

Effects of combined attacks on the technical–tactical and psychophysiological performance of mixed martial arts fighters

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Abstract:

Different types of martial arts (hand-to-hand combat, combat sambo, mixed martial arts (MMA), and pankration) require athletes to undergo versatile training that combines striking and wrestling techniques with sequential transitions between the combat phases: stance, grip, and ground. The key strategy in these disciplines is to use combination attacks, which allow a fighter to maintain dominance during the fight. However, the influence of combination attacks on fighters' overall effectiveness, as well as their connection to psychophysiological factors such as simple and complex visual–motor reactions (CVMRs), remains inadequately studied. **Purpose.** To determine the effectiveness of combination attacks in MMA and their association with fighters' psychophysiological parameters. **Materials and methods.** As part of this study, a 12-week training program was developed specifically to improve combination attacks. The program included practicing combination attacks, simulating combat situations, and improving cognitive abilities. The study involved 80 fighters aged 18–30 from four MMA disciplines: hand-to-hand combat, combat sambo, MMA, and pankration. Participants were divided into two groups. Group 1 followed their discipline's standard training methods, while Group 2 trained using the newly developed experimental program. The program's effectiveness was evaluated by tracking changes in key indicators such as the frequency and effectiveness of attacks, transition times between combat phases, and both simple and CVMRs measured at rest and under physical load. **Results.** The experimental group demonstrated significant improvements: attack frequency increased by 18.1%, attack effectiveness by 15.8%, competition results by 38%, and phase transition time decreased by 25%. Combined attacks were 11.1% more effective than single attacks. Psychophysiological parameters also improved significantly, with simple visual–motor reaction at rest increasing by 12.1%, under load by 14.2%, and CVMR at rest by 10.1%, under load by 13.2%. The highest efficiency gains were observed in performing mixed and ground combinations in MMA and pankration. **Conclusions.** The developed training program has demonstrated its effectiveness in improving fighters' technical and tactical versatility as well as their psychophysiological readiness. The results highlight the importance of combined attacks in achieving outstanding competitive performance.

Key Words: martial arts, technical training, tactical training, training program, multiphase attacks.

Introduction

Different martial arts (such as hand-to-hand combat, combat sambo, mixed martial arts (MMA), and pankration) require a universal training approach. This training is structured around a sequence of attacking actions that combine striking, throwing, and ground techniques, along with smooth phase transitions between stance, grip (throw), and ground fighting (Alzhanov et al., 2021). Modern research underscores the importance of combining various fighting styles to prepare versatile fighters who can adapt effectively to the dynamic nature of combat (Korotkikh, 2015; Sorokanyuk, 2018). However, a systematic study of combined attacks that integrate striking and wrestling techniques remains insufficiently developed. This hinders the development of optimal training programs that incorporate scientific research into fighter training practices.

Psychophysiological parameters such as complex visual–motor reaction (CVMR) and simple visual–motor reaction (SVMR) are crucial for rapid decision-making and the execution of complex attack combinations under high-intensity combat conditions. I. Y. Gorskaya & A. M. Kondakov (2012) demonstrated that fighters with faster reaction rates achieved better performance in complex attacking combinations. Modern training approaches for different martial arts incorporate both traditional techniques aimed at improving technical and tactical skills, as well as innovative programs. For example, functional training improves special endurance, while exercises targeting psychomotor development improve fighters' cognitive abilities (Davidenko et al., 2024). Training these indicators can considerably improve the effectiveness of competitive performance. However, the integration of psychophysiological improvements into athletes' overall training systems remains unresolved. This highlights the need for a comprehensive approach that develops all aspects of competitive preparation, including physical, technical, tactical, and cognitive skills.

The relevance of this study stems from the increasing popularity of various martial arts and the need to improve training methods to prepare versatile fighters capable of adapting to the constantly changing conditions of competitive activity.

Research aim. To determine the effectiveness of combined attacks across different martial arts styles and their relationship with fighters' psychophysiological parameters.

