

Integral method for improving precompetition training of athletes in Mixed Martial Arts

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Abstract:

Background: Correction of the training system in various sports based on the previous competition results analysis is a common practice allowing to quickly increase the training level. However, such studies have not been conducted in MMA for athletes who primarily use a wrestling or striking style of fighting. The purpose of the study was the development and practical implementation of an integral methodology for improving the pre-competition training of athletes, taking into account their fighting style, based on the analysis of the previous competitions results. *Material and methods:* 10 athletes of the Ukrainian national MMA junior team (16-17 years old) took part in the study. At the first stage of the study, the training process of the pre-competition mesocycle and the 2022 European MMA Championship results were analyzed. At the second stage, the methodology for correcting the training process was developed and implemented during 2 months of pre-competition preparation for the 2022 MMA World Championship. At the third stage, there was a comparative analysis of the athletes' performance results in both competitions. *Results:* The study showed that using the "classical" method of pre-competition preparation for the European Championship contributed to the fact that during the competition, 68.7% of the fights were won. The use of the experimental methodology for two months of training contributed to the development of maximal strength by 8.8% in athletes with wrestling style and by 20.6% in athletes with striking style of fighting. The practical implementation of increasing the adaptive body reserves during pre-competition training was carried out during the World Championship. 84.4% of the total number of fights were won. At the same time, the number of fights, which ended early by knockout, painful or choke hold, or with a clear advantage, increased by 19.0% compared to the results of the European Championship. *Conclusions:* The use of the integral training method allowed increasing the implementation of technical skills and functional capabilities of athletes, taking into account their style of fighting in competitive activities.

Keywords: training process, mesocycle, fighting style, MMA, competitions.

Introduction

The modern tendency of MMA development in the world, the use of individual mechanisms for optimizing tactical-technical and physical training indicate the need to find a comprehensive system for improving the training process. The development of innovative methods for increasing functional capabilities, the involvement of additional systems of effective energy supply, the growth of adaptive body reserves, will allow athletes to be as competitive as possible during fights (Alzhanov et al., 2021; Barley & Harms, 2021; Kirk et al., 2021). One of the main aspects of the success of mixed martial arts fighters is the maximum and quick implementation of the adaptive body potential in fights due to powerful technical strikes. The ability to increase the power of attacking and counter-attacking kicks due to the growth of power capabilities is one of the priority tasks of coaches and leading scientists (Chernozub et al., 2018; Fernandes et al., 2018; Iglesias-Soler et al., 2021). In recent years, a number of scientists have paid close attention to the study of the problem of effective implementation of the results of training activities in the competitive process, taking into account the fighting style in MMA (Beranek et al., 2020; James et al., 2020; Manolachi et al., 2020).

The mechanism of applying the main patterns for improving training activities at the pre-competition stage, taking into account athletes' individual characteristics, has not been sufficiently studied in MMA (Bueno et al., 2022; Folhes et al., 2022). Solving this issue is complicated by a variety of factors concerning training activities and their variability, which depend on the nature of adaptive body changes in athletes (Brechtney et al., 2021; Dunn et al., 2022; Polechoński et al., 2022). One of the important directions of improving pre-competition

training is the search for effective ways to increase the body functional capabilities using various strength training programs (Chernozub et al., 2019; Kirk et al., 2020; Giboin & Gruber, 2022). In most cases, MMA athletes and coaches use classical methods, principles, and sets of strength exercises for boxing and freestyle wrestling. At the same time, they do not consider the fact that most athletes use a wrestling or striking style of fighting. This indicates the need to use load modes different in volume and intensity for both styles. This justification is related to the adaptation processes in athletes' bodies, which take place while using load modes of different intensity and energy supply (Omcirk et al., 2021; Camarco et al., 2022; Folhes et al., 2023).

