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Influence of Hand-to-Hand Combat Training on Functional Fitness of Cadets at Higher Educational Establishments of the Ministry of Internal Affairs

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Abstract

Purpose: to analyze the influence of Hand-to-Hand Combat on functional fitness of cadets of a higher educational establishment of the national police of Ukraine.

Materials and Methods. The study involved 125 Cadets at Higher Educational Establishments of the Ministry of Internal Affairs. Research methods: methods of theoretical level of research; empirical research methods: pedagogical observation, pedagogical experiment; chest rheography (to determine functional state of the cardiovascular system); assessment of anaerobic performance according to the Wingate test and physical performance according to the PWC_{170} test; methods of mathematical statistics.

Results: the service and combat activities of police officers in modern social and political environment in Ukraine set high demands to functional capabilities of the body. Hand-to-hand combat can have a significant impact on professional and psychophysiological fitness of personnel for effective actions to apprehend and detain a criminal, as well as under conditions of limited space. Hand-to-hand combat is an effective sport for quality formation of the process of training cadets of the Ministry of Internal Affairs, as evidenced by improvement of all indicators of cadets of the experimental group, namely: heart rate variability, anaerobic and aerobic mechanisms of motor activity.

Conclusions: for the first time, data on HRV, the Wingate test and physical performance of cadets of the Ministry of Internal Affairs were obtained. The changes of these indicators under the influence of Hand-to-Hand Combat classes in annual dynamics have been presented. Positive influence of Hand-to-Hand Combat classes on functional state of cadets has been established, which contributes to increase of the efficiency of their professional activities in future. At the end of the study, cadets of the experimental group had significantly better indicators of functional fitness than the cadets of the control group. The obtained results proved that the developed training program based on the application of Hand-to-Hand Combat is effective and proves expediency of its application in practice.

Key words: Martial Arts, Hand-to-Hand Combat, Cadets**,** Anaerobic Power, Wingate test, Physical Performance.

Анотація

Валерія Тищенко, Світлана Караулова, Андрій Литвиненко, Іван Глухов, Катерина Дробот, Дарина Люта. Вплив занять рукопашним боєм на функціональну підготовленість курсантів закладів вищої освіти МВС.

Мета: здійснити аналіз впливу рукопашного бою на функціональну підготовленість курсантів вищого навчального закладу національної поліції України. **Матеріал і методи.** У дослідженні взяли участь 125 курсантів закладів вищої освіти МВС. Методи дослідження: методи теоретичного рівня дослідження; емпіричні методи дослідження: педагогічне спостереження, педагогічний експеримент; реографія грудної клітки (для визначення функціонального стану серцево-судинної системи); оцінка анаеробної продуктивності за тестом Wingate та фізичної працездатності за тестом PWC170; методи математичної статистики. **Результати**: службово-бойова діяльність працівників міліції в сучасних суспільно-політичних умовах України висуває високі вимоги до функціональних можливостей організму. Рукопашний бій може суттєво вплинути на професійну та психофізіологічну готовність особового складу до ефективних дій із затримання та затримання злочинця, а також в умовах обмеженого простору. Рукопашний бій є ефективним видом спорту для формування якісного процесу підготовки курсантів МВС, про що свідчить покращення всіх показників курсантів експериментальної групи, а саме: варіабельності серцевого ритму, анаеробних та аеробних механізмів рухової активності. **Висновки**: вперше отримано дані щодо варіабельності серцевого ритму, тесту Вінгейта та фізичної працездатності курсантів МВС. Наведено зміни цих показників під впливом занять рукопашним боєм в річній динаміці. Встановлено позитивний вплив занять рукопашним боєм на функціональний стан курсантів, що сприяє підвищенню ефективності їх професійної діяльності в подальшому. Наприкінці дослідження курсанти експериментальної групи мали достовірно кращі показники функціональної підготовленості, ніж курсанти контрольної групи. Отримані результати засвідчили, що розроблена тренувальна програма на основі застосування рукопашного бою є ефективною, та підтверджує доцільність її застосування на практиці.

Ключові слова: єдиноборства, рукопашний бій, курсанти, анаеробна сила, тест Вінгейта, фізична працездатність.

Introduction

Organization of physical training at the appropriate level, as well as the use of applied kinds of sport in the internal affairs bodies, increases physical and psychological fitness of the officers to accomplish operational and official tasks, skillfully using physical strength, combat techniques and special means. One of the objectives of achieving this aim is to master a system of practical and self-defense skills along with personal safety in extreme situations of service activity. Currently, graduates of educational establishments of the Ministry of Internal Affairs of Ukraine often face difficulties with the use of combat techniques during practical activities. This may become an issue when preventing crimes and administrative offenses, both in terms of detention and during protection against violence against citizens and police officers. There are rare cases when employees of internal affairs bodies have to fight against criminals under conditions of mass gathering of people. In such situations, possibility for officers to use firearms it is often hindered or unfeasible, which once again confirms the relevance of confident mastery of unarmed self-defense techniques and hand-to-hand combat as a necessary condition for successful completion of the tasks. To address this issue, it is necessary to improve the content of training of police officers in terms of the formation of abilities and skills to use combat techniques [25].

