Yuvsechko's interpretation, «health insurance (insurance of medical expenses) is intended to cover the costs of treatment, but such coverage is natural, i.e. in the form of medical care, unlike ordinary property insurance» [10].

It should be noted that all the above definitions of health insurance do not provide clarity on the form of health insurance, i.e. they have a general interpretation of mandatory and voluntary health insurance. It can be noted that in countries where health insurance operates in the form of state health insurance, its mandatory form is established, and voluntary insurance is carried out

based on a contract, as well as insurance of ordinary risks in the field of general insurance.

Mandatory health insurance is usually defined as a type of mandatory social insurance and is a system of legal, economic and organizational measures organized by the state aimed at providing the insured person with free medical services under the relevant program in the event of an insured event [11]. A distinctive feature of such insurance is its social orientation, implementation within the framework of relevant state programs, and guarantee by social or other funds [12]. Thus, while voluntary health insurance is provided directly by the insured person or his/her employer, mandatory insurance is provided under the relevant programs, and medical institutions and insurance companies organized in mutual cooperation are used by employers and institutions joined on the basis of the state program.

Therefore, health insurance is a type of personal insurance that provides for the insurer's obligation to make insurance payments (insurance coverage) to the insured person in part or in full to compensate for those additional expenses caused by the insured person's application to a medical institution to receive medical services as a result of an insured event.

Based on the analysis of the above and our own definitions of the concept of health insurance, we can identify important aspects and features of health insurance. These include the social nature of health insurance, the compensation mechanism, the contractual basis of relations, the program basis, the in-kind form, the existence of funds and the principles of their use, the targeting of funds, the guarantee, the content by type (medical, medical and consulting, preventive and other medical services), and the implementation of mandatory and voluntary forms.

The Law of Ukraine «On Insurance» [13], which is intended to harmonize Ukrainian legislation with European principles, does not contain a division of insurance into mandatory and voluntary types. In our opinion, this provision in no way regulates the mandatory state health insurance provided for by special regulations.

Article 46 of the Constitution of Ukraine states that citizens have the right to social protection, including the right to be provided with benefits in case of full, partial or temporary disability [1]. This right is guaranteed by social insurance mechanisms through insurance contributions of citizens, enterprises, institutions and organizations, as well as budgetary and other sources of social security. According to Art. 253 of the «Labour Code of Ukraine» persons working under an employment agreement (contract) at enterprises, institutions, organizations, regardless of the form of ownership, type of activity and business, or for an individual, are subject to mandatory state social insurance [14]. Article 1 of the Law of Ukraine «On Mandatory State Social Insurance» establishes that one of the types of mandatory state social insurance is health insurance [15]. According to clause 2 of part 2 of Art. 25 of the Law of Ukraine «Fundamentals of the Legislation of Ukraine on Mandatory State Social Insurance» the following types of social services and material support are provided under mandatory state social health insurance: diagnostics and outpatient treatment; inpatient treatment; provision of finished medicines and medical devices; preventive and educational measures; provision of medical rehabilitation of persons who have undergone particularly difficult operations or have chronic diseases. The scope of services provided at the expense of mandatory medical insurance is determined by the basic and territorial programs of mandatory medical insurance, which are approved in accordance with the procedure established by law [16].

It should be noted that according to clause 2, paragraph 12, Section 7, «Final and Transitional Provisions» of the Law of Ukraine «On Mandatory State Social Insurance» [15], the Cabinet of Ministers of Ukraine was to prepare and submit to the Verkhovna Rada of Ukraine a draft Law of Ukraine on the introduction of mandatory state social health insurance. Since the adoption of this law and to this day, the relevant law has not been adopted. We agree with the opinion of O. Mykolenko that mandatory social health insurance is a type of state social insurance that differs significantly from health insurance provided in accordance with the requirements of the Law of Ukraine «On Insurance» [17].

Some laws regulating professional activities provide for the definition of the category of persons (e.g., healthcare professionals) subject to mandatory personal insurance, their rights and obligations, as well as the list of insured events and the terms of payment of the insurance amount.

Art. 77 of the Law of Ukraine «Fundamentals of the Legislation of Ukraine on Health Care» enshrines the right to mandatory insurance for healthcare workers, namely the right to: mandatory insurance at the expense of the owner of the health care facility in case of damage to their life and health in connection with the performance of professional duties in cases provided for by law [3]. This type of insurance, according to the provisions of the Law of Ukraine «On Mandatory State Social Insurance», belongs to another type of social insurance – «insurance against industrial accidents and occupational diseases that caused disability» (hereinafter – insurance against occupational diseases), and therefore has its own specifics in legal regulation [15]. The Resolution of the Cabinet of Ministers

of Ukraine № 1662 dated 08.11.2000 y. established the «On Approval of the List of Occupational Diseases of Medical Workers» [18]. In court practice, this list may be interpreted in an expanded manner, namely, «as an exception, a disease not included in the specified list may be recognized as an insured event if, at the time of the decision, medical science has new information that gives reason to consider this disease to be an occupational disease» [19]. In addition, an occupational disease should be considered an insured event «if it is established or detected during the period when the victim was not in labour relations with the enterprise during which he or she fell ill» [19].

In each healthcare sector, there are statutory guarantees and certain mechanisms for exercising the right to mandatory state social insurance for healthcare workers. For example, the provisions of the Law of Ukraine «On Protection of the Population from Infectious Diseases» stipulate that infectious diseases of medical and other employees related to the performance of professional duties in conditions of increased risk of infection with infectious agents (providing medical care to patients with infectious diseases, working with live pathogens and in infectious disease centres, disinfection measures, etc.) are considered occupational diseases. The said employees of state and municipal health care institutions and state research institutions are subject to mandatory state insurance in case of infectious disease in accordance with the procedure and under the conditions established by the Cabinet of Ministers of Ukraine [20]. The provisions of Art. 28 of the Law of Ukraine «On Psychiatric Aid» stipulate that employees involved in the provision of psychiatric aid are subject to state mandatory insurance [21]. Article 22 of the Law of Ukraine «On Prevention of Acquired Immune Deficiency Syndrome (AIDS) and Social Protection of Population» states that HIV infection contracted by a person as a result of performing professional duties is an occupational disease [22]. The Law of Ukraine «On Veterinary Medicine», in paragraph 7 of Art. 12 provides that the life and health of veterinary medicine specialists at the expense of a special fund of the State Budget of Ukraine are subject to mandatory insurance in case of injury or occupational disease sustained in the performance of official duties, in the fight against zoonoses and in direct manipulation of animals [23].

