

Improving the development of special endurance in hand-to-hand combat athletes

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Abstract

The development and improvement of special physical fitness is a key factor in athletic success. Therefore, the search for new tools and methods to improve specialized motor skills in martial arts remains a relevant area in training. **Purpose.** To develop and evaluate a set of specialized preparatory physical exercises aimed at enhancing special endurance in 17–18-year-old hand-to-hand combat athletes at the stage of sports improvement. **Materials and methods.** The project involved 28 hand-to-hand combat athletes aged 17–18 years at the stage of sports improvement, each training for 16 h (8 sessions) per week. The control group (CG, n = 14) and the experimental group (EG, n = 14) followed the standard physical training program outlined by the Federal Standard for this sport. In addition, EG athletes trained for 4 sessions (8 h) per week using the specialized exercise sets we developed to improve special endurance. The proposed exercises closely replicated competitive motor actions in terms of structure, intensity, and coordination. At the beginning and end of the experiment, the Harvard Step Test Index and the level of special motor skills were assessed using a method designed to evaluate the special endurance of martial artists. Additionally, strength endurance was evaluated using push-ups (arm flexion and extension in the prone position) and pull-ups from a high bar hang. Coordination endurance was measured with the 5 × 10 m shuttle run (s), general endurance assessed by the 3000 m run (m/s), and speed endurance determined through the 30-s jump rope test. **Results.** At the end of the research project, athletes in the EG demonstrated a significantly greater improvement in physical performance indicators, as well as in general and special physical fitness, compared to the CG. EG athletes also showed more effective adaptation of the cardiorespiratory system to physical exertion, as indicated by a faster heart rate recovery during rest after the tests. Urgent recovery was 1.87 times faster in the speed component, 1.6 times faster in the strength component, and 1.69 times faster in the complex test compared to the CG. The high effectiveness of the proposed special preparatory exercise set for hand-to-hand combat athletes is further confirmed by the excellent performance of the athletes in amateur sports fights. **Conclusions.** The proposed set of physical exercises can be recommended for inclusion in the training process of 17–18-year-old hand-to-hand combat athletes at the stage of their athletic development.

Key Words: physical education, martial arts, physical fitness, sets of special preparatory exercises, physical testing

Introduction

Martial arts are gaining popularity and becoming increasingly widespread among modern youth (Koshcheyev & Dolbysheva, 2021; Reale et al., 2024; Doherty et al., 2025). One such discipline is hand-to-hand combat, which attracts many athletes and spectators of all ages. The visual appeal of competitions in this sport plays a key role in its attraction. As an amateur sport, hand-to-hand combat is considered one of the safest, promoting physical activity that benefits overall health (Efremenko, 2022). It actively enhances various physical qualities, improving coordination, joint flexibility, reaction speed, and strength (Chernozub et al., 2022). Health improves through regular training, making hand-to-hand combat highly recommended for overall physical

development and body strengthening (Kiehl et al., 2025). It also improves the cardiovascular and respiratory systems (Stergiou et al., 2023). This sport promotes confidence in both physical and mental strength, which is why it appeals to athletes of various ages and fitness levels (Beckner et al., 2024). Hand-to-hand combat techniques include stances, movements, throws, as well as offensive and defensive actions using both hands and feet (Vako et al., 2024; Corcoran et al., 2024). According to statistics, striking techniques are the most frequently used among hand-to-hand combat athletes.

As a result of growing interest, new sports sections, schools, and clubs dedicated to hand-to-hand combat are opening each year in many countries, providing opportunities for enthusiasts to engage in this martial art (Ioannides et al., 2020). The expanding participation of young people presents a challenge for specialists to continually develop effective methods for performing educational and training sessions (Guillermo et al., 2020; Fathir et al., 2021; Sushchenko, et al., 2016). As in other sports, hand-to-hand combat training is divided into general physical training and specialized physical preparation. General physical training lays the foundation necessary for progressing in the sport, and without it, further athletic development is not achievable.