According to statistics, most arrests are done on the ground. Therefore, it is rather urgent to address the issue of increasing the effectiveness of police officer's actions in the event of a transition to a fight on the ground while attempting to arrest offenders. Implementation of tactical plans in extreme conditions depends on the features of the nervous system and temper of police officers, which ultimately determines the style of fighting. Also, efficiency of the cadets in solving the assigned operational tasks depends on the level of their functional fitness. Researchers have studied the issue of reducing efficiency of professional actions depending on physical fitness of the military [40].

These recommendations pose significant contribution to the science and practice of application of martial arts in the educational process of specialists training in various fields, however, the issue of the use of Hand-to-Hand Combat in training of officers for the Ministry of Internal Affairs has been neglected. It is appropriate to take into account the most functionally stressed areas of the neuromuscular apparatus that determine the success of sports activities. This is confirmed by data obtained from athletes of various sports [11, 17, 37] and various martial arts [19, 21, 26]. At the same time, general biological mechanisms of adaptation and compensatory reactions that occur in the body of athletes during the training process, also have a significant impact on the implementation of sensorimotor reactions. In our case, the differences in these reactions are related to the activity of the branches of the autonomic nervous system, which takes a direct part in ensuring the neuro-humoral mechanisms of adaptive and compensatory reactions in the body of highly qualified athletes [29, 30].

Thus, regardless of positive results and practical significance of a small number of works, the impact of the content of the educational process on functional state of the cadets of the Military Academy of the Ministry of Internal Affairs of Ukraine calls for development of the latest training methods that will contribute to the achievement of such a state of functional fitness for future activities, that would remain affective for a long time.

The outcomes delineated in the study embody the intricate synergy of physical, technical, and psychological preparatory modalities. The corporeal facets encapsulate the adeptness in executing diverse physical tasks, the technical dimensions encompass the proficiency in employing Hand-to-Hand Combat techniques, and the psychological readiness manifests in the capacity for strategic cogitation and stress management during training sessions. Thus, the results of functional preparedness bear testimony to the holistic efficacy of various facets of preparation, encompassing physical, technical, and psychological components. Therefore, the search for available means of physical training, which, along with the development of basic physical qualities, would contribute to strengthening of health, improvement of the body's resistance to negative factors, development and improvement of the psychophysiological qualities and functional capabilities of the body, essential for increasing the effectiveness of cadets training, is still urgent today.

Purpose of the study: to analyze the influence of Hand-to-Hand Combat on functional fitness of cadets of a higher educational establishment of the national police of Ukraine.

Materials and Methods

The following research methods were used to achieve research objectives: methods of the theoretical level of research; empirical research methods: pedagogical observation, pedagogical experiment; chest rheography (to determine functional state of the cardiovascular system); assessment of anaerobic performance according to the Wingate test and physical performance by the PWC_{170} test; methods of mathematical statistics.

In order to prove the effectiveness of the improvement program of functional fitness for cadets of higher education institutions at Donetsk State University of Internal Affairs, specifically at the Kryvyi Rih Educational and Scientific Institute, which is dedicated to training specialists for units of the National Police in the city of Kryvyi Rih.with the use of Hand-to-Hand Combat means, indicators of the cardiovascular, automnomic nervous system, aerobic and anaerobic physical capacity were monitored.

Participants. The study was conducted in 2022-2023, in which cadets (men) aged 18-20 years took part. Two groups were formed: an experimental group (EG, n=65) and a control group (CG, n=60). In the experimental group, training sessions were conducted using a developed experimental program incorporating Hand-to-Hand Combat techniques, while cadets in the control group adhered to a previously approved standard training program of the Department of Special Disciplines and Professional Training. This allowed for a comparison of the impact of specific Hand-to-Hand Combat training on their functional preparedness. Each participant signed an informed consent to participate in the research, and all measures were taken to ensure the anonymity of the participants. Participants of the research were treated according to Declaration of Helsinki and Belmont Report.

Training in Hand-to-Hand Combat emphasizes functional readiness and coordination of movements. Studying various techniques and maneuvers helps enhance functional readiness for an effective response in different situations, allowing police officers to adapt their skills to real combat scenarios and providing more effective control over opponents.

Procedure. The implementation of the developed program took place over the course of a year during sports and mass activities, with a weekly commitment of 4 hours. The objectives of the developed program, incorporating elements of Hand-to-Hand Combat, were as follows: improvement of self-defense techniques and hand-to-hand combat, disarming, and

apprehension of individuals posing a threat to public order; enhancement of the functional state of the cardiorespiratory and autonomic nervous systems; increase in the level of professionally important physical qualities (strength and speed endurance, reaction speed, agility, endurance); improvement of professional performance and reliability of the organism (achieving a high level of functioning of systems and organs subjected to the highest load during service activities); refinement of professionally essential character traits: courage, determination, perseverance, and more.