The above analysis of the regulatory material allows us to agree with many scientists who believe that mandatory state health insurance is a legally regulated relationship that develops between insured persons, policyholders, insurers and providers of medical services, aimed at the implementation of citizens' constitutional right to health care, and provides for the material provision of costs for the provision of the necessary volume of medical services through the targeted use of funds from the Health Insurance Fund, which are formed through the payment of mandatory insurance premiums, as well as revenues from other sources provided for by law. In modern Ukraine, a corresponding fund has not been created, and there is no mandatory medical insurance. Certain types of mandatory state social insurance are provided at the expense of the Pension Fund and have dual legal regulation: civil and social.

It is worth noting that on January 30, 2018, the Law of Ukraine «On State Financial Guarantees of Medical Services to the Population» came into force, which launched a medical reform in Ukraine, the main purpose of which is to fundamentally change the principles of medical services [24].

The National Health Service of Ukraine (NHSU) was established as a central executive body that implements state policy in the field of medical care for the population under the program of state guarantees of medical care (medical guarantees program). Among the main functions of the NHSU is performing the functions of a customer of medical services and medicines under the medical guarantees program. The tasks of the NHSU are to conclude, amend and terminate contracts for medical services and reimbursement agreements; to take measures to ensure the targeted and efficient use of funds under the medical guarantee program, including measures to verify compliance by medical service providers with the requirements established by the procedure for using the funds of the medical guarantee program, the terms of medical service contracts. The NHSU cannot be considered a national insurer in the system of mandatory health insurance, as the NHSU executive body ensures the redistribution of budget funds between healthcare institutions based on the costing of medical services provided in accordance with approved packages of medical care programs.

Voluntary health insurance (VHI) includes insurance schemes financed (in whole or in part) by personal insurance payments made by the insured to secure coverage under a specific insurance policy, which is usually attached to the insurance contract and issued by the insurer to the insured. Insurance premiums do not depend on a person's income, although the purchase of VHI by a certain group of the population or the population as a whole may be subsidized by the state. The voluntary form of health insurance is designed to expand the scope of services and improve the conditions for providing preventive, therapeutic, diagnostic and rehabilitation care to the population [6]. The relations between the subjects of the voluntary form of

insurance are built on the basis of the conclusion of two contracts simultaneously: an insurance contract concluded between the insurer and the insured, as well as a contract for the provision of medical and preventive care concluded between the insurance company and the medical institution [9].

Thus, the relations between the parties are regulated by voluntary agreements. It is worth noting that the term «health insurance contract» is not defined either in the legal literature or in the law. Insurance companies use forms of contracts that are not enshrined in the Civil Code of Ukraine or other legal acts – the so-called unnamed insurance contracts, such as a health insurance contract or a medical expenses insurance contract [2].

A characteristic feature of voluntary health insurance (VHI) is the right of the insured to choose an insurance program and a healthcare facility from those offered by the insurer and to establish a contractual relationship with the insurance company.

The purpose of voluntary health insurance is to create an economic interest of the state and employers in improving the health of the population.

The Law of Ukraine «On Insurance» does not distinguish between mandatory and voluntary insurance, and calls health insurance (class 2) sickness insurance, separately distinguishing class 22 – continuous health insurance, class 1 – accident insurance (including in case of occupational injury and occupational disease). At the same time, the legislator notes that this Law does not apply to mandatory state social insurance, and in Art. 89 emphasizes that if the law establishes the obligation of a person to conclude an insurance contract, the object of insurance is determined in accordance with the requirements of the law [13]. Narrowing the concept of health insurance to one of its forms (sickness insurance) is unjustified, both from the point of view of legal theory and practice.

One of the most effective mechanisms for legal protection of the professional activities of healthcare professionals in developed countries is professional liability insurance for medical workers. The development and distribution of professional liability insurance for medical workers today is one of the most pressing problems in domestic medical law and the practice of its application. It is due to the urgent need to increase the level of legal and social protection of medical workers. As for patients, the distribution of insurance, along with the development of pre-trial methods for resolving conflicts between a patient and a healthcare institution or a private practitioner, allows significantly increasing guarantees for compensation for harm to the patient's health that occurred during the provision of medical care.

CONCLUSIONS

According to Part 1 of Article 49 of the Constitution of Ukraine, everyone has the right to health care, medical assistance and medical insurance. At the same time, the absence of a legally established concept of «medical insurance» and its broad interpretation by both theorists and practitioners is an urgent problem. Mandatory state medical insurance in Ukraine covers only some occupational risks related to health within the framework of mandatory state social insurance and is provided for mainly by the norms of social security law contained in special laws. The legal conflict that arose as a result of the inconsistency of medical and social legal norms with the norms of the Constitution of Ukraine, in our opinion, should be resolved in favour of the institution of mandatory medical insurance and by proper regulation of the existing legislative framework. Regarding the prospects for the development of VHI on the Ukrainian market in the post-war period, we can highlight the following areas: expanding the package of guaranteed medical services under VHI programs; the need to adopt a special law on voluntary health insurance and specific measures to develop the VHI market; expanding special programs related to compensation for losses caused by military actions and the consequences of their impact on the health of citizens; convergence of insurance risks and the offer of new VHI products.

The basis for the qualitative development of the healthcare sector is a stable and high-quality health insurance market, where strategic guidelines are based on the criteria for improving the health of the population.

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REVIEW ARTICLE

CONTENTS

The role of menopausal hormone therapy in hormone-dependent carcinogenic mechanisms in the oral cavity: A literature review

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ABSTRACT

Across the world, the incidence of oral squamous cell carcinoma (OSCC) is increasing, establishing it as one of the most prevalent cancers originating in the oral cavity. Estrogen Receptor alpha (ERα) and Estrogen Receptor beta (ERβ) expression were identified and analyzed in normal oral mucosa as well as in squamous cell carcinoma. On a molecular level, estrogens and progestogens, as steroid hormones, influence various biological processes, including reproduction and behavior, by binding to their intracellular receptors. Hypotheses suggest that oral cavity malignancies could be hormonally induced. Periodontal inflammation, mediated by TREM-1, IL-1β, and reduced salivary antibacterial function during hormonal fluctuations, is important in evaluation of etiology of oral cancers and is correlated to hormonal levels. Focal adhesion kinase (FAK) signaling activates ERα through phosphorylation, increasing its transcriptional activity and promoting cell proliferation. Menopausal hormone therapy (MHT) offers both hormonal and non-hormonal treatments, with concerns about overprescription and potential off-label use. In this literature review we aimed to analyze whether there is a link between MHT which consists of estrogen or both estrogen and progesterone and oral cancer risk. A review of the scientific literature covering the years 2018–2025 was carried out, whether estrogens, identified as carcinogens, may be suggested as the potential therapeutic target for OSCC in the future, similar to their well grounded role in the standard management of estrogen receptor-positive breast cancer.

