

The correlation between physical training and the acquisition of technical-tactical procedures in mixed martial arts (MMA)

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Abstract

Background and Study Aim. *Background and Study Aim.* This study examined the relationship between physical training and the development of technical-tactical skills in athletes specializing in advanced mixed martial arts (MMA) performance. Key performance elements (i.e., technique, tactics, striking power, sport-specific speed, endurance, and psychological factors) require holistic training to be effectively integrated and applied during competition. Understanding the interaction of these components is essential for optimizing performance and achieving the highest competitive outcomes in MMA. **Materials and Methods:** To achieve the research objectives, the following scientific methods were employed: theoretical analysis and generalization of specialized literature data; observation and control in sports training; pedagogical observation; tabular method; pedagogical experiment; and statistical-mathematical methods for processing and interpreting recorded data. **Results:** Based on the study of scientific literature, it was established that implementing technical actions in the training of performance athletes has a decisive influence. Ensuring the quality of the instructional-educational process at the advanced training stage and modernizing it is a major concern, influenced by the evaluation system during sports matches, which is refined throughout the instructional-educational process, as well as by the physical preparation of future high-performance athletes. To understand the interaction level of results obtained from final athlete testing, 1,056 correlation coefficients of motor, psychomotor, and technical-tactical parameters were analysed, aiding in the selection and determination of key values in motor capacity development. Following the application of technical-tactical actions based on techniques from boxing, sambo, judo, kickboxing, taekwondo, freestyle wrestling, Greco-Roman wrestling, grappling, and pankration during the experimental phase, the experimental group achieved significant improvements ($P < 0.01$ and $P < 0.05$) in technical-tactical performance during sports matches. **Conclusions.** The study demonstrated that motor skills specific to mixed martial arts, selected as indicators of technical-tactical capacity development, were relevant in competitive activities. This underscores the importance of integrating physical and technical-tactical training to enhance athletic performance in mixed martial arts.

Keywords: mixed martial arts, physical training, procedure, technical training, tactical training, competitive activity, skills, technical-tactical actions.

Introduction

Mixed martial arts is a combat sport and a form of martial arts, combining striking and fighting techniques. Due to the lack of any restrictions on the transition from striking to fighting, the sport requires multiple skill sets, usually derived from different branches of fighting and martial arts (Michalsen et al., 2024). MMA demands high physical capacities from the athlete, both in terms of endurance and strength in speed regime in combination with technical-tactical training, posing very high challenges in terms of optimal development of training programs so that MMA fighters can benefit the most from their use (Overton et al., 2017).

Physical training is an essential and complex component of sports training, which provides the methodological support for the mastering of technical-tactical techniques in a personal style, demonstrating high motor and tactical indexes. In order to emphasize the effectiveness of the introduction and application of elements from the branches of fighting and martial arts in the instructive-educational process, a correlative analysis of the indices investigated in the experimental group was carried out (Leonid et al., 2017; Sergii et al., 2016). In the article we aim to obtain a quantification of how the proposed program will determine the progress obtained by the subjects of the experimental group in the motor and technical-tactical tests (Gheorghiu, 2023).

It is worth mentioning that motor qualities contribute to effective multifunctional training in MMA, the data obtained from the interview analysis reveal that the vast majority of qualified martial arts coaches interviewed, fully agree that in order to develop technical-tactical skills, it is necessary, first of all, to develop endurance and strength: respectively, 88% responses in both cases. The questionnaire items target the speed of execution of motor actions - 76% responses, orientation in space-coordination - 70% and mobility - 40% of opinions. Actually, in the literature (Gheorghiu, 2023; Andriy et al., 2019; Chernozub et al., 2018) emphasizes that at the age of 18-20 years it is necessary to develop specific endurance, strength in the regime of physical qualities, which is also demonstrated by the opinions of specialists. At this age the process of development of the body organs and systems is completed: the body weight increases through muscle mass and the process of growth in height slows down, due to ossification of the skeleton, favoring the development of strength and endurance to maximum levels, through the practice of various sports disciplines (Ghoul et al., 2017). The development of simple endurance, as well as in combination with strength and speed, should be a priority task in training lessons, as it has a direct influence on the appropriation of technical-tactical procedures in mixed martial arts (James et al., 2016).