To correct the training system in various sports based on the analysis of the previous competitions results is a common practice allowing to increase the level of training in a short time. An in-depth analysis of punch combinations, choke or painful hold, powerful counterattacks that did not lead to early victory in MMA fights is one of the main ways to improve the training system (Stellpflug et al., 2022; Tota & Wiecha, 2022). The problem of reducing the number and vividness of victories in MMA fights is the inconsistency of the training process and realizing the individual characteristics of athletes during fights. Only the ability to combine the athlete's individual technical skill, the development of his muscle strength and adaptive body reserves into a single integrated system will allow to achieve the desired result (Pavelka et al., 2020; Chernozub et al., 2022; Vecchio et al., 2022). The growing demands for competitive activity in MMA require scientists to develop innovative methods of improving pre-competition training to increase functional capabilities (Liu et al., 2022; Gottschall & Hastings, 2023). Implementation of the adaptive body potential and athlete's technical skill is one of the key factors that influence on the structure and orientation of these methods. The splendor of MMA fights depends on the technical skill of knockouts, painful and choke hold performed by the athletes. The effectiveness of implementing strikes and wrestling elements during fights depends on the level of strength capabilities development and adaptive body reserves (Giboin & Gruber, 2022; Antonietto et al., 2023). However, there have been no research in MMA, which would allow clearly determining the most effective methods of training athletes with a wrestling or striking style of fighting. The purpose of the study was the development and practical implementation of an integral method for improving the pre-competition training of athletes, taking into account their fighting style and analysis the previous competitions results.

Material & methods

Participants A series of experimental studies took place in 2022 during the European Championship (Georgia, Tbilisi) and the MMA World Championship (USA, Nashville) among juniors (under 18). Research also took place during the pre-competition mesocycle before the 2022 World Championship in "Saigon" sports club in Chernivtsi (Ukraine). The Ukrainian junior MMA national team took part in the study. The team consisted of 10 men aged 17 ± 0.29 years, 5 athletes used a wrestling fighting style, and other 5 participants used a striking style. Their MMA experience is 4 ± 0.34 years. In accordance with the ethical standards of the Helsinki Declaration, the research algorithm and methods were approved by the ethical committee for biomedical research at Lesya Ukrainka Volyn National University. The study participants provided written informed consent according to the recommendations of biomedical research ethics committees, (WHO Regional, 2000).

The competitive activity analysis During the competitive activity, the reasons for winning or losing the fight were determined. Considering that the team place depends on the total number of victories, their early completion is a priority task for the athletes. In the process of research, the following indicators were monitored: the number of early victories obtained by knockout, painful and choke hold, technical knockout and by clear advantage; number of victories by points. The number of defeats with similar parameters were controlled in fights conducted by the research participants.

Maximal muscle strength The development of the maximum muscle strength (1RM) of the athletes was determined before and after 2 months of using the integrated method of improving pre-competition training. During the research, the 1 RM indicator was determined during the following exercises: Smith bench press (pectoral muscles); traction for the head on the block (back muscles); leg press on the block (leg muscles); bench press from behind the head while sitting on a block (deltoid muscles). All exercises were performed in simulators and blocks to reduce the possibility to injure.

Analysis of pre-competition training in MMA Pre-competition training in MMA is evaluated according to the following criteria:

- the mastery level of striking and wrestling techniques and the effectiveness of their implementation in fights;
- the ratio of the functional body capabilities in athletes with the power of attacking and counter-attacking actions;
- a method of the training process correction based on the analysis of the previous competitions results and the training process before them;
- compliance of the training load amount with the physiological processes of adaptation considering the peculiarities of the athlete's style of fighting.

Experimental design At the first stage of the study, the training process of the pre-competition mesocycle and the performance results at the 2022 European MMA Championship were analyzed. At the second stage, the methodology for correcting the training process was developed and implemented during the 2 months of pre-

competition training for the 2022 MMA World Championship. At the third stage, there was a comparative analysis of the results of the athletes' performance in these competitions.

Statistical analysis Statistical analysis of the research results was performed using the IBM *SPSS*Statistics 26 program package (StatSoftInc., USA). Median, lower and upper quartiles, interquartile range (IQR) were determined. The Kolmogorov Smirnov test was used to determine the normal distribution. The G-Power 3.1.96 program was used to calculate statistical power (determining the smallest sample size for the study). The sample size was evaluated using statistical tests: Wilcoxon signet-rank test (one sample case); ANOVA: repeated measures, between factors.