KEY WORDS: carcinogenesis, hormone replacement therapy, oral squamous cell carcinoma, menopausal hormone therapy

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INTRODUCTION

Estrogens have been identified as carcinogens, and their action in promoting cancer is the result of complex molecular mechanisms. Recent studies show that a variety of tumors could be hormonally induced during pregnancy or in young female patients without the established risk factors of alcohol or tobacco use [1]. Researchers highlight the impact of estrogen signaling in various cancers, including non-small cell lung cancer (NSCLC), where estrogen may influence tumor progression, potentially modifying patient prognosis and therapeutic outcomes. Additionally, studies in colorectal carcinoma reveal the variable expression of ERβ isoforms, shedding light on their possible clinicopathological and molecular significance. Furthermore, hypermethylation of the promotor region of the ER gene leads to reduction of the expression as well as deregulation of growth of colonic mucosa [2]. Estrogens may reduce serum insulin-like growth factor-I (IGF-I), which is a crucial factor in the pathophysiology of colorectal and other cancers. Estrogens were observed to participate in mechanisms of tumor volume increase, as shown in an experiment on laryngeal carcinoma [3]. ERβ directly regulates the NOTCH1 gene expression during differentiation *via* RNA polymerase II pause release, whereas mutations in NOTCH1 are linked to the onset of squamous cell carcinoma [4]. Selective estrogen receptor modulators (SERMs), such as tamoxifen, effectively target estrogen receptors and inhibit cancer proliferation [5, 6] and have become the gold

standard of anti-estrogen treatment in breast cancer in postmenopausal women [7, 8]. Other widely used drugs are Aromatase inhibitors; anastrozole, letrozole, and exemestane and Selective estrogen receptor down regulators (SERDs); fulvestrant and elacestrant. Furthermore, for malignancies not exclusively hormone-dependent (like endometrial cancer or ovarian cancer), such as colon cancer, glioma, or lung cancer, estrogen receptor-mediated impacts on the pathogenesis are documented [9].

AIM

The aim of this review is to provide information whether the estrogens used in menopausal hormone therapy have the possible impact on carcinogenic mechanisms in the oral cavity. In consequence, whether there are more possible uses of the potential anti-tumor benefits of estrogen-related medicines, which are now being examined. Together, these findings emphasize the need to understand the nuanced role of estrogen receptors in tumor biology to better assess clinical implications of novel targeted therapies [10].

MATERIALS AND METHODS

In this literature review we aimed to analyze whether there is a link between MHT which consists of estrogen or both estrogen and progesterone and the risk of oral cancer development. A review of the scientific literature covering the years 2018–2025 was carried out, whether estrogens may be suggested as the potentially carcinogen for OSCC in the future. We used search of the PubMed and Scopus databases. Keywords used in the search included „menopause", „estrogen", „periodontal inflammation", „gingivitis" and „oral squamous cell carcinoma".

The search included both peer-reviewed articles published in English as well as original articles.

REVIEW AND DISCUSSION

Menopause is a normal phase in a woman's life characterized by the cessation of the monthly cycle and a considerable decline in hormone levels, particularly estrogen. This life stage often manifests in women aged 45 to 55 and is frequently linked with many symptoms, including hot flashes, nocturnal sweats, sleeplessness, vaginal dryness, mood fluctuations, and an elevated risk of osteoporosis and cardiovascular disease [11]. Indications for menopausal hormone therapy (MHT) include severe vasomotor symptoms, such as hot flashes, and the genitourinary syndrome of menopause, characterized by vaginal dryness and associated issues. This medication may also aid in the prevention of osteoporosis, especially in women at elevated risk of fractures when other treatment options are insufficient or inaccessible [12]. MHT encompasses a broad spectrum of therapeutic options, which can be categorized into both hormonal and non-hormonal approaches. The hormonal therapies include tibolone, combined estrogen and progestin formulations provided by manufacturers, estrogen alone, combinations of estrogen and progestin prescribed by physicians, and localized estrogen treatments. On the other hand, non-hormonal alternatives, often utilized for symptom management, include medications such as citalopram, desvenlafaxine, escitalopram, gabapentin, paroxetine, and venlafaxine [13]. The treatment is widely offered to patients and is often proposed in the private healthcare sector, raising concerns about the potential risk of overprescription [14].There is a debate, whether there is an area of off-label use of the hormone therapy for prolonging the positive self-esteem due to the eradication or covering of symptoms of womens' ageing [15]. The practices outlined above are remnants of an era characterized by limited scientific data when celebrities proclaimed MHT as "the fountain of youth" [14]. Since the introduction and authorization of the first combination oral contraceptive pill, formulations have changed from including high-dose estrogen (150 mcg) to much lower levels (10 and 20 µg). Contraindications mostly include current or historical hormone-dependent malignancies (e.g., breast cancer), uncontrolled hypertension, thromboembolic disorders, active hepatic illness, and gestation. The choice to apply MHT must be personalized, considering the patient's age, duration after menopause, and other risk factors [11]. Hormone treatment may result in side effects such as an elevated risk of venous thrombosis, particularly with oral estrogen.The increased cancer risk, including breast cancer, is associated with prolonged use of combination therapy (estrogen combined with progestogen). The risk of endometrial cancer is also hormone-dependent. The impact on the risk of developing malignancy in endometrial tissue varies depending on the method of hormone treatment. Sequential combined MHT, longer duration of the use with fewer days of progestogen per cycle and higher doses of estrogen slightly increases the risk, while continuous combined estrogen/progesterone therapy decreases the risk when taken orally [16, 17]. Additional potential adverse effects include headaches, nausea, edema, and mood fluctuations [11, 12].