The aim of the work is to increase the efficiency of the instructional-educational process through the mastering of technical-tactical procedures of athletes at the stage of in-depth specialization and orientation towards high performance.

Research Methodology.

The pedagogical experiment was conducted in the framework of sports training lessons of MMA fighters of the "Stefan cel Mare" Police Academy. The experimental sample consisted of 14 MMA fighters at the stage of in-depth specialization and aiming for high performance. Several methodological principles and requirements were the basis for the elaboration of the methodology for the development of physical capacities and technical-tactical components. These have had a positive influence on the following aspects:

- a) *harmonious physical development* - addressed to the development of the general functional capacity of the organism, which leads the fighter to achieve maximum sports form;
- b) *morphological and functional development* of the body for competition - materializes in cardiovascular, metabolic and neuromuscular adaptation, which ensures an increased specific effort capacity, which leads to a higher level of execution of technical procedures and increased efficiency in MMA;
- c) *multilateral physical development through the development of basic and combined motor skills in mixed martial arts* (conditioning qualities - determined by the level of functioning of the body's systems as well as metabolic efficiency; this category includes strength, speed and endurance; coordinative qualities, conditioned by the individual's ability to organize and adjust the movements of the body and its segments, of special value in perfecting technique, developing the rhythm of execution of technical procedures and artistry, forming the ability to orient oneself in space and time, volitional qualities and developing moral qualities);
- d) *development of the capacity and power of the energy systems required in mixed martial arts* - the action on the development of the power capacity is justified by the acquisition of a superior ability to manifest physical qualities and to sustain competitive effort.
- e) *training of intuition - in learning techniques*, intuition must be represented in proportion to the process of abstraction and generalization, in order to achieve optimal learning results;
- f) *the development of perception, accumulation of experience* - a process of cognition that provides information about the objectives and phenomena that are encountered (directly or indirectly). Through this process one becomes aware of the characteristics of space, time, form, shape, size, weight, force, amplitude, trajectory of motor acts and actions in different styles of combat (James et al., 2017);
- g) *development of intuition and reason* - combined in the learning of techniques in MMA, and oral communication has the role of coordinating the process of perception and that of understanding and generalization of specific acts, the formation of a global model of execution, a general motor program, which can always be updated and adapted to tactical actions similar to those for which the technical action was learned;
- h) *development of the complex motor analyzer* - provides a solid foundation for further practice. These are "motor and topographical representations, technical and tactical perceptions and skills, knowledge, rules and schemes of specific development" (Korobeynikov et al., 2018).

The methodology for the development of motor skills and technical-tactical actions had well-defined objectives and proposed the experimentation of a coherent teaching strategy in which the methods and means taken from boxing, sambo, judo, kickboxing, taekwondo, wrestling, Greco-Roman wrestling, grappling and pankration techniques were judiciously selected and used.

Means used to develop motor and technical-tactical skills

In the selection of means, it was taken into account the use of exercises that demand the respective kinematic chains and their use in kinematic structures similar to competition fights.

It is recommended that these exercises, taken from combat and martial arts competitions, should be performed both for the training of motor skills and at the beginning of each psychomotor education activity, in order to prepare and mobilize the body to physical and mental effort.

Subsequently, there were analysed athletes at the stage of in-depth specialization and orientation towards high performance in the competitive process in order to highlight the most effective technical-tactical actions in MMA identified and applied in our research. In their turn, the technical procedures and terminology of the striking technique applied with different body parts of the standing wrestling in MMA were identified in the framework of the MMA National Championship (Table 1).

