

Dynamics of cadets' morphofunctional development in the process of their academic training for law enforcement activities

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ABSTRACT

Aim: To study the dynamics of morphofunctional development indicators in female cadets – future law enforcement officers – in the process of engaging in various types of motor activity during their academic training.

Materials and Methods: The research involved 56 female cadets in their first to third training years. Two groups of female cadets were formed: an experimental group (EG, n = 27), whose members attended the university's CrossFit sports club, and a control group (CG, n = 29), whose members did not engage in additional sports activities, but only participated in the traditional program during their sporting and mass-participation activities (SMPAs). Research methods: theoretical methods, biomedical methods, statistical methods.

Results: It was found that in female cadets who practiced CrossFit, all the parameters studied were significantly ($p \leq 0.05-0.001$) better at the end of the research than in female cadets who practiced using the traditional SMPAs method by the BMI – 1.07 kg/m², the SI – 4.36 %, the VI – 4.14 ml/kg, the RI – 2.99 c. u., HRR1 – 7.4 s, HST1 – 6.8 c. u., PWC – 103.1 kgm/min, BF – by 0.4 %, and SHL – by 3.16 points. The analysis of the dynamics of the studied indicators during the academic training period showed that in the EG, unlike the CG, all studied indicators have a stable tendency to improve.

Conclusions: The data we obtained indicate that CrossFit training sessions effectively contribute to the improvement of the morphofunctional development of female cadets during their academic training for future law enforcement activities.

KEY WORDS: morphofunctional development, health, female cadets, CrossFit, law enforcement activity

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INTRODUCTION

Ukraine's European integration requires the establishment of appropriate standards for the functioning of state institutions and society, including ensuring equal rights and opportunities for women and men in Ukraine's law enforcement agencies and departments [1]. According to statistics, more than 20 % of law enforcement officers in the National Police of Ukraine are women [2]. This trend has been positive in recent years: as in many countries worldwide, Ukraine has seen a significant increase in the number of women in the police force. This is particularly evident in higher educational institutions with specific learning environment (HEIs with SLE), where future police officers are trained for law enforcement activities.

At the same time, the crime situation in the country and the legal regime of martial law require female law enforcement officers to continually enhance their mental and physical training for law enforcement activities under extreme conditions [3, 4]. According to many scientists [5-7], the issue of women's physical readiness for law enforcement activities is particularly acute, in particular during the forcible detention of offenders, the use of physical force, the pursuit of criminals, and other specific conditions of law enforcement activities. Taking into account the physiological and psychological characteristics of the female body, to develop the physical readiness of female cadets for their future professional activities, it is necessary to apply such means of physical training in HEIs with SLE that would simultaneously contribute to the comprehensive

development and improvement of the physical qualities of female cadets, improve their morphological and functional development, promote their health, and be modern, engaging, and accessible to women with different levels of physical fitness, which can be applied in various climatic conditions and training locations, taking into account the legal regime of martial law in Ukraine. According to several scientists [8-10], CrossFit is one of the modern training methods used to train police officers, both men and women, in many countries worldwide.

CrossFit for women is a high-intensity functional training program that combines strength training, cardio exercises, and gymnastics to develop strength, endurance, speed, agility, and flexibility, promoting rapid fat burning and the formation of a harmonious body. It is versatile, suitable for various training levels, and helps improve the figure and overall tone in women [11]. An interesting fact is that CrossFit was created by Greg Glassman and his wife Lauren Jenney in the United States in 2000, specifically for training police officers and firefighters, since the main idea of CrossFit training is to prepare the body for unpredictable situations, which is very important for representatives of law enforcement agencies and departments [12, 13]. According to experts [14], the advantages of CrossFit for female law enforcement officers are: high efficiency and versatility; development of all physical qualities; rapid weight loss due to intense training and a change in appearance; strengthening of the cardiovascular and respiratory systems; improvement of overall physical condition and well-being, increased stress resilience; CrossFit training sessions do not take much time and do not require special conditions for training. Considering that female law enforcement officers are physically inferior to men, which makes them more vulnerable when performing forceful actions in specific law enforcement conditions, many experts [15-18] believe that CrossFit training sessions during their academic training at HEIs with SLE will significantly improve the physical and psychological readiness of female cadets for their future professional activities.