The experimental program incorporating elements of Hand-to-Hand Combat included the following components: stand-up fighting technique: encompassing techniques from boxing and kickboxing, it involved fundamental strikes with hands and feet, evasion, and blocking; defense against knife and pneumatic attacks; ground fighting technique: incorporating basic positions and transitions between them, techniques for twisting and throwing opponents to the ground, transitioning to a controlling position, and techniques for control and tying up; enhancement of physical and functional preparedness of police officers; tactical skills: developing tactical thinking, strategies, and the ability to read an opponent; development of mental strength: involving training to improve endurance, willpower, and concentration during the execution of professional tasks.

Stand-up fighting techniques in Hand-to-Hand Combat for police officers included a variety of grips, strikes, shifts, and defenses utilized for controlling the opponent and creating opportunities to execute binding or takedown techniques: grips involved simultaneous grabs of hands and shoulders, arms and head, or arms and the opponent's body to control their movements and hinder their ability to strike; strikes encompassed various kicks, punches, elbows, and knees to disrupt the opponent's balance and create opportunities for executing binding or takedown techniques; shifts and movements were used to avoid the opponent's strikes and transition to close-quarters contact for the application of binding or takedown techniques; takedown allowed for the transition from the standing position to a controlling position on the ground and the application of ground techniques; defense entailed the use of various techniques to defend against strikes and grabs, providing a means to protect against attacks and create opportunities for executing counterattacks.

The main ground fighting techniques in the experimental Hand-to-Hand Combat program included: grappling, involving various techniques of taking and grabbing that allowed close-contact movement with the opponent on the ground, including different positions such as the wrestler's stance, kneeling combat, and more; takedown, a technique that allowed changing the position from a standing stance to the ground to bring the opponent down; submission involved the use of various binding, bending, and twisting techniques on the opponent's limbs in ground positions to gain control over the opponent; escape allowed freeing oneself from grabs or the opponent's control, providing an exit from a dangerous situation; restart allowed returning to the initial position and restarting the fight if the ground position did not allow for the continuation or conclusion of the fight.

With an extensive training plan in mind, here are some specific Hand-to-Hand Combat techniques and techniques that can be incorporated into a weekly police officer program (Table 1).

The distribution of training sessions per month is presented in Table 2. Each training session began with a warm-up and ended with recovery exercises. At the end of each week, short sparring sessions were held to develop practical skills and prepare for real situations. The tasks and volume of training were adapted according to the state of readiness and needs of the cadets.

To assess functional state of the autonomic nervous system, the CARDIOLAB electrocardiographic complex with the function of heart rate variability analysis was used (National Aerospace University "KHAI", STC of Radioelectronic Medical Devices and Technologies "KHAI-MEDYKA", Kharkiv, registration certificate No. 6037/2007, certificate of conformity No. UA–MI/2p–2765–2009). The heart rate variability analysis technology was based on taking short records (up to 5 minutes) of the patient's electrocardiographic signal, measurement of the time intervals between the R-waves of the monitor electrocardiogram (RR intervals), construction of a dynamic series of cardio intervals (cardiointervalograms or rhythmograms) and further analysis of the resulting rhythmogram by mathematical methods.

The recording of the electrocardiogram was carried out in the supine position with calm breathing at the same time of the day with no previous emotional and physical stress, at least 1.5-2 hours after having a meal. Indicators of total variability (SDNN, RMSSD, AMo, Si, IVR) and periodic components of HRV (TP, VLF, LF, HF, LF/HF, IC, LF %, HF %, VLF %) were studied. The obtained results were compared with the international standards of the Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996.

Table 1

WEEKLY POLICE OFFICER PROGRAM

Indicators		Sets	Repetitions	Rest between sets
Guard passes	Torreando Pass	4	8 per side	1-2 minutes
	Knee Slide Pass	4	8 per side	1-2 minutes
Establishing ground control	Mount	3	5-7	1-2 minutes
	Side Control	3	5-7	1-2 minutes
Submissions	Armbar	4	5-7 per arm	1-2 minutes
Sweeps	Triangle Choke	3	5-7 per arm	1-2 minutes
	Scissor Sweep	3	8 per side	1-2 minutes
Escapes	Technical Stand-Up	3	5-7	1-2 minutes
	Bridge and Roll	3	5-7	1-2 minutes
Throws	Osoto Gari	4	5-7	1-2 minutes
Preparation for standing combat	Sprawls	3	8-10	1-2 minutes
Grappling and control	Collar Choke	4	5-7	1-2 minutes
	Kimura Lock	4	5-7 per arm	1-2 minutes

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Table 2

Monthly training program

Indicators				Sets	Repetitions	Rest between sets
Week 1-2	Monday	Torreando Pass Knee Slide Pass	Torreando Pass	4	8 per side	1-2 minutes
	Wednesday		Knee Slide Pass	4	8 per side	1-2 minutes
	Friday	Mount Side Control	Mount	3	5-7	1-2 minutes
			Side Control	3	5-7	1-2 minutes
Week 3-4	Monday Wednesday	Armbar	Armbar	4	5-7 per arm	1-2 minutes
		Triangle Choke Scissor Sweep	Triangle Choke	3	5-7 per arm	1-2 minutes
	Friday		Scissor Sweep	3	8 per side	1-2 minutes
		Technical Stand-Up Bridge and Roll	Technical Stand-Up	3	5-7	1-2 minutes
			Bridge and Roll	3	5-7	1-2 minutes
Week 5-6	Monday	Osoto Gari Sprawls	Osoto Gari	4	5-7	1-2 minutes
	Wednesday		Sprawls	3	8-10	1-2 minutes
	Friday	Collar Choke	Collar Choke	4	5-7	1-2 minutes
			Kimura Lock	4	5-7 per arm	1-2 minutes

