Dynamics of Indicators of Cadets' Physical Development and Functional Status during Pentathlon

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Abstract The article examines the impact of military pentathlon classes on the dynamics of the cadets' physical development and functional status in the training process. The research was conducted at the Department of Military Training of the National Academy of Internal Affairs (Ukraine) in 2019-2020. The research involved 18-25 years old cadets (men), who studied at the department in 1-4 semesters. Two groups of cadets were formed: the experimental group (EG, n = 44), the cadets of which were engaged in pentathlon, and the control group (CG, n = 45), the cadets of which were engaged in the existing method of physical training. The research of indicators of the cadets' physical development and functional status was carried out on such indicators as body height, body mass, dynamometry of the hands, heart rate, arterial blood pressure, vital capacity of the lungs and design indices. The research methods included analysis of literature, pedagogical observation, medical and biological methods, and methods of mathematical statistics. The positive effect of military pentathlon on the cadets' physical development and functional status was established. At the end of the research, the EG cadets had significantly better indicators of body mass, vital capacity of the lungs, heart rate at rest,

vital index, Robinson index and heart rate recovery time after exercise than the CG cadets. In general, the results suggest that the achieved level of the cadets' physical development and functional status engaged in military pentathlon will in the future improve the efficiency of their professional and service activities.

Keywords Physical Development, Functional Status, Military Pentathlon, Cadets

1. Introduction

The unstable military-political situation in the world, the simultaneous conduct of a number of international armed conflicts in different countries, the improvement and emergence of new methods and forms of armed struggle, equipping the army with new weapons – all this convincingly demonstrates the need to increase defense capabilities to protect their sovereignty, territorial integrity and inviolability [1, 2, 3]. This, in turn, increases

the requirements for professional training of service members. As it is known that no matter how modern and powerful a weapon is, it is still controlled by the military [4, 5].

Modern professional combat activities of service members have a diverse nature and, despite the specialty, they have to perform a variety of combat tasks in extreme environmental conditions in the presence of adverse factors of combat activities: from long combat shifts in a limited space (checkpoints, dugouts, security control points, combat equipment), which were accompanied by low motor activity, emotional and physical tension, stress, to the implementation of long marches in full gear, accelerated movement with additional load (weapons, equipment, ammunition, wounded), manual execution of large volumes works, loading on ammunition equipment, overcoming artificial and natural obstacles, performing tasks at different temperatures, etc. That is, modern professional combat activities of service members are characterized by diversity, tension and specificity, significant physical and mental stress, which in general leads to high requirements for their physical fitness – readiness to act under any conditions of situation, environment and time of day [6, 7, 8].

Negative influence of factors of professional and combat activity, lack of systematic physical training in the combat zone and proper material base cause such consequences as: metabolic disorders, weight gain (overweight), decreased physical fitness, deterioration of health, increased injuries (especially musculoskeletal system), the emergence of various diseases of military servicemen [9, 10, 11].

Physical training is one of the main elements of professional training, an important means of forming the physical readiness of service members for modern professional and combat activities [11, 12, 13, 14, 15]. Military pentathlon can be an effective means of physical training of service members [16, 17].

Military pentathlon includes five different disciplines such as rifle shooting (fast and slow), overcoming a special obstacle course (500 m, 20 obstacles), swimming with obstacles (50 m, 4 obstacles in the water), grenades throwing (accuracy and range), cross-country race (8 km for men, 4 km for women) [18].

Military pentathlon is a fairly young military-applied sport, which originated in France in the middle of the twentieth century. Thus, in 1946, a French officer – Captain Henri Debrus (the President of the International Council of Military Sports in 1948-1953), came up with the idea of holding sports competitions dedicated exclusively to the needs of service members. Captain Debrus created a universal set of exercises that helped increase the training of ground forces. The first competition was organized during military exercise in the gymnastic centre in Freiburg in August 1947 with the participation of teams from Belgium, France and Germany.