PERIODONTAL INFLAMMATION

Periodontal inflammation has recently been proposed as an additional factor contributing to the increased risk

of cancer development [18]. In the article by Yakar et al. [19], the pathomechanism of periodontal inflammation during menopause is discussed, with emphasis on molecular mediators like TREM-1, PGLYRP1, and IL-1β. The study highlights that TREM-1, a receptor expressed on myeloid cells, plays a significant role in the inflammatory process of periodontal disease, specifically by amplifying inflammatory signals. This mechanism is relevant in both chronic and acute periodontal inflammation. In initial stage, pathogens in dental plaque trigger the immune response, leading to the release of cytokines and inflammatory mediators, which includes interleukin-1β (IL-1β). This response marks the beginning of tissue inflammation. In amplification stage, TREM-1 is activated on the surface of myeloid cells, intensifying the inflammatory response by further promoting cytokine release. This receptor enhances the activity of pro-inflammatory mediators, thus amplifying the immune response against periodontal pathogens. In chronic inflammatory stage, continuous activation of TREM-1 and related pathways leads to prolonged inflammation. PGLYRP1, another mediator, works alongside TREM-1 and IL-1β to sustain the inflammatory process, which can lead to tissue destruction if not controlled. TREM-1 is a critical component in the pathomechanism of periodontal inflammation, serving as a receptor that amplifies immune responses during both chronic and acute phases of periodontal disease. This receptor's activity is associated with an enhanced inflammatory response, which is particularly relevant during menopause and may affect immune responses and inflammation in the gingival tissues. The findings suggest that targeting TREM-1 might offer therapeutic potential in managing periodontal inflammation, especially for menopausal women who may experience heightened inflammatory responses due to hormonal shifts [19]. Additionally, estrogen plays a role in angiogenesis by enhancing the expression of vascular endothelial growth factor (VEGF), subsequently impacting gingival vascularization [20].

Other etiological factor of possible hormonal impact is the fact that estrogens may suppress the physiological salivary flow rate. This leads to a reduced natural antibacterial efficacy of saliva, hence disturbing local microbial homeostasis and increasing predisposition to gingivitis and dental caries in the affected women [21, 22]. The authors of cohort study with 103 participants did not found the correlation between hormonal contraception and significant changes in salivary microbiome together with mentioning in the same work that there is present an amount of evidence suggesting a connection between the menstrual cycle and alterations in the microbiome of dental plaque; however, a clear consensus is lacking, and the sample sizes of the cohorts were relatively limited [23].

Other studies also follow the arguments regarding development of gingivitis and suggest the more possible negative outcomes of using of hormonal contraception for oral cavity health. Main observed risks were osteitis following tooth extraction and presence of the Candida species [24]. Jensen et al. reported that women who are taking oral contraceptives had up to sixteen times higher level of Bacteroides species in their dental plaque than the control group [25].

The cross-sectional comparative study conducted among 200 females showed that hormonal contraceptives influence gingival and periodontal disease progression. The methodology was thoroughly and effectively developed, and as the study group only females aged 18 years and above of Jaipur city were included, and the exclusion criteria were consumption of alcohol and tobacco in any form, medical illnesses, being under any type of medications other than OCP, as well as having a periodontal problem or a history of any periodontal treatment prior to 6 months before the study. The study subjects were divided into two groups, i.e., contraceptive users and non-contraceptive users, each group consisting of 100 females. Periodontal status was examined using the Community Periodontal Index (CPI) and Loss of Attachment (LOA), where the use of CPI was particularly appropriate given its status as a validated index enabling scientific comparisons and enhancing the value of the conclusions drawn. Mean CPI score in contraceptive users and non-contraceptive users was 2.34 ± 0.81 and 1.16 ± 0.89 respectively. Mean LOA score in each group was 0.28 ± 0.45 and 0.19 ± 0.50 respectively [26].

The other pathologies connected to inflammation are the oral ulcerations. Altaee et al. in case-control study involving 30 female participants, aged between 18 and 45 years old, found, inter alia, that hormones in oral contraceptive pills markedly elevate the risk of mechanisms that contribute to the development of periodontal diseases. There is increase in the prevalence of oral symptoms, including ulcerative lesions and mucosal discolouration, particularly pyogenic granulomas. Inflammation-associated oral pathologies also include the development of ulcerative lesions. In a case-control study of thirty women aged 18–45 years, Altaee et al. demonstrated that hormonal components of oral contraceptive pills significantly increase risk factors for periodontal disease. Participants using progesterone-containing oral contraceptive pills exhibited a higher prevalence of oral symptoms—most notably ulcerative lesions, mucosal discoloration and pyogenic granulomas—than non-users. The authors propose that progesterone promotes gingival inflammation both by upregulating pro-inflammatory cytokines and

prostaglandin production and by increasing the volume of gingival crevicular fluid in pill users [27].

A cross-sectional analysis of 125 Saudi women (94 oral contraceptive users) by Jawad et al. found that users of combined hormonal pills experienced significantly higher rates of gingival bleeding, dental caries, and oral ulcerations than non-users [28]. Similarly, AlGhamdi et al. confirmed these associations and further concluded that chronic exposure to exogenous estrogen and progesterone in contraceptives leads to measurable increases in gingival crevicular fluid volume and shifts in its inflammatory cytokine profile [29].

ORAL SQUAMOUS CELL CARCINOMA (OSCC)

Oral squamous cell carcinoma (OSCC) is the most widespread oral malignancy. It is the representative of the group of oral cancers that still contributes a substantial disease burden. The first volume of Lancet Oncology Journal in the year 2025 even in its Editorial section discussed the importance of oral cancer incidence and management. The crucial part in the first steps of the oral cancer diagnostic pathway is always played by dentists worldwide. In 2022 more than 350 000 new cases along with 180 000 deaths due to oral cancer were recorded globally; moreover, in Papua New Guinea and Bangladesh oral cancer is the second most common cancer [30].