Anaerobic capacity and anaerobic power are widely used in various types of martial arts, since the decisive moments in these sports are associated with large energy consumption, which cannot be provided solely through oxidative metabolism [34]. Anaerobic metabolism ensures rapid energy at the maximum muscle explosion during a fight, while aerobic metabolism helps maintain effort throughout the fight, as well as restore energy during short periods of rest or reduction in effort. Therefore, we studied bioenergetics of the Wingate-test, i.e., we assessed the contribution of various energy supply mechanisms to overall work performed, which represents a test on a bicycle ergometer with maximum intensity lasting 30 seconds.

The test is used to assess anaerobic performance, including the so-called glycolytic capacity, during which the maximum and average power, as well as the fatigue index (the degree of power reduction in 30 seconds as a percentage) are recorded. Currently, the test is one of the most popular methods in the world to assess anaerobic performance of athletes and is firmly established in the practice of testing anaerobic alactic capacity in many kinds of sport. From a physiological standpoint, the test reflects the work of the adenosine triphosphate/creatine phosphate and glycolytic energy supply systems, which are key at executing throws in martial arts [39].

To administer the Wingate test, a bicycle ergometer with Monark 894E Ergomedic Peak Bike mechanical braking force (Monark, Sweden) was used, which was prepared taking with consideration individual anthropometric data of the athlete: the handlebar handles and seat height were adjusted, pedals were fixed. Before the start of the study, each athlete was instructed in detail about the testing methodology, parameters recorded and rules of safe behavior. Afterwards, short training sessions were carried out with no load applied. Afterwards - sprints with the use of the tested load, and finally - a full-fledged training test simulating the control one. This allowed athletes to prepare the musculoskeletal system, “feel” the ergometer and practice before the control test. The warm-up was followed by a 5-minute rest. The test load was greater than at testing on a manual ergometer, since the upper body has less muscle mass (less myofibrils) and less aerobic capacity (50-60% of the aerobic capacity of the muscles of the legs) [10].

Testing was carried out according to the standard Wingate test protocol. The weight was calculated and set in advance at 7.5% of body weight. After confirming the athlete’s readiness for testing, the subject began to increase pedaling speed and, upon reaching 90 revolutions per minute, the basket carrying the load was lowered, creating resistance, which corresponded to the one at the beginning of the test. Next, the athlete accelerated to the maximum possible speed, followed by maintaining the pedaling intensity for 30 s.

Since there is initial speed, the exercise will have a speed-strength character from the very beginning, and energy supply during the first seconds of the test will be provided almost exclusively due to the alactic mechanism, i.e., the phosphagen system (reserves of adenosine triphosphate (ATP) and creatine phosphate (CrP) in the muscles). To compare, if you start testing without initial speed, you will have to consume some energy to accelerate the flywheel. At the same time, by the moment the optimal speed for development of maximum power has been reached, muscle fibers will be acidified (due to hydrogen ions appearing during the resynthesis of CrP molecules during anaerobic glycolysis). This leads to inhibition of ATP consumption due to the competition of hydrogen ions with calcium ions at the active centers of myosin heads. As a result, the myofibril will not show maximum strength, which means that the strength of the individual muscle fiber and the whole muscle will not reach its possible peak. This will result in lower peak power values, which can be proved by previously published studies [24, 28].

Our objective was to determine the strength endurance of athletes, therefore, starting from the 5th second, a large contribution to energy production came from both aerobic and anaerobic glycolysis. In this sace, the output indicators are determined by the alactic and aerobic power of active

muscles, since the ability to maintain maximum power depends on the reserves of ATP and CrP in the muscles (which, in its turn, depends on the number of myofibrils), as well as on the development of the mitochondrial system (since, on one hand, with oxidative muscle fibers with a large number of mitochondria prevail over glycolytic ones, then fewer hydrogen ions that interfere with muscle contraction are formed; on the other hand, hydrogen ions are utilized in mitochondria) [1].

Using the bicycle ergometer software, the following indicators were recorded: peak power, W; relative peak power, W/kg; average power, W; relative average power, W/kg; minimum power, W; relative minimum power W/kg; power drop, W; relative power drop W/kg; power drop rate W/s; time to reach peak power, ms. Explosive power was calculated as the ratio of peak power to the time of its achievement. Fatigue index or rate of power loss was calculated in two ways:

- as a difference between peak power and minimum power divided by peak power (%);
- as a difference between the relative maximum and relative minimum power in the test, divided by the power drop time (W/kg/s).

Statistical analysis. The database was previously cleared of outlier values associated with first and second level errors. Statistical data processing was carried out using StatSoftInc. Statistics 10 software.