The competition helped to improve international relations, and the military rivalry revealed during the competition was approved by the French military authorities. The French authorities decided to introduce a modified version of a new sport military event called “Military Pentathlon” relying on the consistent actions, determination and devotion of Captain Debrus [19, 20]. Today, military pentathlon is a part of the International Military Sports Council’s competition program; World Championships and World Games among servicemen are held in this type of sport events; teams from more than 40 countries take part in the competition [17, 18]. This sport began to develop in the 90s of last century in the Armed Forces of Ukraine. Today, the championships of the Armed Forces of Ukraine in military pentathlon are held annually, the results of athletes are improved, the best of them participate in international competitions, the training facilities for training and competitions in military pentathlon are improved, the popularity of this sport among cadets is growing.

Military pentathlon can be used effectively as a means of physical training for cadets [21, 22]. However, there is lack of research concerning the impact of military pentathlon as a means of physical training on the dynamics of indicators of cadets’ physical development and functional status.

1.1. The Aim

The aim of the research is to study the influence of military pentathlon on the dynamics of cadets’ physical development and functional status during their training.

2. Materials and Methods

1.2. Participants

The research was conducted at the Department of Military Training of the National Academy of Internal Affairs (Kyiv, Ukraine) in 2019-2020. The research involved 18-25 years old cadets (men), who studied at the department in 1-4 semesters. Two groups of cadets were formed: the experimental group (EG, $n = 44$), the cadets of which were engaged in pentathlon in the course of their physical training, and the control group (CG, $n = 45$), the cadets of which were engaged in the existing method of training. Selection of the cadets into groups was carried out by the method of questionnaires on the cadets’ own accord. The survey was conducted according to the questionnaire developed by authors’ team, which contained 5 questions: 1. What is the purpose of physical training during training? 2. In your opinion, do physical training and sports contribute to the improvement of graduates’ future professional activity? 3. Do physical training and sports improve the physical development and health of cadets? 4. How do you think it is possible to increase the interest of cadets in physical exercises? 5. Do

you want to engage in military pentathlon during physical training during studying? Before conducting the questionnaire, we provided the cadets with information about the history of military pentathlon, its advantages, about coaches, about prospects, about the conditions of military pentathlon classes at the academy. The number of physical training hours for the cadets of both groups was identical. The initial level of indicators of physical development and functional status of the EG and the CG cadets did not differ significantly ($p > 0.05$).

2. Methods

The research of indicators of the cadets' physical development and functional status was carried out on such indicators as body height, body mass, dynamometry of the right and left hands, heart rate (HR) at rest, systolic and diastolic blood pressure and vital capacity of the lungs. Upon determining these indicators of the cadets, we calculated such indices as body mass, vital, strength, Robinson and heart rate recovery time to baseline after 20 squats for 30 seconds. The determination of indicators of the cadets' physical development and functional status was conducted in the division of medical support of the National Academy of Internal Affairs by the medical personnel. Body height and mass were determined using appropriate medical devices. The cadets' body height was measured with a height meter (P1.100, dimensions: 450x400x2210 mm) in a standing position and was determined in centimeters. The cadets' body mass was examined on analyzer scales (TANITA BC-601, weighing limit - 150 kg, error - 100 g). The body composition of cadets was assessed by the ratio of muscle and fat tissue throughout the whole body and separately in the main body segments: arms, legs, abdomen (torso). The cadets' body mass was determined in kilograms. While determining the wrist dynamometry, the cadets squeezed the hand dynamometer alternately with each hand, holding the device in an outstretched hand parallel to the ground. Heart rate and blood pressure were measured with the help of an electronic tonometer. Vital capacity of the lungs was determined using an electronic spirometer in a standing position.

The body mass index was defined as the ratio of the body weight to body height and is expressed in kg/m^2 . The life index (LI) was determined by the ratio of vital capacity to body weight in ml/kg . The strength index was designated by the ratio of the indicators of dynamometry of the stronger hand to body weight in percent. The Robinson index was defined in standard units by the product of the heart rate and systolic blood pressure which was divided by 100. The evaluation of the heart rate recovery time to baseline was held after 20 squats in 30 seconds.

The research methods such as theoretical: analysis of

scientific, educational and methodical literature and experience of best practice were used to clarify the current state of the research problem; empirical: pedagogical observation, medical and biological methods were used to determine the impact of military pentathlon on the dynamics of the cadets' physical development and functional status during their training; methods of mathematical statistics were used to assess the reliability of the difference between the studied indicators and the correct processing of the results. During the researches the authenticity of difference between the indicators of cadets by means of Student's t-test was determined. The dynamics of indicators in each of groups was also estimated. The significance for all statistical tests was set at $p < 0.05$. All statistical analyses were performed with the SPSS software, version 21, adapted to medical and biological researches.