The use of specialized physical exercises in the educational and training process helps develop the motor qualities, skills, and abilities specifically required for hand-to-hand combat. These targeted exercises are incorporated both during training and in competition, often evolving into techniques used in actual competition fights (Francioni et al., 2016). Observations of athletes show that, in martial arts, a high level of anaerobic and aerobic energy system development is a key factor influencing both general and sport-specific physical fitness (Andreato et al., 2016; Tota & Wiecha, 2022). Researchers have found that physiological indicators contribute significantly to the skill level of martial artists, with special endurance being one of the most critical factors. This type of endurance plays a vital role in an athlete's performance during competition (Podrigalo et al., 2016).

There are various ways to develop special endurance, but any of them is based on two fundamental principles. Firstly, it is necessary to improve the power characteristics of the athlete and his aerobic abilities. Secondly, it is necessary to improve its anaerobic capacity (Davidenko et al., 2021). For this purpose, in recent years, high-intensity interval training (Mischenko et al., 2021), which was developed by the Japanese scientist I. Tabata, has been used to develop the general and specific endurance of athletes involved in martial arts. The data from the study by F. Yue et al. (2025) indicate that such training, which is performed through running or sport-specific techniques, effectively improves both aerobic and anaerobic performance in martial artists. The use of high-intensity physical activity based on CrossFit® in the training of elite sambo athletes has shown its high effectiveness compared to a traditional training program (Kudryavtsev et al., 2023).

An analysis of scientific literature shows that in the practice of training hand-to-hand combat athletes aged 17-18, the issue of developing special endurance is addressed fragmentarily, which negatively affects the training of athletes (Vorozheikin, et al., 2020). Thus, the specific features of hand-to-hand combat, which places high demands on the special endurance of fighters, are not taken into account. Often, existing methods of training special endurance for athletes from related types of martial arts are transferred to sports activities. Sensitive periods and psychological characteristics of children and adolescents, which allow a positive influence on the formation of such an important physical quality in this sport, are often not taken into account. The result of this is a decrease in the quality of training of hand-to-hand combat athletes, and in some cases this leads to serious injuries and the inability to continue sports activities (Efremenko, 2022). In our opinion, the use of the proposed special preparatory physical exercises (punches and kicks, throws, jumps) with near-maximum intensity in hand-to-hand combat training at the stage of improving sports skills will contribute to a significant increase in special endurance indicators, which will improve the performance of martial artists aged 17-18 years.

Research aim. To develop and evaluate a set of specialized preparatory physical exercises aimed at enhancing special endurance in 17–18-year-old hand-to-hand combat athletes at the stage of sports advancement.

Material & methods

To achieve this goal, a 5-month pedagogical experiment was performed during the 2023–2024 academic year at the Children's and Youth Sports School in Irkutsk, Russia. The study involved 28 male athletes aged 17–18 years (mean age = 17.7 ± 1.8 years) who were engaged in hand-to-hand combat at the stage of sports improvement. Participants were randomly selected, and the average duration of their martial arts training was 4.4 ± 2.3 years. Written informed consent was obtained from the parents of all participants. The study adhered to the moral and ethical principles outlined in the 2008 Declaration of Helsinki.

The control group (CG, $n = 14$) and the experimental group (EG, $n = 14$) both engaged in athletic training for 16 hours per week, divided into eight sessions. All participants followed a standard physical training program developed in accordance with the 2022 Russian Federal Standard of Sports Training for Hand-to-Hand Combat. In addition to this program, the EG training regimen incorporated specialized preparatory physical exercises to improve special physical endurance. These targeted exercises were performed for 8 hours per week over four training sessions (Table 1).

Table 1. Special preparatory exercise complexes for developing special endurance in hand-to-hand combat athletes