AIM

The aim is to study the dynamics of morphofunctional development indicators in female cadets – future law enforcement officers – in the process of engaging in various types of motor activity during their academic training.

MATERIALS AND METHODS

PARTICIPANTS

The research, conducted in 2022-2025, involved 56 female cadets in their first to third training years at Lviv

State University of Internal Affairs (LSUIA, Lviv, Ukraine), majoring in "Law" specialty. The female cadets were aged 17-22. Two groups of female cadets were formed: an experimental group (EG, $n = 27$), whose members attended the university's CrossFit sports club, and a control group (CG, $n = 29$), whose members did not engage in additional sports activities, but only participated in the traditional program during their sporting and mass-participation activities (SMPAs). The number of hours of motor activity per week for female cadets in both groups was the same: 4 hours of training sessions (2 sessions of 2 hours each) in physical training and 6 hours (3 sessions of 2 hours each) during their SMPAs (training sessions according to the traditional program or training sessions in the CrossFit sports club). The differences that formed the basis of the comparative analysis between the EG and the CG indicators were the content and focus of motor activity training sessions. The training sessions in the EG were conducted by a CrossFit coach using individual and group formats. In contrast, in the CG, they were conducted by a curator (training-year officer) using exclusively group formats based on established options (accelerated movement, exercises on gymnastics equipment, general development exercises). The inclusion criteria for participants were as follows: only female cadets who voluntarily selected a motor activity could participate; there were no health contraindications to participating in any motor activity. The exclusion criterion was female cadets' desire to withdraw from the research at any time. Female cadets from all groups were informed about the objectives of the research, after which they gave their written consent to participate in the research solely for scientific purposes. The research was conducted in three stages: the first at the end of the first training year, the second at the end of the second training year, and the third at the end of the third training year.

RESEARCH METHODS

Theoretical methods, biomedical methods, statistical methods. Theoretical methods were used to conduct the analysis, generalization and analytical review of literature sources on the outlined range of issues (28 sources (2005-2026) from MedLine, Scopus, Web of Science databases were analyzed).

Biomedical methods were used to investigate the effect of CrossFit training sessions compared to a traditional program during SMPAs. The following indicators were studied: body mass index (BMI), vital index (VI), strength index (SI), and Robinson index (RI), heart rate recovery time index (HRRTI), Harvard Step Test Index (HSTI), physical working capacity (PWC), subcutaneous fat level (body fat content (BF)), somatic health level (SHL).

Table 1. The dynamics of the morphofunctional development indicators of female cadets in the EG (n=27) and the CG (n=29) during the research period ($\bar{X}\pm m$)