Materials and methods

This study, performed from January to March 2024, included 80 athletes aged 18–30, each with a minimum of 5 years of experience in various martial arts. Participants were members of the St. Petersburg (Russia) national teams in hand-to-hand combat, combat sambo, MMA, and pankration, competing at regional, national, and international levels. Researchers and specialists from multiple universities in Russia, Kyrgyzstan, and Kazakhstan collaborated on this project. The participants were randomly divided into two groups of 40 each, with 10 individuals representing each martial arts discipline. Group 1 (control, CG; age 25.9 ± 3.2 years, height 176.2 ± 6.6 cm, body weight 79.1 ± 5.1 kg) followed the standard training program based on federal standards specific to their martial arts discipline, focusing mainly on isolated technical and tactical actions such as striking or wrestling. Group 2 (experimental, EG; age 26.2 ± 2.9 years, height 175.1 ± 6.2 cm, body weight 78.5 ± 4.7 kg) trained under a specially designed program aimed at developing combined attacks (Table 1).

Table 1. Program for developing combined attacks in athletes across different martial arts styles

No	Exercises	Training tools and methods	Volume (sets $\times$ $t_{\text{work}} \times t_{\text{rest}}$)	Heart rate, bpm
Basic stage (1–4 weeks)				
1.	Shadow boxing with an emphasis on combinations	Special preparatory exercises	$3 \times 3 \text{ min} \times 1 \text{ min}$	120–140
2.	Defensive actions (dodges, blocks, grips)	Educational and training task without counteraction	$3 \times 3 \text{ min} \times 1 \text{ min}$	120–140
3.	Strikes on a static target for accuracy	Exercises on equipment (bags, mitts, and pads)	$6 \times 1 \text{ min} \times 1 \text{ min}$	130–150
4.	Practicing combinations: "strike–strike", "throw–throw"	Educational and training tasks without counteraction	$3 \times 3 \text{ min} \times 1 \text{ min}$	140–160
5.	Practicing combinations: "strike–catch", "catch–throw", "throw–ground"	Educational and training tasks without counteraction	$3 \times 3 \text{ min} \times 1 \text{ min}$	140–160
6.	Practicing strikes and throws on signal	Educational and training tasks with a partner; exercises on the apparatus	$5 \times 10 \text{ sec} \times 30 \text{ sec}$	150–170
7.	Reaction training	Tasks using light panels and reaction sensors	$6 \times 30 \text{ sec} \times 30 \text{ sec}$	110–130
Integrative stage (weeks 5–8)				
1.	Practicing combinations: "strike–strike", "strike–throw"	Exercises with resistance bands	$3 \times 3 \text{ min} \times 1 \text{ min}$	140–160
2.	Practicing phase transitions: "stance–grip–ground"	Educational and training tasks with conditional counteraction, emphasizing phase transitions	$4 \times 4 \text{ min} \times 1 \text{ min}$	160–180
3.	Sparring with emphasis on "strike–throw" combinations	Educational and training tasks with full counteraction	$5 \times 3 \text{ min} \times 1 \text{ min}$	160–180
4.	Simulating combat situations	Educational and training tasks with full counteraction under time constraints	$10 \times 15 \text{ sec} \times 45 \text{ sec}$	150–170
5.	Training reaction speed	Actions based on visual or auditory signals	$8 \times 30 \text{ sec} \times 30 \text{ sec}$	120–140
6.	Error and tactics analysis	Video analysis of sparring	$1 \times 10 \text{ min}$	
Competitive stage (weeks 9–12)				
1.	Practicing combinations: "punch–throw–ground game"	Educational and training tasks with conditional counteraction	$4 \times 2 \text{ min} \times 1 \text{ min}$	140–160

2.	Sparring with emphasis on "punch–throw–ground game"	Educational and training tasks with full counteraction	3 × 5 min × 1 min	160–180
3.	Modeling combat situations	Educational and training tasks with full counteraction under time constraints	8 × 10 sec × 50 sec	160–180
4.	General sparring	Educational and training tasks with full counteraction and specific tactical objectives	4 × 5 min × 1 min	170–190
5.	Practicing combinations with memorized numbers or colors	Game-based tasks with cognitive load	3 × 2 min × 1 min	150–170
6.	Error and tactics analysis	Video analysis of sparring	1 × 10 min	