Complex No.	Execution mode	Intensity	Heart rate	Rest
1	Series of direct punches, kicks, and direct punches combined with side kicks. Four series are performed, each lasting 180 s.	Series of direct punches performed at moderate intensity for 120 s per series. Series of kicks performed at maximum intensity for 60 s per series. Series of direct punches combined with side kicks performed at moderate intensity for 60 s.	140–150 bpm 160–170 bpm 140–150 bpm	420 s of active rest (walking and relaxation exercises) and passive rest (movement and defense simulations) between series
2	Series of direct and side punches, series of side kicks and upward knee strikes, and combinations of kicks and punches. Four series are performed, each consisting of five maximum-effort 20-s intervals using arms and legs.	At maximum possible force and frequency, a series of straight punches, side punches, upward knee strikes, and combined punches and kicks	160–170 bpm	Mixed rest periods of 90–120 s between approaches and 240 s between series
3	Work with arms and legs on a punching bag. Four series are performed, each lasting 40 s, with 180 s of rest between series. Each series consists of five 8-s approaches, with 15–60 s of rest between approaches.	With maximum possible force and frequency, a series of straight and side punches, kicks, and upward knee strikes.	160–170 bpm	Active rest of 180 s between series and 15–60 s between approaches
4	Work in pairs on punching bags. One athlete holds the bag vertically while the other delivers combinations of punches and kicks. Athletes switch roles every 10 s. Each round lasts 120 s, consisting of six work periods and six rest periods.	With maximum possible force and frequency in combinations of punches and kicks	160–170 bpm	
5	Work is performed on punching bags using a repeated interval mode with alternating physical loads. It begins with combined punches at medium intensity for 20 s, followed by combined kicks in an "explosive" mode for 10 s. This is followed by a 120-s rest. Then, combined kicks in the "explosive" mode are performed for 10 s, followed by combined punches at medium intensity for 20 s.	At moderate intensity, combined punches are performed at a steady pace. In the "explosive" mode, kick combinations on the bag are performed with maximum force and speed.	of 150–160 beats / min 170–180 beats / min	

To develop special endurance in hand-to-hand combat athletes, continuous, repeated, variable, and interval training methods were used. The intensity of physical activity was monitored by measuring the heart rate over 10 s and extrapolating it to a per-minute rate.

During the pedagogical experiment, a milestone test was performed to evaluate various indicators reflecting physical performance and motor qualities related to special endurance. Physical performance at the beginning and end of the experiment was assessed using the Harvard Step Test Index, measured in conventional units. The milestone level of special endurance in athletes from both groups was evaluated through tests measuring speed, speed–strength components, and an integral assessment of this motor quality. The development of speed competence in athletes was evaluated by counting the number of kicks delivered with maximum effort to a punching bag for 10 s, as well as separately with each leg for 5 s, for three rounds of 1.5 min each. The power component of special endurance was assessed by the total number of kicks delivered with the right and left legs to a punching bag during three 60-s rounds. The integrated test for comprehensive assessment of special endurance involved counting the maximum number of punches and kicks delivered to the bag across three rounds, each lasting 1.5 min. Additionally, the athlete's body recovery process was analyzed by measuring the pulse rate for 10 s at the start and end of the first minute of rest after the special endurance test. These measurements were then converted to a per-minute rate.

Additionally, to assess maximal strength endurance, the following tests were used: the number of arm flexions and extensions performed in a prone position, and the number of pull-ups from a high bar hang. Coordination endurance was evaluated using the 5 × 10 m shuttle run, measured in seconds. General endurance was assessed using a 3000 m run, recorded in m/s, while speed endurance was determined based on the number of jumps completed in a 30-s jump rope test. The collected data were statistically analyzed by calculating the arithmetic mean and its standard error. Significant differences between indicators were determined using the Student's t-test, with results considered statistically significant at $p < 0.05$.

Results

Testing of general and special physical fitness, as well as physical performance, in the CG and EG at the start of the study showed no statistically significant differences in indicator values ($p > 0.05$), as shown in Table 2. This suggests that athletes in both groups had a comparable level of development in these motor qualities.

Table 2. Results of baseline testing of physical performance, general, and special physical fitness of athletes in CG and EG, $M \pm m$