Results

Figure 1 presents the integral method developed for improving the process of pre-competition training in Mixed Martial Arts. The presented technique was developed on the basis of the pre-competition training (for the 2022 European MMA Championship) analysis and the results of competitive activities. The following indicators of pre-competition training were evaluated: the volume and intensity of training loads, the values of power load components aimed at increasing functional capabilities and the level of maximum strength, the duration of each load until full muscle fatigue aimed at increasing adaptation reserves. Having analyzed the results of the last competitions, we determined the major factors on which the correction of this methodology depends: the total number of victories obtained in fights; the number of victories by knockout and technical knockout; the number of victories by painful and choke hold; the number of victories by a clear advantage.

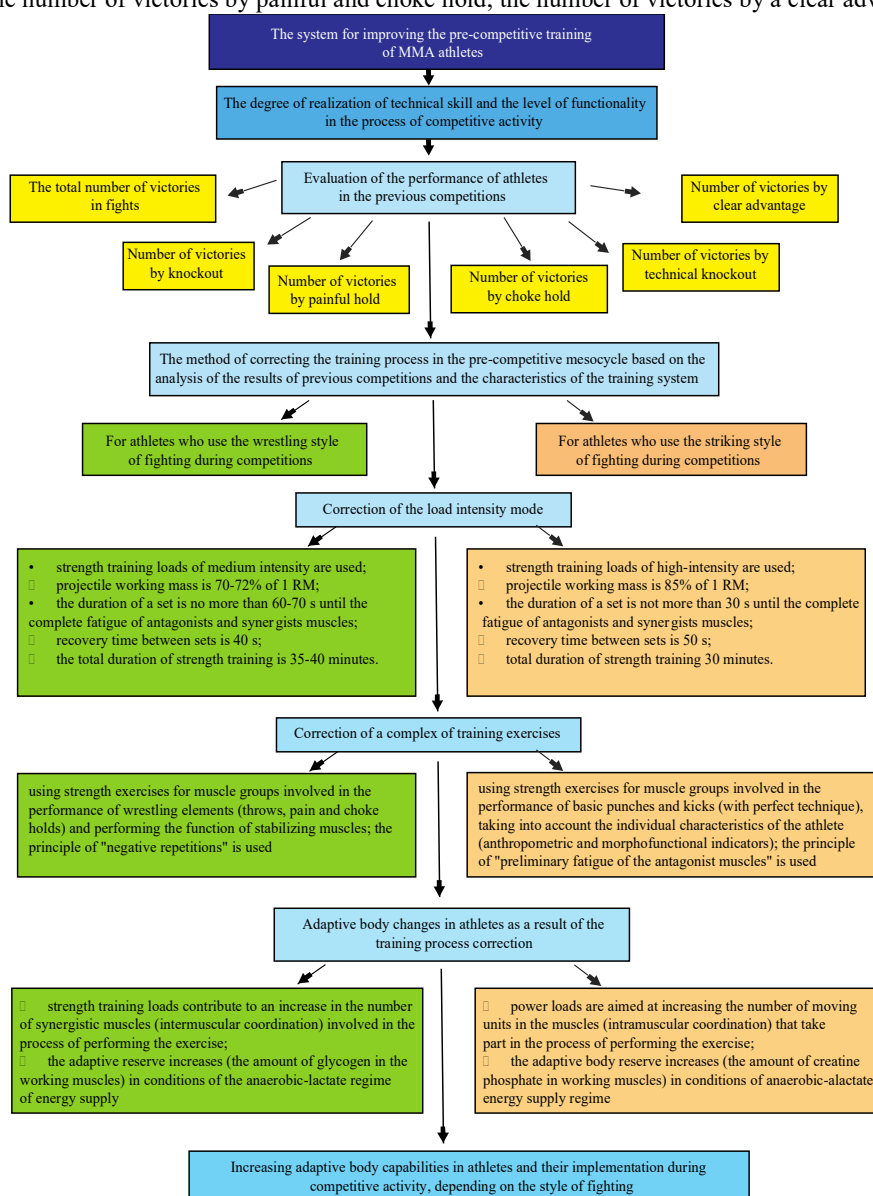


Fig. 1. An integral method for improving pre-competition training of athletes in Mixed Martial Arts