2.1. Ethical Approval

The research was carried out according to the requirements of the Code of Ethics of National Academy of Internal Affairs, which was developed on the basis of Ukrainian and world practices in ethical rulemaking, the recommendations of experts, taking into account the proposals of the structural units of the University. This document was approved by the Academic Council of National Academy of Internal Affairs (protocol No. 01 of 10 January 2019) and implemented by the order of the Rector of the Academy. According to its provisions, the members of the scientific community are guided by the principles of self-sufficiency, independence in the dissemination of knowledge and information, conducting scientific research and the application of results. At the same time, the principles of upholding honesty, fairness, respect, responsibility, following ethical principles and rules of creative activity are taken into account in order to establish confidence in the results of scientific achievements. Informed consent was received from all individuals who took part in this research and people under test who could refuse participation at any time.

3. Results

The research of the dynamics of body height indicators shows that no significant difference was detected ($p > 0.05$) during all training semesters between the indicators of the EG and the CG cadets. There was a tendency to a slight increase in body height in the cadets of both groups during their training, but they are almost unchanged: no significant difference was found between the indicators of the 1st and the 4th year cadets in both groups ($p > 0.05$) (Table 1). The research of body mass indicators shows that both the EG and the CG cadets increased their body mass in the process of training. However, if the difference

between the values of body mass in the 1st and the 4th semesters in pentathletes is 0.4 kg and is unreliable ($p > 0.05$), then in the cadets who were engaged in the traditional method of conducting physical training classes the indicators in the 4th semester (74.3 kg) are significantly ($p \leq 0.05$) worse than in the 1st semester (71.7 kg) by 2.6 kg. At the same time, if the indicators of body mass in the EG and the CG cadets in the course of the 1st - 3rd semesters did not differ significantly ($p > 0.05$), then in the 4th semester the difference is 2.1 kg and is significant ($p \leq 0.05$).

The analysis of the dynamics of the stronger hand dynamometry showed that the strength indicators of the cadets of both groups improved during the training period i. e. the difference between the indicators of the cadets in the 1st and the 4th semester in the EG is 1.5 kg making 0.9 kg in the CG, but the indicators did not change significantly (Table 1). At the same time, the comparative analysis of wrist dynamometry in the EG and the CG cadets showed that no significant difference between the

average values of the studied groups was found ($p > 0.05$) in all training semesters.

The analysis of the heart rate, we found that no significant difference between the EG and the CG was detected ($p > 0.05$) in the course of the 1st - 3rd semesters of training. The indicators of the EG cadets were significantly ($p \leq 0.05$) better than those of the CG cadets by 1.7 beats / min during the 4th training semester (Table 2). The cadets' heart rate of both groups improved during the research period by 2.2 beats / min ($p \leq 0.05$) in the EG, and by 0.3 beats / min ($p > 0.05$) in the CG. The analysis of arterial blood pressure showed that no significant difference was detected ($p > 0.05$) between the average values of the EG and the CG cadets in all training semesters concerning both systolic and diastolic blood pressure (Table 2). Pressure indicators improve in both study groups during the training process, but no significant difference was found in both groups between the cadets' indicators in the course of their 1st and 4th semesters ($p > 0.05$).

Table 1. The dynamics of the indicators of physical development of EG and CG cadets in the process of studying at the academy (Mean $\pm$ SD)