No.	Test type	CG (n = 14)		EG (n = 14)	
		Project start	Project end	Project start	Project end
Physical performance					
1	Harvard Step Test Index, conventional units	60.4 ± 5.3	64.2 ± 6.8	61.6 ± 6.9	72.5 ± 7.8 *
General endurance					
2	3000 m run, m/s	15.3 ± 1.2	14.4 ± 1.4	15.8 ± 1.5	13.1 ± 1.2*
Speed component of special endurance					
3	Maximum number of kicks delivered to a punching bag	8.4 ± 1.3	10.3 ± 1.7	8.2 ± 1.2	12.1 ± 2.1*
4	Jumping rope for 30 s, times	66.8 ± 4.3	77.3 ± 5.6*	65.5 ± 5.1	84.5 ± 7.4*
Coordination component of special endurance					
5	Shuttle run 5 × 10 m, s	7.38 ± 0.23	7.13 ± 0.26	7.35 ± 0.22	6.73 ± 0.20*
Strength component of special endurance					
6	Kicks with both feet delivered to a bag for 60 s, times	43.4 ± 3.2	55.6 ± 4.6*	42.5 ± 3.3	58.2 ± 5.7*
Strength component of endurance					
7	pull-ups from a high bar hang, number of times	12.7 ± 1.39	16.5 ± 1.5*	12.1 ± 1.25	17.6 ± 2.4*
8	Arm flexion and extension in a prone position, number of times	45.1±1.3	51.4±1.6*	46.4±1.1	53.4±2.1*
Integral test of special endurance					
9	Maximum work of legs and arms using a bag, number of times	32.5 ± 2.3 / 72.0 ± 4.5	40.4 ± 3.1* / 78.3 ± 4.8	31.3 ± 2.2 / 70.0 ± 4.0	43.5 ± 3.7* / 86.5 ± 5.3*

Note *. Statistical differences in motor test indicator values after the experiment, $p < 0.05$

The results showed that athletes in the EG had significantly higher values in general performance indicators, measured by the Harvard Step Test Index, as well as in all tests of general and special endurance compared to the CG, with $p < 0.05$. In the CG, a significant improvement was observed in 5 out of 9 tests by the end of the study ($p < 0.05$). The increases in physical performance and fitness indicators for the participants are shown in Figure 1.

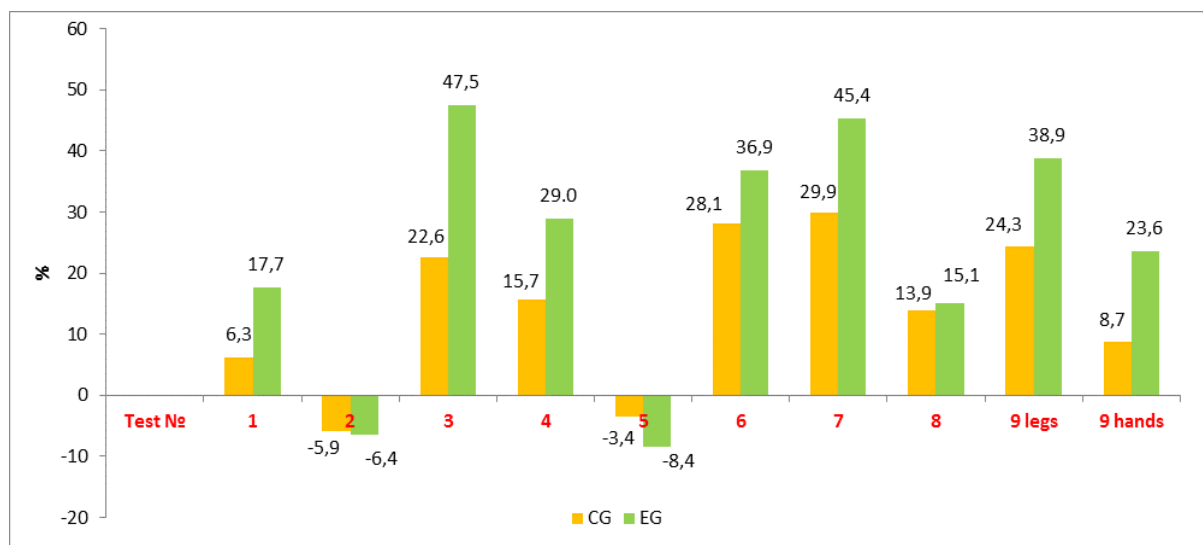


Fig. 1. Increase in physical performance indicators, general and special training in athletes from both groups

It was determined that the marginal improvement in the measured indicators was significantly greater in athletes from the EG compared to those in the CG. The largest increases—exceeding 40%—were observed in the EG for test No. 3 ("3000 m run") and test No. 7 ("Pull-ups from a high bar hang"). Additionally, improvements of over 30% were recorded in test No. 6 ("Kicks with both legs delivered to a bag for 60 s") and test No. 9 ("Maximum work with legs and arms using a bag").