Results

We studied the effects of Hand-to-Hand Combat training on neurovegetative modulation through Heart Rate Variability analysis as a neuroautonomic tool to understand the mechanism underlying the dominance of neurocognition via parasympathetic and sympathetic dominance. The analysis measures successive time intervals between adjacent heartbeats (RR intervals) inter-beat measurement differences (NN intervals) from the sinus source providing information about the autonomictone. To assess adaptive and compensatory reactions and functional state of the autonomic nervous system as well as features of changes in neurohumoral regulation under the influence of developed experimental program of enhancement of the functional system, an analysis of heart rate variability was done among cadets of both groups (Table 3).

Can be seen from the results presented in Table 1, after applying the developed program, the cadets of the experimental group had a significant decrease in the stress indicator (Si) – by 185.65 standard units ($p<0.001$), as well as regulatory systems activity indicator (RSAI) – by 2.60 standard units ($p<0.01$). Among the cadets of the control group, the aforementioned indicators decreased only by 64.51 ($p<0.05$) and 0.64 standard units ($p>0.05$), respectively, which indicates a decrease in the degree of centralization of rhythm control and activity of sympathetic division of the autonomic nervous system.

Table 3

Heart rate variability indicators dynamics of cadets from experimental and control groups during the pedagogical research

HRV indicators	Experimental group (n=65)			Control group (n=60)		
	prior	after	p	prior	after	p
SDNN, ms	19,10±0,92	29,47±0,55 ***	<0,001	19,00±1,52	22,77±1,45	>0,05
RMSSD, ms	14,82±0,73	23,80±0,53 ***	<0,001	14,88±0,62	17,37±1,10	>0,05
GP, ms²	499,40±11,00	894,03±24,31 ***	<0,001	498,40±21,00	589,97±22,10	<0,01
VLF, ms²	215,74±13,40	152,45±10,34 ***	<0,001	215,64±13,40	288,58±13,46	<0,01
LF, ms²	190,32±11,63	337,55±14,77 ***	<0,001	192,32±11,63	198,60±10,75	>0,05
HF, ms²	85,44±5,13	400,29±14,72 ***	<0,001	84,44±5,13	100,78±7,40	>0,05
LF/HF, stand. unt.	3,40±0,50	0,89±0,11	<0,01	3,40±0,70	1,87±0,82	>0,05
IC, stand. unt.	2,48±0,16	1,71±0,28	<0,05	2,38±0,16	2,41±0,30	>0,05
AMo, %	78,12±1,80	69,77±1,83	>0,05	76,12±2,80	73,10±1,61	>0,05
Si, standard units	404,32±18,14	218,67±12,33 ***	<0,001	400,32±18,14	335,78±13,34	<0,05
RSAI, stand. unt.	6,80±0,21	4,20±0,28 *	<0,01	6,89±0,22	6,25±0,89	>0,05
VLF, %	43,26±2,20	17,05±3,50 ***	<0,001	43,26±2,20	48,91±1,66	<0,05
LF, %	38,58±2,93	37,75±1,23	>0,05	38,58±2,93	33,66±2,77	>0,05
HF, %	16,94±2,14	44,77±1,23 ***	<0,001	16,94±2,14	17,09±1,64	>0,05

Note: * – $p<0,05$; **– $p<0,01$; ***– $p<0,001$ at contrasting final indicators of experimental and control groups

The mode amplitude indicator did not show statistically significant changes in all groups (p>0.05). According to the results of the study of impact of the developed program of improving functional fitness of cadets using elements of Hand-to-Hand Combat aimed at the spectral characteristics of heart rate variability, a significant change in total activity of regulatory systems (RS) was established, which increased among cadets of the experimental group by 394.63 ms² (p<0.001); due to predominant increase in power of the low-frequency component of the spectrum (LF) by 147.23 ms² (p<0.001), high-frequency component (HF) by 314.85 ms² (p<0.001) and decrease in central ergotropic contribution (VLF) by 63, 29 ms² (p<0.001). Among cadets of the control group, the increase in total activity of regulatory systems (RS) was almost four times less (by 91.57 ms²) than in the experimental group and occurred due to other contributions of individual components of the spectrum, namely a significant increase in the very low-frequency component (VLF) – by 72.94 ms² (p<0.01), low-frequency component (LF) – by 6.28 ms² (p>0.05) and high-frequency component (HF) – by 16.34 ms² (p>0.05). By the percentage contribution of individual components of total regulatory systems activity during the study, statistically significant changes in the very low-frequency component – by 26.21% (p<0.001) and the high-frequency component – by 27.83% (p<0.001) were observed in the experimental group. At the same time, a significant increase in the very low-frequency component – by 5.65% (p<0.001) was observed in the control group, which indicates an increase in central ergotropic effects and a decrease in parasympathetic effects in heart rate modulation. Comparison of final indicators of heart rate variability revealed significantly better indicators among cadets of the experimental group compared to those in the control group. The value of the standard deviation of N-N intervals (SDNN) was better by 6.70 ms (p<0.001), the square root of the series differences of N-N intervals (RMSSD) was better by 6.43 ms (p<0.001), total activity of regulatory systems (RS) – by 304.06 ms² (p<0.001), the very low frequency component of the spectrum (VLF) – by 136.13 ms² (p<0.001), the low frequency component of the spectrum – by 138.95 ms² (p<0.001), the high frequency component – by 299.51 ms² (p<0.001).