Table 1. Results of the evaluation of technical standing throwing actions at the MMA National Championship

No.	Evaluation indices (no./rep.)	$\bar{X} \pm m$	CV %
1	Taking down the opponent by controlling both of their legs.	80.643 ± 0.608	20.45
2	Sweeping techniques.	29.571 ± 0.532	7.50
3	An inverted wheel technique	33.500 ± 0.442	8.50
4	A major outer reap	33.429 ± 0.402	8.48
5	Sweeping both of the opponent's legs.	23.857 ± 0.404	6.05
6	Throws that involve securing the thighs and lifting the opponent.	17.571 ± 0.500	4.45
7	A major hip throw.	16.714 ± 0.339	4.24
8	A backward sacrifice throw.	16.214 ± 0.408	4.11
9	Counterattack against an outer reap.	14.357 ± 0.401	3.64
10	Throwing over the hip.	13.714 ± 0.462	3.48
11	Wheel over the hip.	13.000 ± 0.348	3.30
12	Body reversal (throw by barrier).	11.643 ± 0.341	2.95
13	Minor inner reap.	11.286 ± 0.370	2.86
14	Throwing over the shoulder.	10.429 ± 0.343	2.64
15	Minor outer reap.	9.714 ± 0.370	2.46
16	Minor outer hook.	8.929 ± 0.339	2.26
17	Throwing over the shoulder with one arm.	7.786 ± 0.261	1.97
18	Takedowns involving hooking techniques.	6.643 ± 0.357	1.68
19	Major outer reversal.	6.714 ± 0.339	1.70
20	Wheel over the shoulders.	5.714 ± 0.304	1.45
21	Major inner reap.	6.143 ± 0.329	1.56
22	Bringing the opponent to the ground by securing the arm and preventing escape.	4.143 ± 0.312	1.05
23	Bringing the opponent to the ground by securing both thighs.	4.071 ± 0.339	1.03
24	Diagonal reversal (angle).	3.643 ± 0.372	0.92
25	Circular side throw.	3.286 ± 0.266	0.83
26	Lower thighs reap by sacrifice.	1.714 ± 0.244	0.43

Note: $n=14$

In analysing the comparative results of MMA athletes participating in the proposed training program, it was observed that taking down the opponent by controlling both of their legs were among the most effective techniques, with a coefficient of variation (CV) of 20.45%. These techniques were frequently applied during competitive matches and were integral to the training process.

In competitive Mixed Martial Arts (MMA), athletes must not only assess their own capabilities but also anticipate their opponents' actions and decisions. External factors contribute to perceptual challenges, including rapid situational changes, spatial and temporal constraints, and unpredictable initiation of actions (Korobeynikov et al., 2017; Podrigalo et al., 2018). These elements complicate the evaluation of combat scenarios and the execution of specialized techniques during training, placing significant demands on the athletes' physical and cognitive functions, thereby increasing mental stress. Notably, even athletes with superior motor skills cannot be entirely certain of the unfolding dynamics within a fight. The orientation in space and time, perception and processing of information, decision making and realization of actions in training and competition processes are complicated, given the major emotional background, the rapid alternation (in some actions), contrasting emotions caused by stress, and sometimes by the influences of the conditions of competitive combat on the body (Podrigalo et al., 2018).

We mention here that, depending on the particularities of each athlete, in terms of the level of motor and technical training, the program was individualized in terms of the number of repetitions of the technical-tactical actions of standing throwing in the training process.

Results

In analyzing the influence of physical training on various technical-tactical indicators, a comprehensive correlation matrix was constructed from 1.056 coefficients. The results, presented in Table 2 and Figure 1, demonstrate a high correlation between physical training and technical-tactical preparation in exercises such as the 20-second trunk lift from a supine position, standing triple jump, and 50-meter sprint. Additionally, reasonable correlations were observed in other exercises, including pull-ups on a fixed bar, push-ups from a prone position, standing long jump, and 1,000-meter endurance run.