Physical work in martial artists is known to place high demands on the cardiorespiratory system owing to significant loads in both aerobic and anaerobic modes. Therefore, assessing the body's immediate recovery through heart rate monitoring during rest is essential for coaches when designing training programs and planning competitions. It was determined that the use of the proposed exercise sets positively influenced the rapid heart rate recovery in athletes from the EG compared to those in the CG, as shown in Table 3.

Table 3. Rapid heart rate recovery at the end of the first minute of rest in athletes from both groups, %

No.	Components of special physical fitness	Restoration of heart rate during rest after test, %	
		CG (n=14)	EG (n=14)
1.	Speed component	13.5	25.3
2.	Strength component	14.2	23.7
3.	Complex test of strength endurance assessment	12.7	21.5

The process of rapid heart rate recovery was significantly better in athletes who followed the proposed set of special preparatory physical exercises compared to those in the CG. Heart rate recovery in the EG was 1.8 times greater for the speed component, 1.6 times greater for the strength component, and 1.7 times greater for the complex test than in the CG. These results indicate that athletes in the EG have higher reserve capacities of the cardiorespiratory system to physical exertion compared to those in the CG.

One of the criteria that characterizes the effectiveness of the proposed set of special preparatory physical exercises is the performance of athletes in amateur sports fights for four months after the completion of the pedagogical experiment. Athletes from each experimental group competed in 16 sports fights of various levels. It was noted that the combatants from the control group won 9 out of 16 fights (56.2%), while the athletes of the experimental group emerged victorious in 14 out of 16 fights (87.5%), which is 1.6 times more effective than the control group. Analysis of the competition results showed that in the control group, due to an obvious advantage, athletes emerged victorious in three out of 9 victories (33.3%). At the same time, in the experimental group, due to an obvious advantage, 7 victories out of 14 (50.0%) were won, which indicates a higher effectiveness of the proposed set of physical exercises for hand-to-hand combat athletes at the stage of their athletic improvement.

Discussion

It is known that the key factor in achieving high sports results among martial artists is a sufficiently high level of development and perfection of special physical fitness (Koshcheyev & Dolbysheva, 2021; Davidenko et al., 2021; Stergiou et al., 2023; Vorozheikin, et al., 2020). In this regard, the search for effective means and methods for developing special motor qualities is an urgent task for martial arts specialists (Guillermo et al., 2020; Fathir et al., 2021; Davidenko et al., 2024).

Scientists' studies show that the ratio of aerobic and anaerobic energy supply processes to the body's muscles has a significant impact on the development of special and general physical fitness in athletes (Andreato et al., 2016; Tota & Wiecha, 2022). At the same time, the main role in the special endurance of martial artists is given to the development of aerobic processes in the body (Kirk et al., 2024). To achieve a high level of oxygen capacity of the athlete's body, good performance of the cardiovascular and respiratory systems is required (Chernozub et al., 2022; Stergiou et al., 2023). This allows, first of all, to develop special endurance not only for the athlete's competitive activity (Podrigalo et al., 2016), but also for performing a large volume of daily training work.

In our research project, the use of the proposed sets of special preparatory physical exercises in the training process, which in terms of intensity of performance during training were close to competitive loads, made it possible to improve the indicators of physical performance, special and general endurance of hand-to-hand combat athletes. This is indicated by the significantly higher values of the Harvard Step Test index, general and special endurance obtained in the experimental group of athletes compared to the control group, which trained according to the standard program. Our data are consistent with the results of the study obtained by other authors using high-intensity loads in the training process (Mischenko et al., 2021; Kudryavtsev et al., 2023). At the same time, we were of the opinion that the inclusion of high-intensity interval training in the training of athletes can lead to a significant increase in the content of lactic acid in the muscles. It is known that it reduces performance, impairs the athlete's attention and can increase the recovery period after exercise (Coco et al., 2022). To prevent the occurrence of such negative consequences, we used the proposed set of specially preparatory physical exercises in the training process of athletes in the experimental group no more than 4 times (8 hours) per week.

In the educational and training process and competitive activities, control over the state of special physical fitness plays a major role. We used tests and scales for assessing special physical endurance, which were developed and tested for martial artists by V.A. Bobrovsky et al. (2017). The use of control tests in the

activities of a trainer allows solving the problems of selecting athletes for competitions, objectively assessing the condition and fitness of athletes, and making timely adjustments to the training process.

