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: $BI = (d \times 1000) / l$. 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: $SI = (D / m) \times 100$, 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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