The chief component of this technique is an integral approach to the implementation of technical skill and the level of functional capabilities during the competition, taking into consideration the peculiarities of the processes of adaptation to physical stimulus. The presented method primarily analyzed the features of the pre-competition training system, considering the style of fighting (wrestling or striking) used by the athlete in competitive activities. Correction of training load indicators and training exercises depend on adaptive body changes in athletes, which occur in response to this stimulus. Increasing the adaptive body capabilities in athletes and implementing them in competitive activities depending on their fighting style is the main goal of the developed integral pre-competition training method.

Figure 2 shows the changes in maximum muscle strength indicators in athletes of wrestling and striking style of fighting during the study.

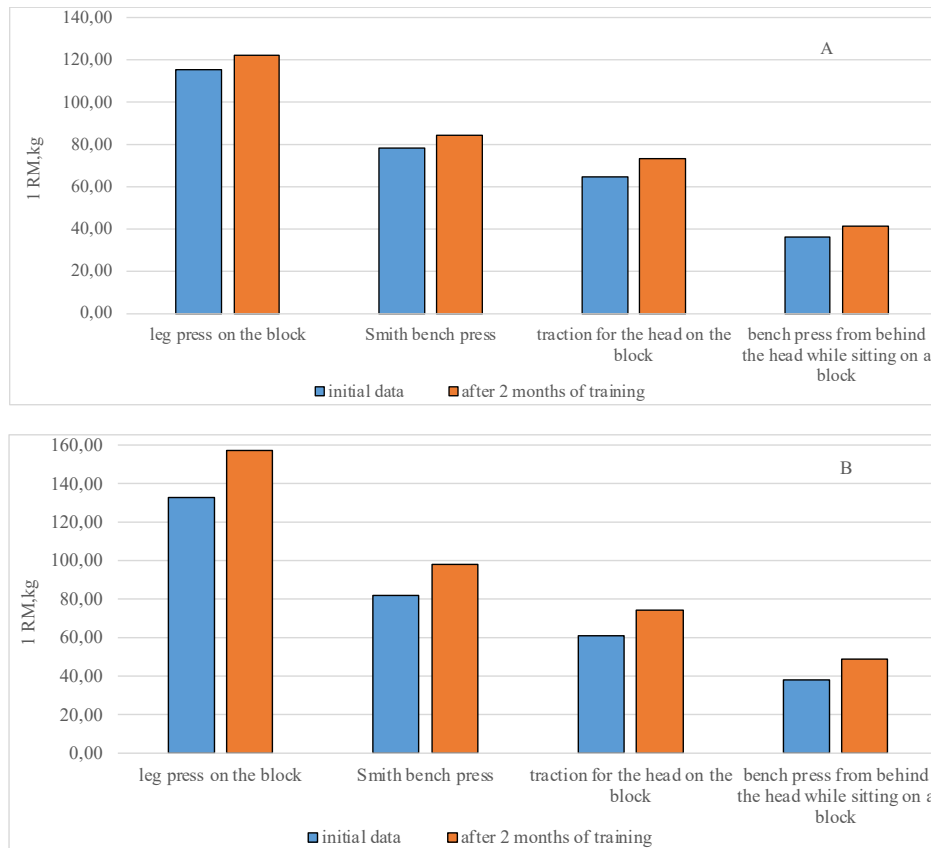


Fig. 2. Changes in maximal muscle strength (1 RM) during control exercises in athletes using a wrestling (A) and striking (B) fighting style

The results revealed at the beginning of the study indicated that athletes who used two different fighting styles had an almost identical level of maximal strength development. Only the power capabilities of the leg muscles during the "leg press on the block" exercise were 15.2% ($p < 0.05$) higher in athletes with a striking style of fighting compared to the athletes with wrestling style of fighting.