Research stages	EG (n=27)	CG (n=29)	Significance of the difference	
			t	p
BMI, kg/m ²				
1 st	21.35±0.25	21.21±0.21	0.43	p>0.05
2 nd	21.16±0.24	21.67±0.23	1.44	p>0.05
3 rd	21.05±0.22	22.12±0.29	2.94	p≤0.01
t ₁₋₃ (p)	0.57 (p>0.05)	2.54 (p≤0.05)		
SI, %				
1 st	48.51±1.13	48.34±1.24	0.10	p>0.05
2 nd	52.12±1.07	50.19±1.18	1.21	p>0.05
3 rd	55.82±0.98	51.46±1.11	2.94	p≤0.05
t ₁₋₃ (p)	4.89 (p≤0.001)	1.87 (p>0.05)		
VI, ml/kg				
1 st	49.19±1.23	49.63±1.30	0.25	p>0.05
2 nd	52.37±1.19	49.67±1.27	1.55	p>0.05
3 rd	54.16±1.18	50.02±1.22	2.44	p≤0.05
t ₁₋₃ (p)	2.92 (p≤0.05)	0.34 (p>0.05)		
RI, c. u.				
1 st	89.05±0.98	89.25±1.02	0.14	p>0.05
2 nd	86.37±0.96	88.06±1.03	1.20	p>0.05
3 rd	83.72±0.94	86.71±1.05	2.12	p≤0.05
t ₁₋₃ (p)	3.93 (p≤0.001)	1.74 (p>0.05)		
HRRTI, s				
1 st	103.6±2.51	102.5±2.49	0.31	p>0.05
2 nd	94.6±2.45	98.6±2.52	1.14	p>0.05
3 rd	89.4±2.23	96.8±2.50	2.21	p≤0.05
t ₁₋₃ (p)	3.56 (p≤0.001)	1.62 (p>0.05)		
HSTI, c. u.				
1 st	63.5±1.49	65.2±1.65	0.77	p>0.05
2 nd	75.8±1.42	70.5±1.56	2.51	p≤0.05
3 rd	83.2±1.41	76.4±1.50	3.30	p≤0.01
t ₁₋₃ (p)	9.91 (p≤0.001)	5.02 (p≤0.001)		
PWC _{170'} , kgm/min				
1 st	664.6±32.11	673.2±40.25	0.17	p>0.05
2 nd	707.2±29.27	675.4±37.82	0.66	p>0.05
3 rd	790.6±28.25	687.5±33.59	2.35	p≤0.05
t ₁₋₃ (p)	3.21 (p≤0.01)	0.48 (p>0.05)		
BF, %				
1 st	18.3±0.13	18.5±0.17	0.93	p>0.05
2 nd	18.1±0.12	18.3±0.16	0.96	p>0.05
3 rd	18.0±0.08	18.4±0.14	2.48	p<0.05
t ₁₋₃ (p)	1.90 (p>0.05)	0.44 (p>0.05)		
SHL, points				
1 st	4.08±0.71	4.19±0.87	0.11	p>0.05
2 nd	6.18±0.55	5.45±0.71	0.81	p>0.05
3 rd	9.29±0.48	6.13±0.65	3.91	p≤0.05
t ₁₋₃ (p)	6.08 (p≤0.001)	1.79 (p>0.05)		

Note: \bar{X} – arithmetic mean; m – error of arithmetic mean; t – Student's test value; p – level of significance of the differences between studied indicators

Source: compiled by the authors of this study

The body mass index was calculated as body weight divided by height squared. The vital index was determined by the ratio of vital lung capacity to body weight. The ratio of the dynamometry of the stronger hand to body weight determined the strength index. The Robinson index was determined by the ratio of the product of the resting pulse and systolic blood pressure to 100. The heart rate recovery time index was calculated as the time required for the heart rate to return to baseline after 20 squats in 30 seconds. The somatic health level (SHL) of female cadets was determined by the sum of points for each of the five above-mentioned indices and was assessed as follows: 3 points or less – low SHL; 4-6 points – below average SHL; 7-11 points – average SHL; 12-15 points – below average SHL; 16-18 points – high SHL [19].

The Harvard Step Test Index allows assessing the functional state of the cardiorespiratory system and, in general, the level of physical fitness. In our research, we used a 3-minute HSTI with a 45 cm high step. The index was determined in c. u. according to the formula: $HSTI = (300 / (f_2 + f_3 + f_4)) \times 100$, where f_2 , f_3 , and f_4 are the HR indicators for 30 seconds at the 2nd, 3rd, and 4th minutes of rest. The assessment of the functional capacity of female cadets using a 3-minute step test was carried out as follows: 90 c. u. and above – excellent level of fitness; 80-89 – high level; 65-79 – average; 55-64 – below average; 55 and below – unsatisfactory level [20].