Thus, cadets of the experimental group significantly expanded the range of parasympathetic influences, which indicates an increase in the adaptive capabilities of the autonomic nervous system, while sympathicotonia was observed among cadets of the control group, which indicated excessive ergotropic influence and the predominance of excitation processes in state of rest, which is an irrational adaptive reaction of the body leading to depletion of resources. Overall, the beneficial effect of physical exercise on vegetative regulation was characterized by an increase in parasympathetic and baroreflex effects on the cardiovascular system, a decrease in the tonic effects of the sympathetic nervous system, and a decrease in tension of the vegetative regulation system.

To determine the effectiveness of the proposed experimental program in terms of anaerobic performance indicators, the Wingate test was repeatedly used, the results of which are presented in Table 4.

As a result of the applied experimental program, cadets of the experimental group showed improvement of their anaerobic capacity during the 30-second Wingate test. At the same time, application of the standard training program did not result in a significant change among cadets of the control group. In both experimental and control groups, an unreliable change in the fatigue coefficient was observed, which indicates improvement in recovery processes and an increase in adaptive capabilities of the body of cadets of the experimental group while under physical workload.

Among the presented results, peculiar interest posed the average ratio of low-intensity and high-intensity activity, which will serve as a kind of “expectation” for the ratio of high-intensity loads with formation of metabolites and low-intensity ones, during which these metabolites can be utilized. After applying the experimental program, cadets of the experimental group showed, at the end of the pedagogical study, an improvement in the absolute value of peak power by 120.00 W (p<0.001), relative peak power by 1.73 W/kg (p<0.001), absolute average

Table 4

Wingate test indicators dynamics of cadets from experimental and control groups during the pedagogical research

Indicator, unit of measurement	Experimental group (n=65)			Control group (n=60)		
	prior	after	p	prior	after	p
Peak power, W	570,87±9,71	690,87±9,77***	<0,001	569,77±10,71	599,47±9,71	>0,05
Relative peak power, W/kg	8,13±0,26	9,86±0,29***	<0,001	8,14±0,26	8,54±0,22	>0,05
Average power, W	399,01±8,78	490,11±8,82***	<0,001	396,01±8,78	414,88±7,21	>0,05
Relative average power, W/kg	5,68±0,22	7,02±0,23***	<0,001	5,69±0,19	5,91±0,18	>0,05
Minimum power, W	226,26±7,22	289,26±7,57***	<0,01	222,29±7,21	230,29±7,09	>0,05
Relative minimum power, W/kg	3,18±0,17	4,13±0,13***	<0,001	3,19±0,17	3,28±0,16	>0,05
Fatigue coefficient, %	60,99±1,55	58,13±0,41**	>0,05	60,79±1,35	61,58±0,95	>0,05

Note: **– p<0,01; ***– p<0,001 at contrasting final indicators of experimental and control groups

power by 91,10 W (p<0.001), relative average power – 1.34 W/kg (p<0.001), minimum power – 63.00 W (p<0.01), relative minimum power – 0.95 W/kg (p<0.001). Cadets of the control group, at the end of the pedagogical study, showed only tendency to improve absolute peak power by 29.70 W (p>0.05), relative peak power – by 0.40 W/kg (p>0.05), absolute average power – 18.87 W (p>0.05), relative average power – 0.22 W/kg (p>0.05), minimum power – 8.00 W (p>0.05), relative minimum power – 0.09 W/kg (p>0.05). Also, the peak power indicator was better with cadets of the experimental group compared to cadets of the control group by 91.40 W (p<0.001), relative peak power – by 1.32 W/kg (p<0.001), absolute average power – 75.23 W (p<0.001), relative average power – by 1.11 W/kg (p<0.01), minimum power – 58.97 W (p<0.001), relative minimum power – by 0.85 W/kg (p<0.001), fatigue coefficient – by 3.45% (p<0.01), respectively. The dynamics of changes in Wingate test indicators (in %) with cadets of the experimental and control groups during the pedagogical experiment is presented in Figure 1. As can be seen from the data, the peak power indicator improved among cadets of the experimental group by 21.02% compared to 5.21% of the cadets in the control group, relative peak power – by 21.27% and 4.91%, absolute average power – by 22.83% and 4.76%, relative average power – by 23.59% and 3.86%, minimum power – by 27, 84% and 3.59%, relative minimum power – by 29.87% and 2.82%, fatigue coefficient – by -4.69% and 0.79%, respectively. Thus, the obtained indicators once again proved the effectiveness of the developed program for the cadets of the experimental group in terms of improving anaerobic performance.

The results of the analysis of changes in physical performance according to the PWC_{170} indicator among the cadets of the experimental and control groups are presented in Table 5. After applying the developed experimental program, cadets of the experimental group showed a significant improvement in indicators of physical performance and aerobic metabolism, in contrast to the cadets of the control group. The absolute value of PWC_{170} plausibly increased by 240.07 kgm/min (p<0.001), relative PWC_{170} – by 3.95 kgm/min/kg (p<0.001), maximal oxygen absorption – by 11.76 ml/min/kg (p<0.001), which indicates the improvement of work capacity and aerobic capabilities of cadets and the creation of optimal prerequisites to increase endurance and form applied skills.