Table 2. Correlation between experimental variables of motor ability indices and the efficiency threshold of fighters' technical-tactical actions

No.	Physical training parameters	Correlation coefficient	No.	Technical and tactical training parameters
1	20-second trunk lift from a supine position	0.640	8	Generalized efficiency coefficient of technical-tactical actions
2	Pull-ups on a fixed bar	0.478	9	Total number of effective defensive actions
3	Push-ups from a prone position	0.507	10	Total number of effective technical defensive actions
4	Standing triple jump	0.671	11	Total number of technical attacking actions performed
5	Standing long jump	0.573	12	Circular punch strikes on the heavy bag for 8 seconds (number per repetition)
6	1,000-meter endurance run	0.522	13	Total number of technical attacking actions
7	Speed run 50 m	0.609	14	Takedown actions to the ground using various techniques for 30 seconds

In close positive direct correlation are the variables 50 m speed running and takedown actions to the ground using various techniques for 30 seconds ($r = 0.609$, $P < 0.05$). The statistical significant relationship between the calculated parameters expresses a high value with 95% significance, shown in Figure 1.

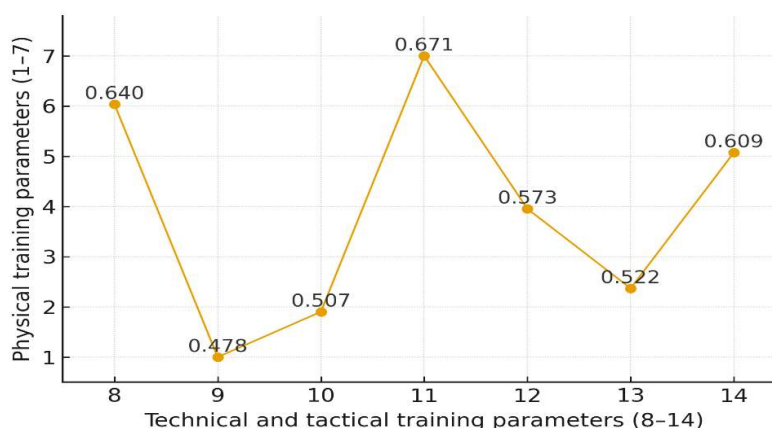


Figure 1. Correlation of the parameters of the experimental variables of physical training and technical-tactical actions at the completion stage of the competitive cycle

The high correlation observed can be attributed to the fact that execution speed plays a crucial role in developing specific combat reflexes during competitive situations. This development depends on movement direction and the execution of technical maneuvers, which in turn enhance aerobic endurance. Although the push-ups from a prone position test falls into the category of reasonable correlation ($r = 0.507$), it is positioned at the upper limit. This can be explained by the synchronized development of two major muscle groups: the extensors of the scapulohumeral belt and the back muscles. Performing technical-tactical maneuvers in mixed martial arts stimulates the development of the flexor muscles of the scapulohumeral belt, as evidenced by effective defensive actions during competitive matches ($P < 0.05$).

If the correlation is of the same direction, the values of the motor actions and those of the technical-tactical training influence each other. The same level of correlation is found in the test "Pull-ups on a fixed bar", "Standing long jump", "1000 -m endurance running", which can be explained by the fact that the speed of movement develops more slowly at older ages, the execution of technical procedures should only favour the achievement of maximum performance in competition, particularly taking advantage of the level of physical training of the athlete at the stage of in-depth specialization and orientation towards high performance. Correlation coefficients ranged from $r = 0.478$ to 0.573 , $P < 0.05$. In order to find the effectiveness of the program used, the total contribution of technical actions in the National MMA Championship was analyzed. In the given competition, MMA fighters occupying top places in world ratings participated. The volume of technical training of MMA fighters required in the training program was determined by analyzing the competitive matches, respectively, we found that during the sports event, out of the total number of technical actions, a total of 1181 effective technical actions were applied, including 739 actions from the kicking technique, 379 actions from the throwing technique and 63 actions from the ground fighting technique (Table 3).