Oral cavity cancer, the sixth most common malignancy in the world, is also the 18th most commonly diagnosed malignancy globally, accounting for 2.0% of all cancer cases in 2020 according to the GLOBACAN database [31]. Oral cancers are more common in people older than 60 years but the prevalence is increasing in women and in younger people. Effective smoking control efforts may have contributed to the decline in oral cancer rates associated with tobacco use, a significant risk factor. Additional risk factors are alcohol consumption and human papillomavirus infection (HPV). The incidence is higher in men than in women. The study by Grimm et al. [32] did not find the expression of ER alpha in oral mucosa in OSCC samples from female patients whereas it was confirmed on male patients. ER alpha expression was also found in oral precursor lesions (squamous intraepithelial neoplasia). On the contrary, in a study conducted by Marocchio et al. [33] as well as by Doll et al. [34] ER alpha and beta were expressed in female oral mucosa cells, while ER beta was in female with OSCC in findings provided by Akyu Takei et al. [35]. Moreover, there is the cross-talk between ER and epidermal growth factor receptor (EGFR) in head and neck squamous cell carcinoma as well as relatively strong effect of estrogen and Epidermal Growth Factor (EGF). Chang et al. [36] examined the mechanism underlying ERα activation and showed the correlation with focal adhesion kinase (FAK) signaling, which activates the FAK/AKT pathway, enhancing the phosphorylation of ERα at Ser118 in OSCC cells. This phosphorylation increases ERα activity, promoting cell growth and proliferation in oral squamous cell carcinoma. Non-smoking and non-drinking (NSND) patients with oral cavity cancer are mainly observed among older women [37]. Farshadpour compared 195 NSND patients with HNC and 4209 patients with HNC retrospectively. Of the NSND patients with HNC, 142 (73%) were women, with a mean age of 73 years (median 76, range 20–97). Similarly, in a retrospective study on 287 patients with oral cavity cancer, 70 (24.4%) patients had NSND, of whom, 53 (18.5%) were women (M:F; 1:3.12). Moreover, of the 39 (13.6%) NSND patients, 28 (9.75%) were women over the age of 70. In that mentioned study, an increased risk was observed with increasing age (≥70 years) (HR: 3.219; 95% CI: 2.408–4.303), whereas smoking and alcohol consumption were not associated with the risk of oral cavity cancer in postmenopausal women [38]. In a screening examination conducted from 1 January 2002 to 31 December 2019, the number of participants diagnosed with oral cancer in retrospective cohort study by Yuk et al. in each group were as follows: 1782 (0.2%), 308 (0.2%), 159 (0.1%), 121 (0.3%), 15 (0.3%), and 4 (0.2%) in the non-MHT, tibolone, combined estrogen plus progestin by manufacturer (CEPM), oral estrogen, combined estrogen plus progestin by physician (CEPP), and topical estrogen groups, respectively [39]. In the Cox proportional hazard analysis adjusted for variables such as age, BMI, socioeconomic status (SES), region area, Charlson Comorbidity Index (CCI), parity, age at menarche, age at menopause, smoking, alcohol, physical exercise, and period from menopause to inclusion, the number of participants diagnosed with oral cancer increased in the tibolone (hazard ratio [HR]: 1.175, 95% confidence interval [CI]: 1.031–1.338) and oral estrogen groups (HR: 1.633, 95% CI: 1.35–1.976). That analysis of the results suggests that MHT increases the risk of oral cavity cancer in postmenopausal women. However, Fernandez et al., in a network analysis of case-control studies, which included 253 participants, showed a nonsignificant reduction in risk for cancers of the oral cavity, esophagus, pharynx and larynx, as well as for thyroid cancer, Hodgkins's, non- Hodgkin's lymphomas and myelomas. In that study there is mentioned that the reduction in risk for mentioned cancers should be considered always with the warnings about limited statistical power included in that study due to the low prevalence of HRT in that population and

low incidence for some of the cancers [40]. The same small number of participants are also in another study the factor of inconsistency in results analysis [41]. In the mentioned cohort study oral cancer diagnosed in HRT-use compared with non-use adjusted HR = 0.72 95% CI 0.55, 0.95).

CONCLUSIONS

In this literature review, we highlight the need for further research into the hormonal dependency of oral cancers. Specifically, the potential impact of endogenous versus artificial sex hormones, including molecular and clinicopathological aspects, requires in-depth evaluation. Additionally, alternatives to oral MHT should be explored to identify and evaluate the potential risks. Moreover, it must be highlighted that the globally-used MHT not only consists of oral estrogen, but there are alternative methods. Furthermore, it is critical to emphasize that MHT is not limited to oral estrogen, and individualization of treatment plans based on patient-specific risk factors is essential. This includes careful consideration of age, duration of therapy, and personal and family history of hormone-dependent cancers. The further research should also focus on new ways of pharmacotherapy, for example the potential use of tamoxifen or other drugs that target FAK. Other forms that seem not to share the same risk in cancer development are vaginal, topical estrogens and non-hormonal approaches, such as above mentioned antidepressants and gabapentin. In conclusion, understanding the nuanced interplay between hormonal treatments and cancer risk is vital to improving patient outcomes. Further studies should focus on clarifying the differences in carcinogenic potential between endogenous and artificial hormones, as well as evaluating the long-term safety of alternative therapies.

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CONFLICT OF INTEREST
The Authors declare no conflict of interest

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CASE STUDY

CONTENTS

Surgery to remove the plate from the distal radius with simultaneous reconstruction of the lacerated flexor pollicis longus tendon performed under WALANT: A case report

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ABSTRACT

The tendon rupture was caused by the protruded distal edge of the palmar plate inserted for fixation of the distal radial fracture 2 years earlier. The patient was a 28-year-old patient who had stopped bending the distal phalanx of his right thumb 2 months prior to the presentation.
Performance of anaesthesia and operation is presented in details. The operation went smoothly, bleeding was minimal despite the relatively extensive wound, and the patient felt only little pain at the end of the operation.

KEY WORDS: WALANT, distal radius plate fixation, flexor pollicis longus rupture, tendon grafting

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INTRODUCTION

Isolated injuries to the flexor pollicis longus (FPL) tendon occur when the hand is injured by a sharp object. They are relatively common, especially in young men, they occur at work, household activities, or in fights with sharp tools. Injuries caused by the circular saws are also common, in which, in addition to the FPL laceration, digital and metacarpal bone fractures and nerve injuries frequently occur. A relatively rare cause of damage to the FPL tendon is its rupture due to rubbing against the implant, placed at the distal end of the radius. These fractures are common, particularly in the older population, and one of the methods of surgical treatment is their fixation with the titanium palmar plate. If the implant is placed correctly, there is no need to remove it in the future because it is designed to stay permanently. The plate is made of titanium, does not corrode and is biocompatible. However, if the plate is placed incorrectly (which happens in about 10% of patients), it can cause complications, one of which is a rupture of the FPL tendon, which rubs against the upper edge of the plate and eventually ruptures. This was the cause of the damage to this tendon in the described case: the plate was fixed too distally (distal to the so-called "watershed line") caused the FPL tendon to rupture [1-4].

Repair of tendon injuries are now often performed under WALANT (Wide Awake Local Anaesthesia with no Tourniquet). This method of anaesthesia, performed by surgeons themselves, without the anaesthesiologist assistance, has gained great popularity in the last 10 years. It was developed and popularized by Canadian surgeon Mr Donald Lalonde, who published several papers on the subject and produced a book [1-3]. This contributed to the popularization of this technique, which has been used in the authors' institution for about 15 years [4-6]. In most cases, WALANT is used for minor operations, performed in an out-patient setting, such as carpal tunnel release, trigger finger or Dupuytren's contracture. More complex operation are rare performed in this anaesthesia due to their long duration, greater tissue exposure, which increases the risk of pain for the patient and worsens the surgeon's working conditions. For these operations, brachial plexus block anaesthesia is usually used, and the bloodless field is achieved by a tourniquet inflated on the arm of the patient. The aim of the study is to present a case where a relatively extensive and long-lasting surgery was successfully performed under WALANT delivered by the surgeons themselves and without anaesthesiologist assistance.