Analysis of changes in physical performance in the control group showed no statistically significant changes registered during the pedagogical experiment. The absolute value of PWC_{170} plausibly increased by 64.17 kgm/min (p>0.05), the relative value of вPWC_{170} – by 1.74 kgm/min/kg (p>0.05), maximum oxygen absorption – by 2.56 ml/ min/kg (p>0.05), indicating a slight improvement in work capacity and aerobic capacity of cadets, as well as the need to revise the standard training program for cadets regarding improvement of their aerobic capacity. At the end of the formative stage of the pedagogical research, the absolute indicator of PWC_{170} was plausibly higher among the cadets of the experimental group compared to the other group by 174.80 kgm/min (p<0.001), the relative vPWC_{170} by 2.11 kgm/min/kg (p<0.01), relative maximum oxygen absorption (rMOA) – by 8.80 ml/min/kg (p<0.01), which indicates positive impact of the developed program for improving functional fitness using Hand-to-Hand Combat means on increasing aerobic capacity of cadets of military education institutions.

The indicator of absolute physical working capacity (aPWC_{170}) increased among cadets of the experimental group by 31.66%; in the control group – by 8.45%, relative physical working capacity (вPWC170) – by 36.43% and 15.90%, relative maximum oxygen absorption (rMOA) – by 30.13% and 6.49%, respectively, which indicates the advantages of the developed program for improving physical and functional fitness of cadets of military education institutions.

Discussion

The conducted experiment is a logical supplement to our previous research in the field of improving effectiveness of training of cadets of the National Police of Ukraine [36], which training requires immediate modernization, which would be accompanied by introduction of various new educational programs and technologies of education and training. Unfortunately, the educational environment is currently not combined with an assessment of the safety and impact of conditions, programs, methods and modes of learning on the ability to work, the functional state of the body and the state of health of those who study, which in the future will affect the duration and effectiveness of their professional life. Modern studies of training of cadets of the national police mostly focus on the application of applied sports, in particular certain types of martial arts. According to the results of academic research, improvement of general physical qualities of cadets of various specialties, in particular, officers of the Ministry of Internal Affairs of Ukraine have been proposed: Prontenko K. V. [27] – by means of kettlebell lifting; L.M. Balushka [4] – wrestling; Romanchuk, S. et al. [33], Otkidach, V., Zolochevsky, V., & Kuryshko, E. [23] – military-applied all-around events. However, unfortunately, we did not find the use of Hand-to-Hand Combat means in educational process of training of cadets of the national police.

Analysis of academic and methodological references showed that there are only few works, the authors of which studied the issue of combining the process of formation of hand-

Table 5

Dynamics of PWC_{170} test indicators among cadets of the experimental and control groups during the pedagogical research

Indicator, unit of measurement	Experimental group (n=65)			Control group (n=60)		
	prior	after	p	prior	after	p
aPWC_{170}, kgm/min	758,18±8,65	998,25±11,31***	<0,001	759,28±8,65	823,45±10,66	>0,05
rPWC_{170}, kgm/min/kg	10,84±0,27	14,79±0,91**	<0,001	10,94±0,27	12,68±0,95	>0,05
rMOA, ml/min/kg	39,02±0,56	50,78±0,82**	<0,001	39,42±0,99	41,98±1,25	>0,05

Note: * – p<0,05; **– p<0,01; ***– p<0,001 at contrasting frinal indicators of experimental and control groups

to-hand combat skills and development of the corresponding physical qualities of cadets [7]. They claim that physical training is the foundation that will lead to the most effective implementation of their professional duties in future. The main skills for the effectiveness of cadets' professional activities are the perfect mastery of hand-to-hand combat techniques and the maximum manifestation of physical qualities, in particular, agility, speed, speed-strength abilities and endurance. However, the results of these studies are related to military specialties. Also, these works emphasize the importance of developing general, strength endurance, and strength [14], coordination abilities [3]. A number of works address the use of hand-to-hand combat in special physical training [12, 15]. At the same time, the issue of influence of physical fitness content on functional indicators of the body of cadets of the Ministry of Internal Affairs has not been adequately studies and needs thorough analysis.

Having decided to check what can be improved in professional training of police officers in Ukraine, based on the data that the probability of fighting on the ground is very high, we chose system of hand-to-hand combat, which has the most advanced and diverse fighting technique on the ground [5], as a hand-to-hand combat method to defeat an enemy that uses no weapons or only short-barreled weapons. In recent years, the role of Hand-to-Hand Combat worldwide has grown exponentially. As a result, researchers strived to increase the quality of researched physical and physiological reactions at training. Nevertheless, there is a strong need for a better understanding of the aforementioned aspects in order to provide ideal recommendations for training and impacting the body.