Table 3. Application of technical actions at the National MMA Championship

No.	Technical actions	Effective technical actions		Total contribution
		Application direction	No. total	
1.	Standing combat striking techniques		739	62.57%
1.1.	Punches to the head	direct	157	36.26%
		lateral	240	55.42%
		from bottom to top	35	8.083%
Total			433	58.59%
1.2.	Punches to the body	direct	5	45.45%
		lateral	6	54.55%
Total			11	1.49%
1.3.	Kicks to the lower body	with the outer thigh	170	72.34%
		with the inner shin	65	27.66%
Total			235	31.80%
1.4.	Kicks to the body	with the knee	35	72.92%
		direct	7	14.80%
		low-kick	4	8.33%
		circular	2	4.170%
		Total	48	6.50%
1.5.	Kicks to the head	with the knee	1	8.42%
		circular	11	91.67%
Total			12	1.62 %
2.	Standing fight technique - throws		379	32.09%
2.1.	Techniques for bringing the opponent to the ground		250	65.96%
2.2.	Throwing techniques		123	32.45%
2.3.	High-amplitude throws		6	1.580%
3.	Ground technical actions		63	5.34%
3.1.	Finishing technical actions with punches to the head	punches to the head	29	70.73%
		punches to the body	12	29.27%
Total			41	65.08%
3.2.	Finishing technical actions with knee strikes to the ground		5	7.93%
3.3.	Joint-locking techniques		9	14.29%
3.4.	Strangulation techniques:		8	12.70%
TOTAL			1181	100%

Note: n=14

The data presented in the table indicate that, during competitive matches, striking techniques account for 63% of all effective technical actions, followed by throwing techniques at 32%, and ground fighting techniques at 5%, shown in Figure 2.

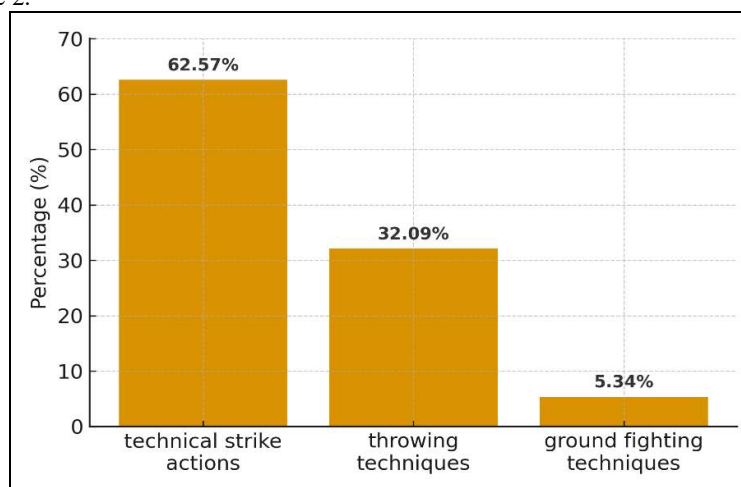


Figure 2. Ratio between the actual technical actions applied in the National MMA Championship

The analysis of the competitive matches of the National MMA Championship showed that in MMA fighting technical actions based on technical procedures from boxing, sambo, judo, kickboxing, taekwondo, wrestling, Greco-Roman wrestling, grappling and pankration are used. Respectively, the match was conducted in a combined style of striking and throwing, with transition from standing to ground fighting and with the application of strangulation and joint-locking, both to the upper and lower limbs (Antonietto et al., 2023). The refinement of technical techniques consists in adapting the technique to the ever-changing conditions of combat,