All participants trained 16–20 hours per week, with the pedagogical experiment focusing only on technical and tactical training sessions held for 2 h, three times a week. The experimental program aimed to develop fighters' skills progressively through three stages. During the basic stage (weeks 1–4), the focus was on mastering basic combinations such as "punch–grip," "grip–throw," and "throw–ground." Additionally, emphasis was placed on improving accuracy, movement speed, basic defensive techniques, and psychophysiological indicators. The integrated stage (weeks 5–8) focused on combining striking and wrestling techniques, developing the ability to transition smoothly between combat phases, improving tactical thinking, increasing attack variability, and advancing psychophysiological training. During the competitive stage (weeks 9–12), fighters mastered the use of combined attacks under conditions simulating actual competitions, while further developing tactical variability, stress resistance, and adaptability to different combat situations.

The effectiveness of the experimental program was evaluated using the following methods. Psychophysiological parameters (CVMR and SVMR) were analyzed using the NS-Psychotest computer complex (Neurosoft "Psychotest", Neurosoft LLC, Ivanovo, Russia). Video recordings of sparring and competitions were reviewed, analyzing three fights per fighter before and after the experiment to assess technical and tactical indicators such as combined attack execution, speed of phase transitions, and tactical variability. Statistical analysis was performed with IBM SPSS Statistics 26, using Student's t-test to determine the significance of differences between groups.

The frequency of attacks was determined as the ratio of the number of attack attempts to the total number of technical actions performed. Attack effectiveness was calculated as the percentage of successful attacks executed with decisive strikes or evaluated wrestling techniques. The average combination length was measured by counting the number of actions in a single sequence of technical actions. The competition results of athletes from the CG and EG were compared based on their performance at the 2023 and 2024 St. Petersburg City Championships in various martial arts disciplines. The comparison was performed after the athletes had completed the experimental program for developing combined attacks.

Results

One of the main goals of the study was to identify changes in the psychophysiological characteristics of fighters. The CVMR indicates athletes' ability to quickly transition between the "stance–grip–ground" phases and choose the most suitable attack option under time constraints. Meanwhile, the SVMR measures reaction speed during technical actions. To evaluate the program's impact, these parameters were assessed under two conditions: at rest and under load, the latter following intense exercise simulating competitive stress (3 min of equipment work at a rhythm of 160–180 bpm). Data analysis revealed significant improvements in the EG compared to the CG, as shown in Table 2.

Table 2. Changes in psychophysiological parameters of SVE athletes at rest and under load

Parameter	Group	Rest (before), ms	Rest (after), ms	Load (before), ms	Load (after), ms
CVMR	375.0 ± 15.2	337.1 ± 12.5	400.0 ± 18.3	347.2 ± 14.1	375.0 ± 15.2
	370.6 ± 14.3	363.4 ± 12.4	395.5 ± 16.2	389.7 ± 15.3	370.6 ± 14.3
SVMR	210.0 ± 18.4	184.7 ± 14.2	275.7 ± 20.1	236.4 ± 16.3	210.0 ± 18.4
	205.4 ± 17.2	201.0 ± 16.1	270.6 ± 19.5	265.6 ± 17.0	205.4 ± 17.2

The 12.1% increase in SVMR at rest in the EG indicates improved accuracy and speed in executing technical and tactical actions. A 10.1% improvement in CVMR at rest allowed EG athletes to respond faster to opponents' moves, particularly during changes in distance and phase transitions. Under load, EG fighters showed a 14.2% increase in SVMR and a 13.2% increase in CVMR, demonstrating their improved ability to react quickly in hypoxic conditions and perform attacking actions more rapidly during intense physical exertion. In the control group, changes were minimal, especially under load (1.5%–2.0%), highlighting the limitations of standard training methods. The experiment's results demonstrated a significant improvement in technical and tactical indicators as well as competition results in the experimental group, as shown in Table 3.