The physical working capacity of female cadets was determined using the PWC_{170} test with a bicycle ergometer. The female cadets performed two consecutive pedaling exercises (at a pace of 60 rpm) on a bicycle ergometer for 5 minutes each, with a 3-minute rest interval between them. In the last 30 seconds of the fifth minute of each exercise, the heart rate was counted. The power of the first and second exercises was determined using tables. The PWC_{170} value was calculated using the formula: $PWC_{170} = N_1 + (N_2 - N_1) \cdot [(170 - f_1) / (f_2 - f_1)]$, where N_1 is the power of the first load (determined according to the table depending on the body weight of the study participant); N_2 is the power of the second load (determined according to the table depending on N_1); f_1 , f_2 – HR at the end of the 1st and 2nd loads in 30 seconds [21].

Body fat content (in percent) was assessed using a caliper. Fat fold thickness was measured at four locations on the body: abdomen, front of the shoulder (biceps), back of the shoulder (triceps), and back under the shoulder blade. Based on the sum of these four measurements, a result was obtained, which was compared with the Jackson-Pollock table data [22], and the body fat content was assessed. The norm for women under 20 years of age is considered to be a fat content of 17.7 %, and for women under 25 years of age, 18.4 %.

STATISTICAL METHODS

Statistical 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. 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.

FRAMEWORK

This scientific article was carried out according to the plan of the research work of the National Academy of Internal Affairs for 2020-2026 "Psychological, pedagogical and sociological support of law enforcement officers» (state registration number 0113U008196).

RESULTS

The results of the study of the dynamics of the morphofunctional development indicators of female cadets in the EG and the CG during the research period are presented in Table 1.

The study of the BMI in female cadets of the EG and the CG shows that at the 1st stage, the indicators of both groups did not differ significantly ($p > 0.05$). At the 2nd stage, a difference was observed in the BMI indicators between female cadets in the EG and the CG, although it was not statistically significant ($p > 0.05$). Only at the 3rd stage of the research the BMI indicators in female EG cadets differ significantly from those in the CG, by 1.07 kg/m² ($p \leq 0.05$). During the research, the BMI in female cadets of the EG did not change ($p > 0.05$), while in the CG it significantly worsened by 0.91 kg/m² ($p \leq 0.01$), which indicates the advantage of CrossFit training sessions compared to the traditional SMPAs program in terms of improving the anthropometric data of female cadets.

The analysis of the SI, which reflects the development of strength qualities in female cadets in relation to their body weight, showed that at the 1st and 2nd stages, no

significant difference was found between the EG and the CG ($p > 0.05$). At the 3rd stage, the SI indicators in female cadets of the EG were significantly better than in the CG by 4.36 % ($p \leq 0.05$). The dynamics of the SI among female cadets in both groups are positive. Still, CrossFit has a more pronounced effect on the development of strength qualities in female cadets of the EG: in the EG, the SI indicators improved significantly by 7.31 % ($p \leq 0.001$), and in the CG, by 3.12 %, but the difference is not significant ($p > 0.05$). This underscores the effectiveness of CrossFit training sessions in enhancing the physical development of female cadets.

The study of the VI, which characterizes the functional capabilities of the respiratory system of female cadets, shows that the indicators of the EG and the CG at the 1st and 2nd stages are significantly the same ($p > 0.05$). At the 3rd stage, a significant difference was found between the VI indicators in female cadets of the EG and the CG – 4.14 ml/kg ($p \leq 0.05$). During the research period, the average VI value in female cadets in the EG improved by 4.97 ml/kg ($p \leq 0.05$), and in the CG by 0.61 ml/kg ($p > 0.05$). All of this underscores the advantage of CrossFit training sessions over the traditional SMPA program in improving the functional capabilities of the respiratory system of future law enforcement officers.