characterized by great uncertainty and an acute shortage of time. Overlearning leads to the consolidation of skills and provides the possibility of their application in any conditions even after a long lack period of practicing them (Hanat et al., 2021; Beranek et al., 2021). The data presented in Table 2. show that, out of the total number of technical actions, the technique of strikes specific to standing wrestling has a greater applicability in the analyzed competition, which constitutes 62.57% of the total number of actions (739 technical strikes). Out of the total number of strikes specific to standing wrestling, the following are applied: punches to the head in the proportion of 58.59%, of which 240 lateral punches (55.42%), direct punches 36.26% and bottom-up punches - 8.083%. Regarding Punches to the body, the value obtained by the experimental group (1.49%) is lower compared to other types of punches, but high values are recorded for direct punches (45.45%) and lateral punches (54.55%). Regarding kicks to the lower body, the experimental group obtained an average value of 235 technical actions applied, which is slightly higher than the value of other kicks, with a high share of strikes to the outer thigh (72.34%).

Referring to the technical action "Kicks to the body", it can be seen that the total number obtained by the experimental group (48 reps. in total 6.50%), is lower than the average value of the standing fight technique, including: knee kicks – 72.92%; direct – 14.80%; circular – 8.33%, semicircular – 4.17%. Referring to the "kicking to the head" test, a total share of 1.62% is found, of which: knee kicks - 8.42%, circular - 91.67%. The second position in the frequency of applicability of technical actions in the MMA competitive matches analyzed, is occupied by the actions of standing fight technique - throws, where a total weight 32.09% is observed; it is found that, of the total number of effective techniques for bringing the opponent to the ground constitute 250 rep., throwing procedures – 123 rep. and high-amplitude throws – 1.58 rep.

The last position in the hierarchy of the frequency of application of technical actions by MMA fighters in the analyzed competition is occupied by technical actions on the ground, with a total share of 5.34%.

We note that the competitive programs of mixed martial arts will be further improved due to the tendency of including in these programs elements of increased difficulty, complexity and virtuosity of kicking, techniques for bringing the opponent to the ground, throwing techniques, high-amplitude throws, finishing technical actions with knee strikes to the ground, joint-locking and strangulation techniques taken from boxing, sambo, judo, kickboxing, taekwondo, wrestling, Greco-Roman wrestling, grappling and pankration (Breachey et al., 2021; Hartmann, 2012). The notion of "degree of complexity" designates the summative weight or difficulty of the technical-tactical procedures and of the artistic-motor and psychomotor actions performed, each of the technical actions being assessed according to a rating grid and the coefficient that is applied separately to each technical element to identify the generalized efficiency coefficient of the technical-tactical actions, the total number of effective defensive actions, the total number of effective defensive technical actions, the total number of effective attacking technical actions performed, and the total number of attacking technical actions performed during sports matches (Ghoul et al., 2019).

Thus, analysing the requirements of the competition program approved by the International MMA Federation in order to direct and develop mixed martial arts in the world, following the observational experiment of 18-20 years old athletes, the national program for the development of groups of technical-tactical difficulties applied in sports competitions was determined.

Discussion

Statistical processing of information reduces and sometimes eliminates the researcher's subjectivity, contributing to increased scientific objectivity. A fundamental principle of the methods used is to achieve a high level of motor and technical-tactical skills before the stage of advanced specialization and during sports matches. This principle was implemented through:

a) The analysis of the data regarding the ratio between the numbers of technical actions accumulated during competitive matches also allowed us to make the following observations: Takedowns and throws are much more effective than simple techniques for bringing the opponent to the ground due to various difficulties, such as the almost identical number of executions, totaling 47.11%. This shows that a much larger number of throwing techniques allowed for the accumulation of a greater number of victories. The technical actions of the an inverted wheel technique (80.643 ± 0.608) and the major outer reap (33.429 ± 0.402) also proved to be among the most effective and frequently applied technical actions in MMA competitive matches. Therefore, the application of a much smaller number of finishing techniques, such as the performing a lower thigh sweep through sacrifice (0.43%), allowed MMA fighters to score fewer victories compared to the use of takedown and throwing techniques. High-amplitude throws are very difficult to apply in high-level competitions, and their efficiency rate, compared to others, is very low. The same could be said for body punches adapted from boxing, sambo, judo, kickboxing, and taekwondo.