To assess the effectiveness of the use of Hand-to-Hand Combat means in the educational process of cadets of the Ministry of Internal Affairs with purpose of increasing their functional fitness, we used indicators of heart rate variability (HRV), indicators of anaerobic work capacity according to the Wingate test and physical work capacity according to the PWC_{170} test.

A large number of articles on HRV monitoring in recent years confirm high interest of researchers in studying this indicator of heart function during physical activities, especially in sports. [3, 16]. The shift from sympathetic to vagal tone has been studied for various types of athletes, but, interestingly, there is very little research in the field of martial arts specifically [9]. It can be argued that scientific achievements regarding the study of heart rate variability of athletes are quite significant. Numerous studies compare HRV between athletes of various sports, which suggests the possibility of monitoring HRV indicators to improve physical and physiological conditions [6, 18]. Thus, Morgan S. J, [22] notes that in 86% of academic papers, highly qualified athletes improved psychophysiological indicators, which allowed them to improve their athletic results due to training under the control of HRV. It has also been shown that exposure to intense physical activity leads to plausible changes in several parameters related to central and peripheral level of movement regulation [13]. Moreover, researchers primarily focused on asymmetric changes in indicators of central settings switching, which characterize central mechanisms of the motor response organization. These changes were characteristic of individuals with different variants of the formation of overstrains of the autonomic nervous system under the influence of intense physical load, and reflected a persistent predominance of the activity of the sympathetic and parasympathetic link of heart rhythm regulation [31, 32].

The research by Wang X., Yan C., Shi B., Liu C., Karmakar C. [41] revealed no relation between exercise load/intensity and HRV at all. These results confirm that a combination of indicators should be used to monitor athlets' cardiac autonomic activity. In the paper by Thamm A, et al. [35] RMSSD decreased after hypertrophic and maximal strength training, regardless of the type of load. Optimal values of the sympathovagal index (LF/HF<1.0) are accompanied by the predominance of the parasympathetic link of the autonomic nervous system, which is more pronounced with athletes of the MS-MSMK level [42].

For the first time, we received data on HRV indicators when using Hand-to-Hand Combat means in educational and training process of cadets of the Ministry of Internal Affairs. Our study confirmed the data of Lee [20] that the values of peak power and average power obtained from Hand-to-Hand Combat athletes are higher, both of healthy people and of our cadets. The next test we used to assess anaerobic performance in combat sports was the Wingate test. Moreover, maintaining high intensity efforts is associated with anaerobic capacity and power, i.e. power refers to peak and power refers to average value over 30s on the Wingate test. Most studies tackling development or verification of specific control tests aim to correlate with Wingate test results or maximum lactate levels obtained from field tests [2]. The disadvantages of this approach lie in the fact that they do not link objective indicators, such as time of various processes in a wrestling match. A number of researchers have obtained indicators showing a high class of athletes [8], which was proven by the results of our research. In his reserach, Yevtushenko O.V. provides the following values of physical performance at the stage of advanced basic training of wrestlers: 694.25 kgm/sw/14.89 kgm/sw/kg, MOA 55.78±0.82 ml/sw/kg [43].

The obtained data on the presented indicators of heart rate variability, the Wingate test of physical work capacity of the experimental group match a sufficiently high level of sports fitness of athletes, and indicate positive influence of Hand-to-Hand Combat means on functional fitness of the body of cadets of the higher education institution of the National Police of Ukraine.

Conclusions

Implementation of the developed experimental program to improve functional fitness of cadets with the use of Hand-to-Hand Combat means contributed to a significant improvement in the functional state of the autonomic nervous system and to an increase in physical capacity. At the end of the pedagogical experiment, cadets of the experimental group, compared to the cadets of the control group, showed an improvement in peak power by 91.40 W ($p<0.001$), relative peak power by 1.32 W/kg ($p<0.001$), absolute average power by 75 .23 W ($p<0.001$), relative average power – by 1.11 W/kg ($p<0.01$), minimum power – 58.97 W ($p<0.001$), relative minimum power – by 0.85 W /kg ($p<0.001$), fatigue coefficient - by 3.45% ($p<0.01$); the absolute indicator of PWC_{170} – by 174.80 kgm/min ($p<0.001$), the relative PWC_{170} – by 2.11 kgm/min/kg ($p<0.01$), the relative maximum oxygen absorption (rMOA) – by 8.80 ml/min/kg ($p<0.01$.

HRV measurements in time and frequency domains were taken into account after testing for normality distribution followed by a t-test to compare the mean ±SD. measurement in the frequency domain. Low-frequency normalized unit (LF nu) and low-frequency to high-frequency ratio (LF/HF ratio) showed a significant decrease in the experimental group, quantifying the sympathetic composition, while high-frequency normalized units (HF nu) displayed a significant increase and predicted increased parasympathetic tone. Cadets who practiced Hand-to-Hand Combat proved to have higher HRV and greater involvement of the parasympathetic nervous system, which promotes resistance to stress and improved recovery time.

Thus, the presented experimental material makes it possible to apply the developed program using Hand-to-Hand Combat means to improve functional fitness of cadets of military education institutions.

Conflict of interest. The authors declare that there is no conflict of interest that could be perceived to prejudice the impartiality of the article.

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