The data we obtained from testing special physical endurance in hand-to-hand combat athletes confirmed the high level of reliability of the data obtained in the control tests. These data do not contradict the results obtained by the developers of the above tests and scales for differentiated assessment of quantitative indicators of special endurance of martial artists.

Effective development of an athlete's special endurance is also a necessary factor for faster recovery of the body's functional systems after physical exertion. In order to assess short-term recovery after training loads of athletes of both experimental groups after performing test tests of special training, we studied the heart rate at the beginning and end of the first minute of recovery during rest. The results of our study showed that the rate of recovery of the heart rate was significantly higher in athletes of the experimental group, which confirms the effectiveness of the proposed special preparatory physical exercises and does not contradict the conclusions of the authors (Bobrovsky et al., 2017; Gryaznykh, et al., 2021). The effectiveness of the proposed set of physical exercises for improving the special physical endurance of hand-to-hand combat athletes is confirmed by a significant increase in the effectiveness of the competitive activity of athletes compared to the achievements of athletes from the control group. Similar high performance of athletes in the experimental group was noted by other researchers in mixed martial arts (Davidenko et al., 2024), who used an improved training program for mixed martial arts athletes.

The high performance of athletes in the experimental group that we obtained at competitions allows us to recommend the developed set of specially preparatory physical exercises in the training process of hand-to-hand combat athletes aged 17-18 years at the stage of their athletic improvement.

Conclusion

A set of specially designed preparatory physical exercises was developed and tested in a pedagogical experiment to improve special endurance in 17–18-year-old hand-to-hand combat athletes at the stage of athletic improvement. These exercise complexes closely mimic competition loads in terms of intensity and execution frequency and were implemented in four training sessions per week over five months.

Upon completion of the research project, athletes in the EG demonstrated a significantly greater improvement in the Harvard Step Test and special endurance index compared to those in the CG.

Athletes in the EG demonstrated more effective cardiorespiratory adaptation to physical activity than those in the CG. Specifically, after testing, their heart rate recovery during rest was 1.8 times greater in speed endurance, 1.6 times greater in strength endurance, and 1.7 times greater in the complex test compared to the CG. The high effectiveness of the proposed set of physical exercises for hand-to-hand combat athletes is demonstrated by the significantly better performance of the EG athletes in amateur fights. This supports recommending the use of these specially designed preparatory exercises in the training programs of hand-to-hand combat athletes aged 17–18.

Conflicts of interest. The authors declare no conflict of interest.

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References:

- Andreato, L. V., Santos, J. F., Esteves, J. V., Panissa, V. L., Julio, U. F., & Franchini, E. (2016). Physiological, nutritional and performance profiles of brazilian jiu-jitsu athletes. *Journal of human kinetics*, 53, 261–271. <https://doi.org/10.1515/hukin-2016-0029>
- Beckner, M. E., Stein, J. A., Lee, M. R., Knapik, J. J., Farina, E. K., Smith, T. J., Van Dam, D., Barringer, N. D., Larsen, M., & Lieberman, H. R. (2024). Sex differences in mood, hormone and immune response to combatives training in West Point Cadets. *Psychoneuroendocrinology*, 159, 106656. <https://doi.org/10.1016/j.psyneuen.2023.106656>
- Bobrovsky V.A., Kladov E.V., Martynenko A.N., & Bobrovsky A.V. (2017). Methods employed to estimate the level of martial art fighters' special endurance. *Psychopedagogy in law enforcement*, 2(69), 64–68. <https://cyberleninka.ru/article/n/metodika-otsenki-urovnnya-razvitiya-spetsialnoy-vynoslivosti-edinobortsev>
- Chernozub, A., Manolachi, V., Korobeynikov, G., Potop, V., Sherstiuk, L., Manolachi, V., & Mihaila, I. (2022). Criteria for assessing the adaptive changes in mixed martial arts (MMA) athletes of strike fighting style in different training load regimes. *Peer J*, 10, e13827. <https://doi.org/10.7717/peerj.13827>
- Coco, M., Buscemi A., Tušák, M., Perciavalle, V., Nifosi A., Cavallari, P., & Perciavalle, V. (2022) Attentive Processes and Blood Lactate in the Sambo. *Internatoinal Journal of Environmental Research and Public Health* 19, 1113, doi.org/10.3390/ijerph19031113