CASE REPORT

The institution headed by the author was visited by a 28-year-old patient who had stopped bending the distal phalanx of his right thumb 2 months prior to the presentation. This indicated damage to the FPL

Fig. 1: a). X-ray of the distal radius of the patient at presentation (p-a view); b) X-ray of the distal radius of the patient at presentation (lateral view). Note protrusion of the distal edge of the plate
Picture taken by the authors

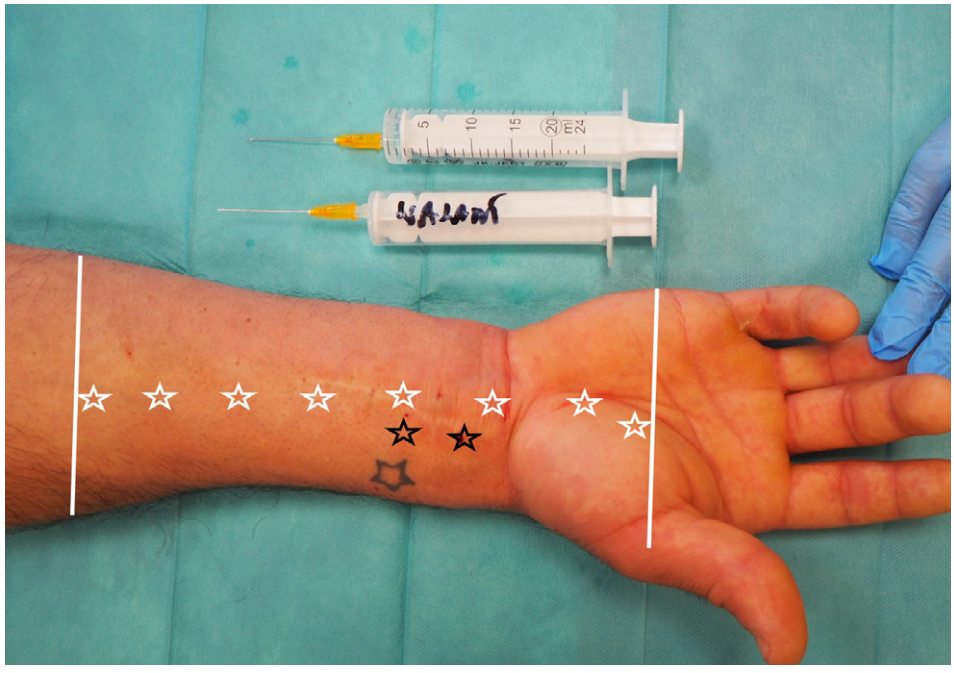

Fig. 2. Sites of injection of the anaesthetic solution marked with asterixis
Picture taken by the authors

tendon. When asked about the possible cause, he reported that 2 years ago he had underwent plate fixation of the distal radius fracture, which he suffered as a result of a fall from a bicycle. The postoperative course was uncomplicated and the patient regained full function of his hand. The X-ray taken during the consultation showed that the plate is screwed to the bone too distally, which, as mentioned earlier, poses a risk of tera of the FPL tendon on the distal edge of the plate (Fig. 1 a, b). This was the probable mechanism of the tendon damage. The patient has been scheduled for surgery.

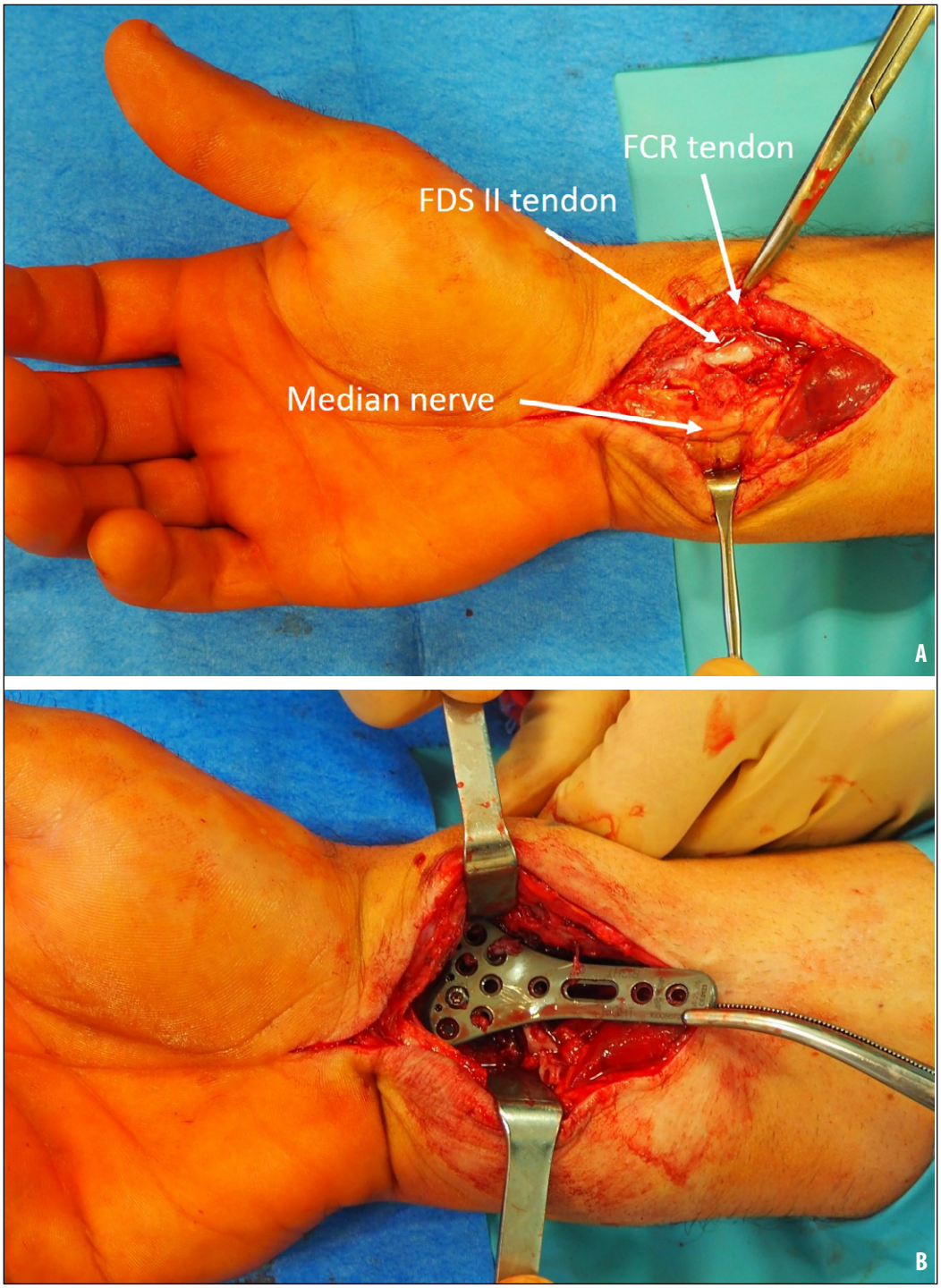

Fig. 3: A). Anatomical situation after opening of the forearm. Note bloodless operative field.
B). Removal of the palmar plate
Picture taken by the authors