Training semesters	EG (n=44)	CG (n=45)	Level of significance
Body height, cm			
1 st	176.9 $\pm$ 1.64	177.1 $\pm$ 1.49	p>0.05
2 nd	177.2 $\pm$ 1.57	177.3 $\pm$ 1.51	p>0.05
3 rd	177.3 $\pm$ 1.49	177.4 $\pm$ 1.47	p>0.05
4 th	177.3 $\pm$ 1.52	177.5 $\pm$ 1.46	p>0.05
Body mass, kg			
1 st	71.8 $\pm$ 0.69	71.7 $\pm$ 0.72	p>0.05
2 nd	71.9 $\pm$ 0.65	72.5 $\pm$ 0.68	p>0.05
3 rd	72.1 $\pm$ 0.66	73.7 $\pm$ 0.69	p>0.05
4 th	72.2 $\pm$ 0.62	74.3 $\pm$ 0.70	p $\leq$ 0.05
Stronger hand dynamometry, kg			
1 st	38.7 $\pm$ 0.87	38.9 $\pm$ 0.83	p>0.05
2 nd	39.1 $\pm$ 0.85	39.2 $\pm$ 0.77	p>0.05
3 rd	39.8 $\pm$ 0.82	39.5 $\pm$ 0.75	p>0.05
4 th	40.2 $\pm$ 0.80	39.8 $\pm$ 0.74	p>0.05

Legend: Mean - arithmetical average, SD - standard deviation, p - the significance of the difference between the indicators of EG and CG

Table 2. The dynamics of the indicators of functional status of EG and CG cadets in the process of studying at the academy (Mean $\pm$ SD)

Training semesters	EG (n=44)	CG (n=45)	Level of significance
Heart rate at rest, beats / min			
1 st	71.3 $\pm$ 0.71	71.1 $\pm$ 0.62	p>0.05
2 nd	70.4 $\pm$ 0.68	70.9 $\pm$ 0.59	p>0.05
3 rd	69.9 $\pm$ 0.65	70.8 $\pm$ 0.58	p>0.05
4 th	69.1 $\pm$ 0.62	70.8 $\pm$ 0.57	p $\leq$ 0.05
Systolic blood pressure, mmHg			
1 st	122.0 $\pm$ 0.79	122.2 $\pm$ 0.71	p>0.05
2 nd	121.7 $\pm$ 0.78	122.0 $\pm$ 0.70	p>0.05
3 rd	121.6 $\pm$ 0.76	121.9 $\pm$ 0.69	p>0.05
4 th	121.5 $\pm$ 0.75	121.9 $\pm$ 0.69	p>0.05
Diastolic blood pressure, mmHg			
1 st	70.7 $\pm$ 0.63	70.6 $\pm$ 0.64	p>0.05
2 nd	70.6 $\pm$ 0.62	70.5 $\pm$ 0.64	p>0.05
3 rd	70.5 $\pm$ 0.62	70.5 $\pm$ 0.63	p>0.05
4 th	70.4 $\pm$ 0.61	70.5 $\pm$ 0.63	p>0.05
Vital capacity of the lungs, ml			
1 st	4159.8 $\pm$ 67.84	4167.1 $\pm$ 65.12	p>0.05
2 nd	4280.2 $\pm$ 63.21	4186.4 $\pm$ 64.87	p>0.05
3 rd	4359.4 $\pm$ 61.63	4194.2 $\pm$ 64.05	p>0.05
4 th	4437.9 $\pm$ 58.25	4202.8 $\pm$ 63.76	p $\leq$ 0.05

Legend: Mean - arithmetical average, SD - standard deviation, p - the significance of the difference between the indicators of EG and CG

The research of the dynamics of the indicators of the lungs vital capacity shows that the functional status of the respiratory system in the cadets of the EG significantly improved during military pentathlon i. e. the difference between the indicators of the cadets of the 1st and the 4th semesters is 278.1 ml ($p \leq 0.05$). It was also found that there is insignificant ($p > 0.05$) improvement in the vital capacity of the lungs in the cadets of the CG in the process of their training according to the traditional method of conducting physical training classes. The comparative analysis of the indicators of the lungs vital capacity showed that no significant difference between the indicators of the respiratory system in the cadets of the EG and the CG was detected ($p > 0.05$) in the 1st - 3rd semesters. Moreover, the indicators of the EG cadets were significantly better than in the CG by 235.1 ml ($p \leq 0.05$)

in the 4th semester (Table 2).