Table 3. Changes in technical and tactical indicators and competition results of athletes across different martial arts disciplines

Indicator	CG		EG	
	Before	After	Before	After
Frequency of attacks, %	43.3 ± 5.0	43.2 ± 4.5	44.0 ± 5.1	62.1 ± 4.6
Efficiency of attacks, %	31.7 ± 3.1	32.5 ± 3.2	30.9 ± 3.0	46.7 ± 3.3
Average combination length	2.8 ± 0.3	2.9 ± 0.3	2.8 ± 0.3	3.4 ± 0.2
Phase transition time, s	2.8 ± 0.2	2.7 ± 0.2	2.8 ± 0.2	2.1 ± 0.1
Competition placement	43.3 ± 5.0	43.2 ± 4.5	44.0 ± 5.1	62.1 ± 4.6

Source: compiled by the authors

The 18.1% increase in attack frequency in the EG indicates a more active use of multi-phase combinations. A 15.8% increase in effectiveness confirms improved attack quality related to better coordination and faster execution. Additionally, a 25.0% reduction in phase transition time highlights the fighters' improved ability to quickly adapt to changing combat conditions, thereby minimizing the opponent's chances for counterattack. In disciplines focused on work in a stance (hand-to-hand combat, MMA), the average combination length in the EG increased from 2.8 to 3.4 actions. Additionally, efforts to develop combined attacks contributed to a consistent improvement in competition results for the EG, with an average advancement of 1.9 places.

Analysis of video recordings revealed that the most effective combinations were those that paired distracting strikes with quick throws. For instance, the combination "side strike–one-leg pass–side position" in pankration and "strike–two-leg pass–finishing move" in MMA gave fighters a tactical advantage in 60.4% of cases. Further data analysis indicated that the frequency and effectiveness of attacks increased differently across various martial arts disciplines (Table 4).

Table 4. Frequency and effectiveness of attacks in different martial arts disciplines before and after the experiment

Discipline	Attack frequency, %		Effectiveness of attacks, %		Increase, %	
	before	after	before	after	frequency	effectiveness
Hand-to-hand combat	45.5 ± 3.1	53.8 ± 4.2	30.6 ± 2.8	39.0 ± 3.2	8.3	8.4
MMA	57.2 ± 4.1	69.6 ± 5.2	33.9 ± 3.1	44.5 ± 3.1	12.4	10.6
Combat sambo	51.8 ± 3.2	62.7 ± 4.3	39.6 ± 3.2	50.9 ± 3.5	10.9	11.3
Pankration	49.0 ± 3.3	62.3 ± 4.4	36.8 ± 3.3	48.6 ± 3.4	13.3	11.8

Source: compiled by the authors

The greatest increase in attack frequency was observed in MMA (12.4%) and pankration (13.3%), attributed to the universality of their rules. The greatest improvement in attack effectiveness occurred in pankration (11.8%) and combat sambo (11.3%), indicating the focus on finishing attacks on the ground. Hand-to-hand combat showed moderate increases in both frequency (8.3%) and effectiveness (8.4%) owing to a less prominent ground phase and limited variability in phase transitions. In combat sambo, a strong emphasis on throws and mixed combinations contributed to a significant increase in attack effectiveness.

As part of the experiment, a detailed analysis of combination attack types was performed, including striking, throwing, mixed (punch–throw, throw–ground), and ground combinations (punch–painful choke–change of position), as shown in Figure 1.