In addition to removal of the plate, a simultaneous reconstruction of the FPL tendon was planned. The standard approach in this situation is two-stage operation: in a first step a silicone rod (tendon prosthesis) is implanted, followed by tendon grafting, 2-3 months after first operation. But after some thought, it was decided to perform a one-stage tendon reconstruction. The premise for such a decision was the zone of damage: III and IV in the Kleinert classification, i.e. areas where the tendons are not surrounded by a fibrous sheath. This location makes it unnecessary to create a canal for the transplanted tendon (palmaris longus, PL), as in the case of flexor tendon reconstruction in zone II. Therefore, for the patient's quicker recovery, it was decided to perform a simultaneous retrieval of the palmar plate and FPL tendon reconstruction using PL tendon graft. Such a complex and supposedly long-lasting surgery is performed as standard under brachial plexus block anaesthesia and with the use of a tourniquet. The authors decided to try to perform it under WALANT, which was a challenge, because such a complex surgery has not been described to date under local anaesthesia.

Fig. 4. Additional anaesthesia in the thumb
Picture taken by the authors

THE ANAESTHESIA

The WALANT was performed in the procedure room at the surgical ward, about 15 minutes before the patient was transported to the operating theatre. A 40 ml of a standard solution of 1% lidocaine with added adrenaline at a dilution of 1:100,000, buffered with sodium bicarbonate, was used. To anesthetize a relatively large area, 10 injections had to be made, administering 4-5 ml of solution at each injection. The anaesthesia included the place where the plate was located (the area that roughly corresponds to the scar after the first surgery), but also the area where the PL tendon will be collected for grafting (up to the middle of the forearm) and the area where the distal FPL tendon stump may be located, i.e. on the metacarpal. The injection sites are marked with white stars in Fig. 2. Black stars mark places where the needle was inserted deeply, up to the plate.

THE OPERATION

The operation was performed without the use of a mobile X-ray device (fluoroscope) and without the assistance of an anaesthesiologist. The surgery consisted of two stages: removal of the plate from the distal radius, and then FPL reconstruction with PL tendon grafting.

STAGE 1: REMOVAL OF THE PLATE

Removal of the palmar plate consists of the same stages as fixation of the fracture. It even is more difficult due to adhesions which surround implant and soft tissue.

• Incision is made through the scar from previous surgery on the distal part of the forearm, which is extended distal to the wrist. After dissecting the subcutaneous tissue, the FCR tendon is identified and released from adhesions. In the presented case, the median nerve entrapped in the scar was present under the skin and the superficial flexor tendon of the index (FDS II) surrounded by a connective tissue capsule (Fig. 3 a).

• The proximal stump of the FPL was located deeper, at the upper pole of the wound, under the FCR tendon (not visible in the Fig. 3a).

• After dissecting the space between the FCR tendon and the FDS II, the plate was exposed, the screws were removed from it and the plate was separated from the bone (Fig. 3 b).

During this stage of the operation, the patient did not feel any pain and the operating conditions were good.

STAGE 2: FPL RECONSTRUCTION

Since the FPL tendon rupture occurred as a result of abrasion at the edge of the plate, a large defect of the tendon length was to be expected, and thus the need for a tendon graft. An attempt to find the distal stump at the lower pole of the wound failed, so it was decided to find the FPL tendon on the thumb and then deliver it to the wound on the wrist. However, this required an additional anaesthesia with 5 ml of WALANT solution (Fig. 4).