When studying the RI indicators characterizing the functioning of the cardiovascular system in female cadets, no significant difference between the EG and the CG indicators was observed at the 1st and 2nd stages of the research ($p > 0.05$). At the 3rd stage, the RI indicators in the EG were significantly ($p \leq 0.05$) better than in the CG, by 2.99 c. u. During the academic training period, the RI indicators in both groups improved, but in the EG the changes were significant ($p \leq 0.001$) and amounted to 5.33 c. u., while in the CG they were not significant ($p > 0.05$) and amounted to 2.54 c. u.

Analysis of the HRRI after 20 squats over 30 minutes showed that, at the 1st and 2nd stages, the HRRI indicators for female cadets in the EG and the CG did not differ significantly ($p > 0.05$). A significant improvement in the HRRI was observed in female cadets of the EG at the 3rd stage of the research. This value is 89.4 s and is significantly better than that of the CG (96.8 s), by 7.4 s ($p \leq 0.05$). During the research period, the HRRI improved by 14.2 s ($p \leq 0.001$) in the EG and by 5.7 s ($p > 0.05$) in the CG, which proves the effectiveness of CrossFit training sessions in strengthening the cardiovascular system of female cadets.

The functional capabilities of the cardiorespiratory systems of female cadets in the EG and the CG were also assessed using the 3-minute Harvard Step Test Index. At the 1st stage, there were no significant differences between them ($p > 0.05$). In the subsequent stages, the

HSTI indicators in the EG were significantly better than those in the CG, by 5.3 c. u. in the 2nd stage ($p \leq 0.05$) and by 6.8 c. u. in the 3rd stage ($p \leq 0.01$), respectively. During the research period, the indicators improved significantly in both groups ($p \leq 0.001$), but in the EG the increase was 19.7 c. u., and in the CG it was 11.2 c. u.

To determine the physical working capacity of female cadets, we used the PWC₁₇₀ test. Thus, the analysis of physical working capacity indicators at the 1st and 2nd stages of the research showed that the EG and the CG indicators did not differ significantly ($p > 0.05$). At the 3rd stage, the EG indicators were substantially better than those of the CG, by 103.1 kgm/min ($p \leq 0.05$). During the research period, the PWC₁₇₀ indicators for female cadets in both groups improved; however, the changes in the EG were significant ($p \leq 0.01$), whereas in the CG they were not significant ($p > 0.05$). This indicates that CrossFit training sessions are more effective in improving the physical working capacity of female cadets during their academic training. The analysis of fat content in the cadets' bodies showed that, at the 1st and 2nd stages of the research, the EG and the CG indicators were not significantly different ($p > 0.05$). At the 3rd stage, the body fat content in the EG female cadets was considerably lower than in the CG by 0.4 % ($p \leq 0.05$). The fat tissue indicators in female cadets of both groups are within the age norm.

The comparative analysis of the SHL among female cadets showed that, in the 1st and 2nd stages of the research, the EG and the CG indicators did not differ significantly ($p > 0.05$). The somatic health level in female cadets in the EG at the 3rd stage was considerably better than in the CG by 3.16 points ($p \leq 0.001$). During the research, the SHL improved in both groups; however, in the EG, the difference between female cadets' indicators at the 1st and 3rd stages was 5.21 points ($p \leq 0.001$), whereas in the CG it was 1.94 points ($p > 0.05$). At the end of the research, the SHL among female cadets in the EG was assessed as average, whereas in the CG it was assessed as below average.

The research indicates that CrossFit training sessions have a more pronounced effect on the morphofunctional development and somatic health levels of female cadets during their academic training for future law enforcement activities, compared with the traditional SMPAs program.