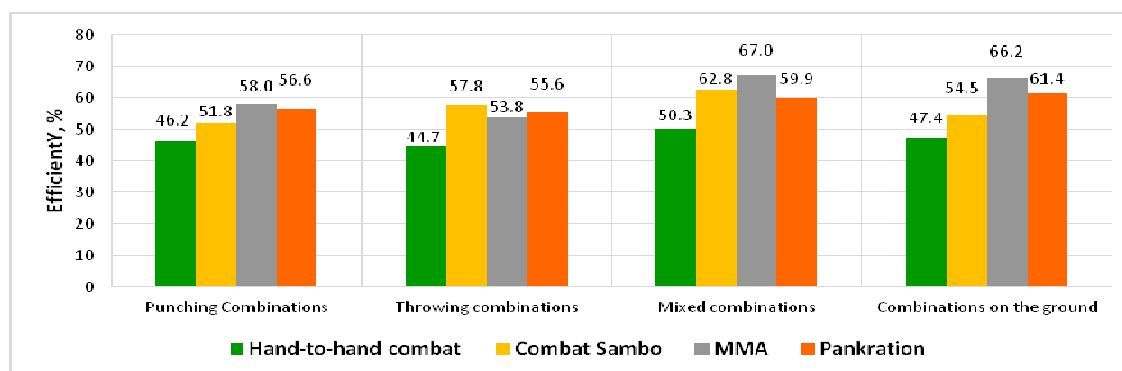


Fig. 1. Effectiveness of combined attacks across different martial arts disciplines after the experiment

The most effective combinations across all disciplines are mixed combinations (60%) and ground combinations (57%), while striking and throwing combinations are effective only in specific competitive scenarios in individual fight phases. The CVMR and SVMR indicators show strong significance in executing complex attacking combinations. Additionally, the analysis reveals a high correlation between psychophysiological parameters and various technical and tactical indicators, as presented in Table 5.

Table 5. Correlation between psychophysiological parameters and technical–tactical indicators of athletes across different martial arts disciplines

Parameter	Correlation coefficient (r)	Significance level (p)
CVMR and attack effectiveness	0.78	< 0.01
SVMR and attack effectiveness	0.82	< 0.01
CVMR and average combination length	0.75	< 0.01
SVMR and phase transition time	0.80	< 0.01

The most pronounced effect of the SVMR is observed in the effectiveness of attacks and the average duration of combinations. Athletes with higher SVMR values quickly chose the optimal attack when adjusting distance, smoothly transitioned between fight phases (from stance to hold or hold to ground), minimized transition time, and more effectively completed tactical attack objectives. SVMR is closely related to attack effectiveness and phase transition time, highlighting its importance in successfully executing offensive actions.

Dicussion

Intense physical activity in MMA causes muscle tissue damage and activates inflammatory processes that persist for at least 24 hours after training or competition (Tota & Wiecha, 2022). The ability of fighters to maintain a high level of reaction and endurance in hypoxic conditions is determined by adaptation to the dynamic conditions of the fight. This is especially important for disciplines with frequent phase transitions "stand-grip-ground", such as MMA and pankration, where alternating aerobic and anaerobic modes of work require high physical fitness (Kostikiadis et al., 2018).

For effective recovery and improving competitive performance, it is necessary to implement a structured training plan that provides for alternating loads of different intensities (Marques et al., 2017; Kirk et al., 2021). Data from A. Chernozub et al. (2019) indicate that adjusting strength training parameters in MMA plays a key role in developing the adaptive capabilities of fighters. High-intensity, short-duration loads improve strength endurance and muscle adaptation, which is important for fighters using the wrestling style of fighting.