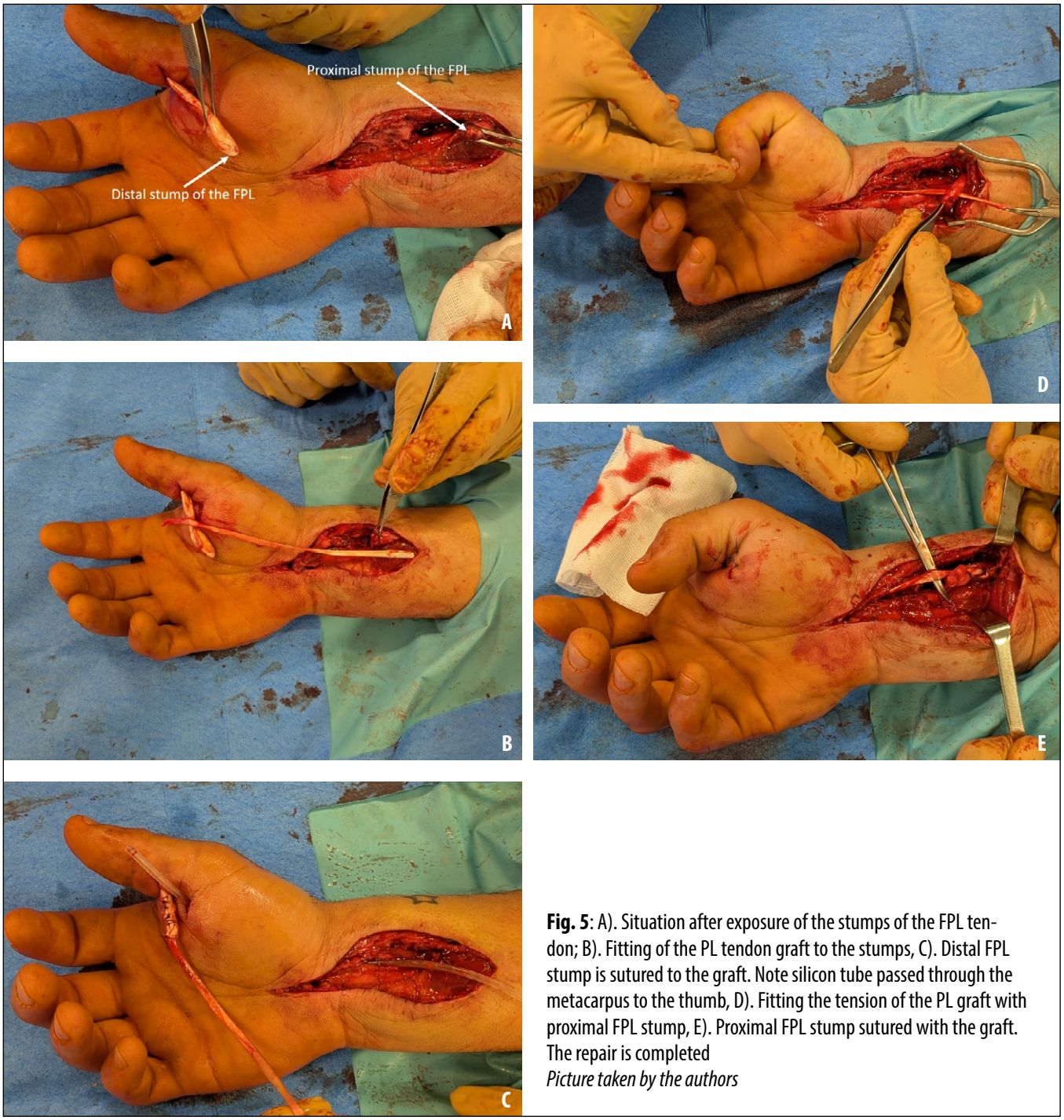

Fig. 5: A). Situation after exposure of the stumps of the FPL tendon; B). Fitting of the PL tendon graft to the stumps, C). Distal FPL stump is sutured to the graft. Note silicon tube passed through the metacarpus to the thumb, D). Fitting the tension of the PL graft with proximal FPL stump, E). Proximal FPL stump sutured with the graft. The repair is completed
Picture taken by the authors

• After making an incision on the proximal phalanx of the thumb, the FPL was dissected and pulled outwards (Fig. 5 a)

Pulling out the distal stump 2 months after the tendon rupture was difficult due to strong adhesions; considerable force had to be used to "tear" the distal stump from the surrounding tissues.

• Figure 5a shows the situation after dissecting both tendon stumps. Note, that the gap between tendon stumps was about 10 cm.

• The next stage of the operation was harvesting the PL tendon for grafting. After finding its distal end on the wrist and dissecting it from adhesions, the entire PL tendon was harvested with a tenolizer. Fig. 5 b shows the fitting of the PL tendon to the FPL tendon stumps.

• Then, a silicone tube was passed through the space on the metacarpal so that the graft could be pulled through this place without making an additional incision (Fig. 5 c).

• The end of the PL tendon graft was sutured to the distal stump of the FPL using the Pulvertaft technique (Fig. 5 c).

• Then the graft was pulled to the wound on the forearm, after suturing its distal end to the drain.

Fig. 6: A). Intraoperative flexion of the thumb, B). Intraoperative extension of the thumb
Picture taken by the authors

• After pulling the PL tendon, its free end was sutured to the proximal stump of the FPL tendon. This part of the operation is important because the tendons must be sutured under the optimal tension. After making three "threadings" of the PL graft in the proximal FPL stump, the author keeps both tendons under tension so that the thumb is in flexion and the proximal FPL stump tendon is stretched (Fig. 5 c). The situation after the completion of tendon reconstruction is shown in Fig. 5 e.

• After the repair was completed, the patient was asked to flex and extend the thumb actively to ensure that the reconstruction was performed under the appropriate tension (Fig. 6 a, b).

• Finally, the thumb was immobilized in a plaster splint.

The entire operation lasted 2 hours and during the last 20 minutes, the patient began to feel pain in the forearm, which could be due to the metabolized lidocaine and the cessation of its activity in the tissues. For this reason, the patient was given 100 mg of ketoprofen i.v., which allowed him to comfortably complete the operation.

The WALANT is a new quality in hand surgery which significantly improves conditions of the work of surgeons. The most important advantage is that it can be delivered by the surgeon himself, without the participation of an anaesthesiologist. Compared to simple infiltration anaesthesia, the WALANT makes the conditions of a bloodless surgical field, which usually requires use a tourniquet. Operating under WALANT allows the patient to move with the operated fingers, which is important for control of the quality of the repair performed. The WALANT is suitable for most hand surgeries, both on soft tissue and bones. It is particularly useful for tendon repair and corrective osteotomies of finger bones. In the described case, this anaesthesia was successfully used for a relatively complex operation of removal of the plate and simultaneous reconstruction of the FPL tendon. The operation went smoothly, bleeding was minimal despite the relatively extensive wound, and the patient felt only little pain at the end of the operation.

The literature offers several reports on use of WALANT in various hand surgeries, most of them minor and performed in an out-patient setting. More extensive operations are rare reported and most of them are case reports. The repair of the damaged FPL tendon under WALANT anaesthesia was reported in this journal in 2019 [4]. However, it was a much simpler operation compared to the one reported here.

One of the bigger series comes from the authors' institution. The authors report that in a period of 10 years (2013-2022), a total of 5638 operations were performed under WALANT performed by surgeons themselves. Efficacy of these procedures was 98% in terms of no pain experienced by the patients during surgery. A total of 203 (3,6%) adverse reactions were noted associated with anesthesia, most of them transient, not requiring emergency intervention and without serious consequences. In only 12 cases (0,02%) adverse effects caused cancellation and postponing of scheduled operation. The authors conclude that WALANT performed by surgeons themselves is effective and safe method of anaesthesia for hand surgery operations [6].

Sim et al. (2019), reported results of analysis of 1994 local and regional anaesthesia for hand surgery operations performed by surgeons in tertiary orthopedic department in Singapore. Almost 100% efficacy of anaesthesia was noted. Adverse events occurred in 67 patients (3,4%), but none of them was serious or life-threatening. The authors emphasize benefits associated with non-engagement of anesthesiologists and significant reduction of costs at this setting [7].

Kurzman et al. (2021) presented results of meta-analysis of literature on efficacy and safety of WALANT for surgery on upper limbs. They reviewed 80 papers published in years 2005-2022 and found high level of efficacy, safety and multiply benefits associated with operating without anesthesiologist's assistance: greater availability of surgeries for patients burdened with concomitant diseases, shortening the waiting time and reduction of costs. The reviewed studies show that WALANT allows operating patients at older age, with obesity and other concomitant diseases for whom standard anaesthesia (general or regional) might be dangerous, and who (for this reason) are frequently disqualified by anesthesiologists from surgery [7].

CONCLUSIONS

To the best knowledge of the authors, the described case is the first in the literature concerning such a complex hand surgery. With the passage of time and gaining experience, more and more complex operations are performed under WALANT in the authors' institution. The authors believe that presentation of this case will be interesting for hand surgeons and will encourage them to extend the scope of operations performed under WALANT.

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CONFLICT OF INTEREST
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