Analysing the body mass index, we found that the body mass index is better in the EG compared to the CG in all training courses, but no significant difference was recorded ($p > 0.05$). The body mass index of the cadets of both groups during all training semesters is within the normal range for men (18.50–24.99 kg / m²). The analysis of the dynamics of the body mass index during the research period shows that there are fairly stable values of the body mass index in the EG: the difference between the indicators in the 1st and the 4th semesters is 0.05 kg / m² and is unreliable ($p > 0.05$); the CG indicators during the 4th semester were significantly worse than during the 1st one by 0.07 kg / m² ($p \leq 0.05$) (Table 3). Herewith, the indicators of the cadets of both investigated groups on all training courses are within normal range.

Table 3. The dynamics of the indicators body mass index, vital index, strength index, Robinson index and heart rate recovery time to baseline after 20 squats for 30 seconds of EG and CG cadets in the process of studying at the academy (Mean $\pm$ SD)

Training semesters	EG (n=44)	CG (n=45)	Level of significance
Body mass index, kg / m ²			
1 st	22.94 $\pm$ 0.37	22.76 $\pm$ 0.34	p>0.05
2 nd	22.97 $\pm$ 0.36	23.12 $\pm$ 0.33	p>0.05
3 rd	22.96 $\pm$ 0.36	23.46 $\pm$ 0.32	p>0.05
4 th	22.99 $\pm$ 0.35	23.83 $\pm$ 0.33	p>0.05
Vital index, ml/kg			
1 st	57.94 $\pm$ 0.94	58.11 $\pm$ 0.91	p>0.05
2 nd	59.52 $\pm$ 0.89	57.74 $\pm$ 0.90	p>0.05
3 rd	60.46 $\pm$ 0.86	56.29 $\pm$ 0.88	p $\leq$ 0.01
4 th	61.47 $\pm$ 0.84	56.57 $\pm$ 0.85	p $\leq$ 0.001
Strength index, %			
1 st	53.89 $\pm$ 0.81	54.25 $\pm$ 0.77	p>0.05
2 nd	54.38 $\pm$ 0.79	54.07 $\pm$ 0.75	p>0.05
3 rd	55.20 $\pm$ 0.78	53.59 $\pm$ 0.74	p>0.05
4 th	55.67 $\pm$ 0.77	53.57 $\pm$ 0.75	p>0.05
Robinson index, c. u.			
1 st	86.98 $\pm$ 0.85	86.88 $\pm$ 0.84	p>0.05
2 nd	85.67 $\pm$ 0.83	86.49 $\pm$ 0.83	p>0.05
3 rd	84.63 $\pm$ 0.80	86.31 $\pm$ 0.81	p>0.05
4 th	83.96 $\pm$ 0.79	86.30 $\pm$ 0.81	p $\leq$ 0.05
Heart rate recovery time to baseline after 20 squats for 30 seconds, seconds			
1 st	134.8 $\pm$ 2.90	136.1 $\pm$ 2.91	p>0.05
2 nd	126.2 $\pm$ 2.83	131.2 $\pm$ 2.86	p>0.05
3 rd	119.4 $\pm$ 2.78	124.6 $\pm$ 2.82	p>0.05
4 th	110.1 $\pm$ 2.74	118.5 $\pm$ 2.79	p $\leq$ 0.05

Legend: Mean - arithmetical average, SD - standard deviation, p - the significance of the difference between the indicators of EG and CG

The research of vital index indicators shows no significant difference between the indicators of the EG and the CG cadets ($p > 0.05$) in the 1st and the 2nd semesters. The EG cadets' vital index was significantly better than in the CG during the 3rd semester by 4.17 ml / kg ($p \leq 0.01$), and it was higher by 4.90 ml / kg ($p \leq 0.001$) during the 4th semester (Table 3). The analysis of the vital index dynamics during the experiment shows that the indicators significantly improved in the EG by 3.53 ml / kg ($p \leq 0.05$), and, on the contrary, they deteriorated in the CG by 1.54 ml / kg, but with insignificant difference ($p > 0.05$). The research of the strength index shows that the indicators of the EG and the CG cadets do not differ significantly ($p > 0.05$) at all times of their training. The analysis of the Robinson index shows no significant difference between the EG and the CG indicators ($p > 0.05$) in the 1st - 3rd semesters. The Robinson index was