The analysis of the results obtained after two months of training using the proposed integral pre-competition preparation method showed positive dynamics in all study participants. The greatest increase in the 1 RM indicator by 29.1% ($p < 0.05$) was found while performing the exercise "bench press from behind the head while sitting on a block" in athletes of the striking style of fighting. The smallest increase by 7.5% ($p < 0.05$) was observed in athletes of the wrestling style during the exercise "Smith's bench press". The research revealed that the studied indicators increased by an average of 2.3 times in athletes with striking style of fighting compared to the results of other participants.

The comparative analysis of the performance of the youth national team of Ukraine at the 2022 European and World MMA Championships is shown in fig. 3. The analysis is based on the results of quantitative indicators of victories and defeats.

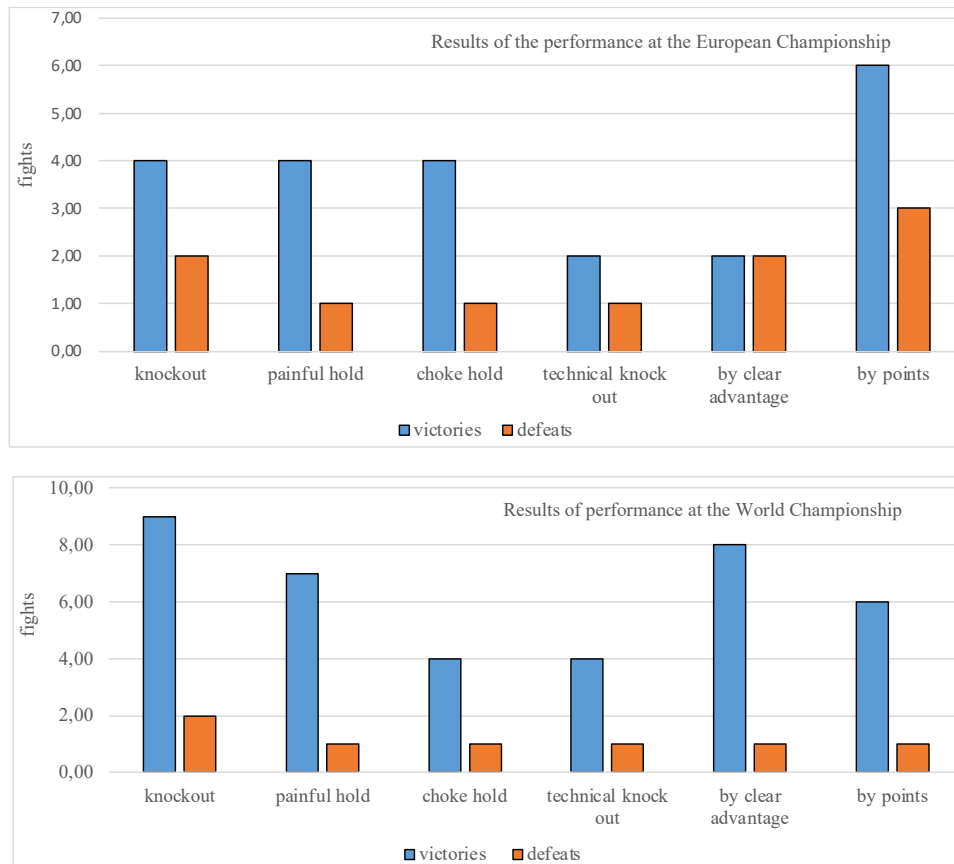


Fig. 3. Comparative analysis of the performance of the youth (men under 18) national team of Ukraine at the 2022 European and World MMA Championships

The results of competitive activity indicated that during the European Championship athletes won in 68.7% of fights. After using the integral method in the pre-competition mesocycle for 2 months, the percentage of victories in fights during the World Championship increased to 84.4%.

The quantitative difference of victories and defeats obtained by knockout, painful and choke hold differs significantly during both competitions, which are considered in this work. During the European Championship, the largest number of victories (18.7% of the total number of fights) were obtained by counting points. The lowest percentage of victories in these competitions (6.2%) was obtained by technical knockout and by a clear advantage. The biggest number of defeats (9.3%) were based on the results of counting the points. At the World Championship, most victories (20.0% of the total number of fights) were got by knockout. The lowest percentage of victories (8.8%) was obtained during the performance of choke hold and technical knockout. The highest number of defeats (4.4%) during these competitions was registered during knockouts.