The results of the studies by Çağrı et al. (2011) emphasize a close relationship between reaction speed and decision-making style in combat athletes, with fighters using an attacking strategy demonstrating better results. Athletes in the EG demonstrated the transfer of improvements in CVMR and SVMR to competitive activity. This indicates the practical effectiveness of the developed training program. Improvement in the speed of CVMR and SVMR in the experimental group was accompanied by a significant increase in the effectiveness of attacks, which confirms the findings of I. Bocharin et al. (2024) on the high importance of sensorimotor reactions for fighters. It was found that high speed of psychomotor processes allows minimizing the reaction time to the opponent's actions, especially in the final stages of attacks, such as transitions to the ground or performing painful holds. These changes also contribute to the increase in the accuracy and coordination of movements, which is most noticeable when performing complex attacking combinations. In combat sambo, combinations such as "catch - throw - hold" ensured a high level of effectiveness, which confirms the importance of the speed of throws for achieving a dominant position (Ushakov, 2006; Kondakov, 2010). The speed of reaction in the phase transitions "stand - catch", "catch - ground" is a key factor in the tactical advantage for disciplines with a multi-phase structure, such as combat sambo, pankration and MMA. The increase in the PZMR and its high correlation with the speed of phase transitions confirm the need to include exercises for the development of psychomotor and cognitive abilities in training programs. This is consistent with the approach to training fighters based on the development of their ability to adapt to dynamic changes in the situation in a fight (Taymazov et al., 2021).

Video analysis showed that the most effective were mixed and ground fighting combinations. In MMA, multi-phase combinations such as "punch - takedown - finishing move" were highly effective, which confirms the importance of long combinations for maintaining a tactical advantage (Davidenko & Bolotin, 2022). In combat sambo, mixed combinations were the most successful, which is associated with an emphasis on dominance on the ground through throws (Kondakov, 2010).

In pankration, combinations with a continuous attack were effective, for example, "side punch - throw with leg grab - hold" (Kudryavtsev et al., 2023). These results emphasize the importance of attack variability, which ensures the versatility of fighters.

In MMA, key attention is paid to completing attacks through finishing moves after taking the opponent to the ground. As noted by A.Vorozheikin et al. (2024), the effectiveness of such actions depends not only on

physical training, but also on the ability of fighters to analyze the opponent's behavior and adapt a tactical strategy. Regular use of video analysis in training plans helps to improve the understanding of phase transitions, as well as the development of tactical variability of attacks (Osipov et al., 2017). In hand-to-hand combat, moderate dynamics of technical and tactical indicators were observed. This is explained by a smaller number of phase transitions and the specificity of the discipline rules, which limits the variability of attacks.

Despite the significant results, some aspects require further study. For example, research by A.E. Bolotin et al. (2021) showed that complex combinations may be less effective in disciplines with limited fight time or narrow phase frames, such as kickboxing or hand-to-hand combat. At the same time, I. Gheorghiu (2023) emphasizes that the introduction of multiphase attacks combining the techniques of various fighting styles allows fighters to increase their reaction speed and has a positive effect on their speed-strength qualities. The inclusion of simulation of situations with limited combat time in the EG training process improved the tactical variability of fighters, which confirms the data of A. Osipov et al. (2017) on the importance of using situational exercises in training athletes.

Conclusion

An 18.1% increase in the frequency of attacking actions and a 15.8% improvement in their effectiveness confirmed the success of training focused on mastering multiphase combinations. The results demonstrated that combined attacks were 11.1% more effective than single attacks. This directly influenced competition outcomes, with the EG showing a 38% increase in average results, while the CG experienced a 10.2% decline.

The increase in both attack frequency and effectiveness highlights the importance of training psychomotor and cognitive abilities to increase decision-making speed. These skills are crucial for successfully performing complex attack combinations. The strong correlation ($r = 0.82$) between the effectiveness of attacks and psychomotor functions further supports the inclusion of such exercises in training programs.

A comparative analysis revealed that the increase in attack frequency was most significant in MMA and pankration, attributed to the flexibility of their rules that allow the use of multiphase combinations. In contrast, combat sambo focuses more on finishing attacks with holds, painful, and choking techniques, while hand-to-hand combat mainly involves short combinations with minimal phase transitions. The implementation of an experimental program combined with video analysis for error correction and tactical adjustments allowed the EG fighters to reduce phase transition time by 25% and improve the accuracy of their actions.

The results confirm that incorporating combined attacks into the training of martial arts athletes improves their competitive performance by increasing both the frequency and effectiveness of attacks, shortening phase transition times, and increasing tactical variability. The developed training program is highly adaptable, making it suitable for sports schools and clubs training fighters across various martial arts disciplines.

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

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