significantly better in the EG cadets than in the CG cadets during the 4th semester by 2.34 conditional units ($p \leq 0.05$) (Table 3), which indicates the effectiveness of military pentathlon on the development of functional capabilities of the cadets' cardiovascular system. The analysis of the Robinson index dynamics showed a positive trend in both groups of the cadets of interest, but the indicators improved significantly ($p \leq 0.05$) in the EG, and they did not change significantly ($p > 0.05$) in the CG. The research of heart rate recovery time to baseline after 20 squats for 30 seconds shows that the indicators in the EG and the CG were significantly equal ($p > 0.05$) during the 1st - 3rd semesters. The indicators of heart rate recovery were significantly better in the EG during the 4th semester than they were in the CG by 8.4 seconds ($p \leq 0.05$) (Table 3). The analysis of changes in the studied indicators showed significant improvement ($p \leq 0.001$) of heart rate

recovery time in both groups, but more pronounced changes occurred in the EG.

4. Discussion

Exploring best practices in the organization of physical training in the armies of the world's leading countries and NATO testifies that the purpose of physical training in the armed forces of the United States, Germany, France and other countries is to achieve and maintain full physical readiness of its personnel for combat under the influence of physical and mental stress. The system of physical training of the US military has a clear military-applied orientation. Physical training classes use long marches over rough terrain, swamps, in bad weather and with soldier's pack which should exaggerate the full combat one. Imitation devices such as fire, smoke, explosions, shooting, naturalistic models of distorted corpses, blood, odours are widely used during obstacle classes [23, 24, 25]. The main task of combat, physical and psychological training of French service members is to develop their abilities to mobilize all forces to solve specific tasks. Regular sports and participation in competitions are the main means of educating such abilities according to the experts [26, 27]. The concept of physical training in the German armed forces is based mainly on the means and methods of sports training. The purpose of physical (sports) training in the Bundeswehr is the educational impact on the whole personality of the service members through drilling in movements, health promotion and rational use of free time [28, 29].

The scientists [30, 31, 32] point out that a service member, in difficult combat conditions against the background of significant physical fatigue and high nervous tension, is required to have a high level of comprehensive physical fitness; he must be able to quickly switch from one activity to another: from movement on combat vehicles to movement on foot, from running with overcoming obstacles to accurate shooting and throwing grenades, and so on. The authors emphasize the use of military sports multiathlon (in particular military pentathlon) in the training of service members, as they have a strong special orientation and close connection with combat training. One of the main features of military pentathlon is its complex nature. In military pentathlon competitions, the service members perform various movements and actions that are inherent in combat activities [17, 22].

The effectiveness of military pentathlon in improving the physical training of service members of reconnaissance units of the Armed Forces of Ukraine was proved in the research by O. V. Rolyuk and other scientists [18]. The scientists [21, 22] note the positive impact of military pentathlon on the development and improvement of military-applied motor skills in cadets

investigating the sporting aspect of military pentathlon. Our research has shown that military pentathlon has also a positive effect on improving the cadets' physical development and their functional status as well as strengthening their health in the training process. The cadets who were engaged in military pentathlon had significantly better ($p \leq 0.05-0.001$) indicators of body mass, vital capacity of the lungs, vital index, strength index, heart rate, Robinson index, heart rate recovery time to baseline than the cadets who were engaged in the traditional method of physical training. Our research expands the results of research by other scientists on the effectiveness of military-applied sports [33-51].

5. Conclusions

High efficiency of military pentathlon classes on improving the cadets' physical development and functional status in the training process was revealed: the cadets who were engaged in military pentathlon had, at the end of the research, significantly better ($p \leq 0.05-0.001$) indicators of body mass (by 2.1 kg), heart rate at rest (by 1.7 beats / min), vital capacity of the lungs (by 235.1 ml), vital index (by 4.90 ml / kg), Robinson index (by 2.34 conditional units) and heart rate recovery time after exercise (by 8.4 seconds) than the cadets who practiced traditional methods of physical training. The results suggest that the achieved level of the cadets' physical development and functional status engaged in military pentathlon will in the future improve the efficiency of their professional and service activities.

Prospects for Further Research

The influence of pentathlon classes on the physical development and functional status of female cadets is supposed to be studied.

Disclosure Statement

No author has any financial interest or received any financial benefit from this research.

Conflict of Interest

The authors state no conflict of interest.

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