b) Knowledge of methodological aspects, such as: synchronizing the learned techniques with their applicative value in combat (abstract techniques that lack competitive effectiveness are not taught); they must be accessible to the fighter's motor and intellectual level. Here, individualization plays the main role. According to Gheorghiu (2023), repetition under conditions analogous to competition, using various tactical schemes, leads to increased effectiveness in their later application.

c) Creating new specific techniques taken from boxing, sambo, judo, kickboxing, taekwondo, freestyle wrestling, Greco-Roman wrestling, grappling, and pankration, with which to change old patterns, is a requirement for success in MMA fighters.

d) The synthesis of the data recorded in the experimental group of subjects is the result of exercises taken from wrestling and martial arts used to develop motor abilities in terms of determining the level of development of basic physical qualities.

e) Applying actions from the striking techniques, it is clearly observed that the experimental group in the researched sample is substantially approaching the maximum MMA benchmarks. The vast majority fall into the category of average and poor indices, according to the total weight and classification presented. Therefore, the actions from striking techniques require approaches to improve them at the national level. It is important to emphasize that athletes in the experimental group, at the stage of deep specialization, demonstrate a good willingness to acquire technical-tactical techniques specific to combat/martial arts, and thus, initiating and learning the technical basics of different sports branches constitutes the main task in mixed martial arts (Kasper et al., 2019).

f) The analysis of the average indices of the researched group in relation to the effective technical actions applied in the National MMA Championship revealed that these are below the maximum benchmarks of the relevant federation, being at an average level. Speaking about the reaction speed of the lower and upper limbs, we observe that the indices are lower than the average level of throwing/takedown actions on the ground, which is at a medium-high level, closer to the model values of the relevant federation (Kirk et al., 2020). As a result of this analysis, we found that the technical-tactical preparation, which underpins the MMA athlete, is average in the initial stage, especially regarding the technical actions on the ground. In this context, it is important to mention that correlating physical training with the mastery of technical-tactical procedures in mixed martial arts allows us to emphasize the necessity of focusing on developing execution speed, especially for techniques performed with both upper and lower limbs, within specialized training sessions. These sessions should incorporate methods adapted from wrestling and martial arts disciplines, tailored to the athlete's motor and intellectual level, to ensure effectiveness and applicability in competitions (Kostikiadis et al., 2018).

Conclusions

1. At the initial stage, athletes in the phase of advanced specialization oriented toward high performance demonstrated high values of technical actions in stand-up combat, as follows: roundhouse kicks to the head – 91.67%; knee strikes to the head – 72.92%; leg kicks to the outer thigh – 72.34%; and ground finishing actions through arm strikes to the head – 70.73%.

2. The characteristics of the technical profile actions specific to physical preparation were expressed through the predominance of stand-up striking techniques and through throwing and takedown techniques, which highlight the high level of physical preparedness of the analyzed athletes.

3. The experimental program was designed by combining technical elements from various combat disciplines — freestyle wrestling, Greco-Roman wrestling, judo, sambo, jiu-jitsu, grappling, kickboxing, taekwondo, karate, and pankration — with the aim of developing the motor, psychomotor, and technical-tactical capacities of athletes undergoing advanced specialization.

4. The statistical analysis of the correlation coefficients of the 1056 tested parameters made it possible to determine the relationships among experimental variables and to identify the most significant values of the athletes' preparedness at ages 18–20, revealing an increase in the correlation between motor ability indicators and the performance of technical-tactical actions in mixed martial arts.

5. The results of the pedagogical experiment demonstrated a significant improvement in strength capacities, as evidenced by the following tests: 50-m sprint and trunk lifts from the supine position for 20 s, strength under speed conditions. Moreover, the total number of offensive technical actions showed a strong correlation, emphasizing the crucial role of strength and speed development in optimizing the technical-tactical efficiency of mixed martial arts fighters.

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