- Corcoran, D., Climstein, M., Whitting, J., & Del Vecchio, L. (2024). Impact Force and Velocities for Kicking Strikes in Combat Sports: A Literature Review. *Sports (Basel, Switzerland)*, 12(3), 74. <https://doi.org/10.3390/sports12030074>
- Davidenko, I. A., Bolotin, A.E., & Sergeev, A. N. (2021) Factors determining the high efficiency of training using combinations of impact and wrestling equipment in combat sambo. *Pedagogical-psychological and medical-biological problems of physical culture and sport*, 1, 12-18. <https://doi.org/10.14526/2070-4798-2021-16-1-12-18>
- Davidenko, I., Bolotin, A., Pronin, E., Anisimov, M., Petrov, V., Vorozheikin, A., Tyupa, P., Melnichuk, A., Kovalchuk, A., & Tyrina, M. (2024). Assessing the efficacy of an experimental strength and conditioning program for professional mixed martial arts athletes. *Journal of Physical Education and Sport*, 24 (1), Art 5, 36 – 43. <https://doi.org/10.7752/jpes.2024.01005>
- Doherty, C. S., Barley, O. R., & Fortington, L. V. (2025). Incidence of Health Problems in Australian Mixed Martial Arts and Muay Thai Competitors: A 14-Month Study of 26 Combat Sports Events. *Sports medicine - open*, 11(1), 60. <https://doi.org/10.1186/s40798-025-00880-3>
- Efremenko, M. A. (2022). Development of special endurance in athletes in hand-to-hand combat. *Psychology and pedagogy of service activity*, 4, 143-146. <https://doi.org/10.24412/2658-638X-2022-4-143-146>
- Fathir, L. W., Hartanto, S., & Kusnanik, N., W. (2021). Strength, endurance and speed development using functional strength training (FST) program for recreational runners performance. *Journal of Physical Education and Sport*, 21 (4), Art 330 pp 2453 – 2457. DOI:10.7752/jpes.2021.s4330
- Federal standard of sports training in the sport of hand-to-hand combat, approved by order of the Ministry of Sports of Russia. Dated 11/15/2022. No. 985. <http://publication.pravo.gov.ru/Document/View/0001202212130043?ysclid=mck1kzjb7h768894552>
- Francioni, F. M., Figueiredo, A. J., Terribili, M., & Tessitore, A. (2016). Analysis of the intraseasonal stability of field test performances in young academy soccer players. *Journal of sports sciences*, 34(10), 966–972. <https://doi.org/10.1080/02640414.2015.1082612>
- Gryaznykh, A., Butakova, M., Grebenyuk, L., Kiseleva, M., Nasyrov T., Kolokoltsev, M., Anton Vorozheikin, A., Romanova, E., Bayankin, O., Kowalski, W., Tyupa, P. (2021). Effect of carbohydrate intake on endogenous hormones: Anabolic and catabolic orientation content of highly qualified sportsmen-combat athletes. *Journal of Physical Education and Sport*, 21(3), 1421–1428. <https://doi.org/10.7752/jpes.2021>
- Guillermo, A. S. A., Pedro, B. C. C., Manuel, A. G. A., & Koscheev, A. (2020). Some features of increasing special flexibility in taekwondo. *Sports visnik of Pridniprov'ya*, 19, 1-196. <https://doi.org/10.32540/2071-1476-2019-1-191>
- Ioannides, C., Apostolidis, A., Hadjicharalambous, M., & Zaras, N. (2020). Effect of a 6-week plyometric training on power, muscle strength, and rate of force development in young competitive karate athletes. *Journal of Physical Education and Sport*, 20 (4), Art 236, 1740–1746, <https://doi.org/10.7752/jpes.2020.04236>
- Kiehl, D., Purcell, J., Pezzullo, L., Nixon, R. M., Martenson, M., Vincent, K. R., & Vincent, H. K. (2025). Ten-year patterns of emergent concussion injuries among various martial arts disciplines. *Injury*, 56(6), 112289. <https://doi.org/10.1016/j.injury.2025.112289>
- Kirk, C., Clark, D., & Langan-Evans, C. (2024). The influence of aerobic capacity on the loads and intensities of mixed martial arts sparring bouts. *Journal of sports sciences*, 42(22), 2093–2102. <https://doi.org/10.1080/02640414.2024.2419239>
- Koshcheyev, A., & Dolbysheva, N. (2021). Basics of planning a pre-competitive mesocycle during taekwondo training. *Journal of Physical Education and Sport*, 21 (4), Art 204, 1613-1621. <https://doi.org/10.7752/jpes.2021.04204>
- Kudryavtsev, M., Osipov, A., Guralev, V., Ratmanskaya, T., Aldiabat, H., Aldiabat, I., Kolokoltsev, M., Davidenko, I., Glukhov, A., & Karpenko, E. (2023). Effect of short-term functional training intervention on athletic performance in elite male combat sambo athletes. *Journal of Physical Education and Sport*, 23 (2), Art 39, 328 – 334. <https://doi.org/10.7752/jpes.2023.02039>
- Mischenko, N., Kolokoltsev, M., Gryaznykh, A., Vorozheikin, A., Romanova, E., & Suslina, I. (2021). Endurance development in Taekwondo according to the Tabata protocol. *Journal of Physical Education and Sport*, Vol 21 (Suppl. issue 6), Art 421, 3162 – 3167, <https://doi.org/10.7752/jpes.2021.s6421>
- Podrigalo, L.V., Ermakov, S.S., Alekseev, A.F., & Rovnaya, O.A. (2016). Studying the interrelationships of morphofunctional indicators of students engaged in martial arts. *Physical education of students*, 20(1), 64–70. <https://doi.org/10.15561/20755279.2016.0109>
- Reale, R., Wang, J., Hu Stull, C., French, D., Amasinger, D., & Wang, R. (2024). Acute and chronic weight-making practice in professional mixed martial arts athletes: An analysis of 33 athletes across 80 fights. *International journal of sport nutrition and exercise metabolism*, 34(5), 275–285. <https://doi.org/10.1123/ijsnem.2023-0229>
- Stergiou, M., Robles-Pérez, J. J., Rey-Mota, J., Tornero-Aguilera, J. F., & Clemente-Suárez, V. J. (2023). Psychophysiological responses in soldiers during close combat: implications for occupational health and