DISCUSSION

Scientists [3] report that the number of female cadets is increasing annually, indicating their readiness to perform the demanding profession of law enforcement on par with men. Today, women in uniform perform the

same tasks as men and therefore must be trained on a par with them. At the same time, specific physiological and psychological characteristics of the female body, according to many scientists [15], should be considered when training women in HEIs with SLE. One of the main factors affecting the physiological characteristics of the female body is hormones. There are differences in hormone levels, such as testosterone and estrogen, between women and men. Women have significantly lower testosterone levels than men and higher estrogen levels. These hormones can affect women's physical abilities, including muscle development and endurance [16, 23]. The female body differs from the male body, particularly in physiological traits such as adipose tissue distribution and hormonal balance. Hence, it should be emphasized that this can affect their physical abilities, including muscle mass, stability, and movement speed. It is also essential to understand that some exercises may be more difficult for women due to their physiological characteristics, as well as a more delicate skeletal system, which makes them more vulnerable to injury.

Given that women have lower lung capacity, training should be aimed at improving their cardiorespiratory function. To do this, it is essential to include various types of aerobic training that increase lung capacity and improve blood circulation. When training with weights, it is necessary to stick to the permissible weight and perform the exercises correctly to avoid injury. It is also essential to pay attention to stretching and increasing flexibility to reduce the risk of injury and improve exercise effectiveness [14]. In addition, according to scientists [24], it is essential to account for the menstrual cycle in women, as it can affect their physical activity and endurance. During menstruation, women may experience pain and discomfort, which can worsen their training results. Therefore, women should be able to adapt their training schedules to their menstrual cycles, reduce their workloads, and rest during menstruation [25].

It is also important to consider the psychological characteristics of women. Women may be more prone to stress and anxiety, which can affect their physical activity and training performance. Therefore, it is necessary to create a supportive psychological environment, support women during training, and help them stay motivated [2, 5, 26]. Taking the above into account, as well as the experience of training women in the security forces of leading countries around the world, we proposed CrossFit training sessions for female cadets – future law enforcement officers – with the aim of developing and improving their physical qualities, improving their morphofunctional condition, promoting their health, and improving the effectiveness of their training for future professional activities. This is confirmed, in particular,

by the data we have obtained, as positive dynamics are observed in most indicators.

Based on our research, we have established that CrossFit training sessions, with their numerous advantages, have had a positive impact on the physical development of female cadets during their academic training and on the functional capabilities of their primary physiological systems. At the same time, physical working capacity increased, and body fat decreased, as evidenced by a decrease in body mass index among female EG cadets. The results of our research extend and complement the conclusions of many scientists [3, 12-14, 18, 23, 27, 28] regarding the effectiveness of CrossFit in improving the professional performance of modern law enforcement officers.

CONCLUSIONS

We studied the dynamics of the morphofunctional development of female cadets in the process of various types of motor activity during their academic training. It was found that in female cadets who practiced CrossFit, all the parameters studied were significantly ($p \leq 0.05-0.001$) better at the end of the research than in female cadets who practiced using the traditional SMPAs method. Thus, at the 3rd stage of the research, the EG showed significantly better indicators than the CG: the BMI – 1.07 kg/m², the SI – 4.36 %, the VI – 4.14 ml/kg, the RI – 2.99 c. u., HRR1 – 7.4 s, HSTI – 6.8 c. u., PWC – 103.1 kgm/min, BF – by 0.4 %, and SHL – by 3.16 points. The analysis of the dynamics of the studied indicators during the academic training period showed that in the EG, unlike the CG, all studied indicators have a stable tendency to improve. At the same time, the somatic health level in the EG female cadets at the end of the research corresponds to the average level (9.29 points), and in the CG – below average (6.13 points).

In general, as a result of CrossFit training sessions, the cardiovascular and respiratory systems of female cadets in the EG improved; the efficiency of these systems at rest and under load increased, and their reserve capacity increased. The recovery period after load decreased, working capacity improved, and body weight and fat content stabilized. The data we obtained indicate that CrossFit training sessions effectively contribute to the improvement of the morphofunctional development of female cadets during their academic training for future law enforcement activities.

PROSPECTS FOR FURTHER RESEARCH

It is planned to investigate gender differences in the manifestation of stress symptoms among future law enforcement officers during their academic training under crisis conditions.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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