- fitness in tactical populations. *Healthcare (Basel, Switzerland)*, 12(1), 82.
<https://doi.org/10.3390/healthcare12010082>
- Sushchenko, V., & Vorozheikin V. (2016) Indicators determining the readiness of instructors in hand-to-hand combat of law enforcement agencies for pedagogical activity. *Scientific notes of the P.F. Lesgaft University*, 142(12), 127–130. <http://lesgaft-notes.spb.ru/node/9987>
- Tota, L. M., & Wiecha, S. S. (2022) Biochemical profile in mixed martial arts athletes. *Peer J*, 10:e12708. <https://doi.org/10.7717/peerj.12708>
- Vako, I., Kashuba, V., Khmel'nitska, I., Radchenko, Y., Radchenko, A., Carp, I., & Krupenya, S. (2024). Utilizing technology to develop fundamental motor skills in young athletes specializing in hand-to-hand combat. *Journal of Physical Education and Sport*, Vol. 24 (issue 2), Art 36, 303 - 312. <https://doi.org/10.7752/jpes.2024.02036>
- Vorozheikin, A., Tyupa, P., & Volkov, A. (2020) The state and promising directions of scientific research on the sport "Hand-to-hand combat" based on the analysis of scientific and methodological literature. *Health, physical culture and sports*, 1(17), 133–146. Available from <http://hpcas.ru/article/view/7478>.
- Vorozheikin, A., Tyupa, P., Volkov, A. (2020). The stage of initial sports training for girls specializing in the sport of hand-to-hand combat, in the context of the requirements of the federal standard. *Health, Physical Culture and Sports*, 2(18), 99–114. [https://doi.org/10.14258/zosh\(2020\)2.13](https://doi.org/10.14258/zosh(2020)2.13)
- Yue, F., Wang, Y., Yang, H., & Zhang, X. (2025). Effects of high-intensity interval training on aerobic and anaerobic capacity in olympic combat sports: a systematic review and meta-analysis. *Frontiers in physiology*, 16, 1576676. <https://doi.org/10.3389/fphys.2025.1576676>