Discussion

The study is devoted to researching the impact of the developed integral method of pre-competition training in MMA on increasing the adaptation reserves of athletes and their implementation in competitive activities. The comparative analysis of the 2022 European and World MMA Championships results of the Ukrainian youth national team was conducted, taking into account the pre-competition training peculiarities. The presented work is one of the few researches that study the mechanisms of improving the training process in MMA, depending on fighting style (Chernozub et al., 2019; Liu et al., 2022). The results indicated that during pre-competition training, the correction of load regimes and sets of exercises must be carried out taking into consideration the processes of adaptation to the relevant stimuli. The obtained results will contribute to the improvement of the pre-competition training and search for optimal loads in pre-competition mesocycles. It will help to better understand the principle of developing an integrated method for pre-competition training based on the analysis of competitive and training activities.

The lack of uniform mechanisms for improving the training process of athletes with a striking and wrestling style of fighting is one of the unresolved problems of the pre-competition training system in MMA. The search for effective mechanisms of the implementation of technical mastery in combination with the level of

athletes' adaptive body reserves is one of the most controversial scientific problems in MMA (Dunn et al., 2022; Antonietto et al., 2023).

The research results showed that athletes of the striking style who used high-intensity strength training loads and the principle of "premature fatigue of the agonist muscles" achieved the greatest increase in the maximum strength development. Their changes in 1 RM indicator exceeded the results of athletes who used medium intensity loads and the principle of "negative repetitions" by 2.3 times. The obtained results confirmed the data of scientists (Tota Wiecha, 2022) regarding the increase in the level of intermuscular coordination and adaptation reserves (the amount of muscle glycogen) when using medium intensity training loads. High-intensity loads are aimed at increasing the activity of mobile units and the amount of creatine phosphate in working muscles in conditions of anaerobic-alactate type of energy supply. The accelerated development of the maximum muscle strength indicator occurs due to the increase in intra-muscular coordination and the improvement of the creatine phosphokinase mechanism of ATP resynthesis (Chernozub et al., 2022).

The analysis of the competition results showed that using of the proposed methodology in the pre-competitive mesocycle allowed to increase both the number of victories and the splendor of fights. The concentration on the style of fighting and correction of the training process increased the number of victories by knockouts, painful hold and by clear advantage. The obtained results complement the works of scientists who were involved in the processes of adaptive body changes in MMA athletes in conditions of anaerobic load regimes (Antonietto et al., 2023; Gottschall & Hastings, 2023). These experts claim that high-intensity power loads in the conditions of the anaerobic-alactate mode of energy supply contribute to the growth of explosive power. It is possible that these adaptive changes in the muscles contribute to the increase in the number of knockouts performed by striking style athletes. Loads of medium intensity, which contribute to increasing the level of intermuscular coordination, are primarily aimed at developing strength endurance and increasing adaptation reserves (Chernozub et al., 2019; Giboin & Gruber, 2022). The adaptive body changes in athletes of the wrestling style of fighting contribute to an increase in the number of premature victories by painful hold and by a clear advantage. The data presented in this paper complement the research results of the above scientists and reveal one of the most controversial issues regarding the search for effective ways to improve pre-competition training in MMA.

Conclusions

The use of an integral method for improving pre-competition training allowed quick mobilizing of the athletes' adaptive reserves taking into account their style of fighting. The proposed mechanism for correcting load regimes, depending on the wrestling or striking style of fighting, contributed to an increase in competitive performance by 15.7% after two months of training. Changes in the system of pre-competition training also contributed to the growth of the maximum strength indicator by 2.5 times over the same period of time. The practical implementation of the proposed method positively influenced the number of early victories by knockout, painful hold, and by a clear advantage.

Application of the research results into the system of pre-competition training and competitive activity will allow to find effective ways to optimize loads depending on athletes' style of fighting. Using the developed training methodology allows to increase the degree of implementing technical skill and individual characteristics of athletes in competitive activities to ensure the processes of long-term adaptation.

The obtained results reveal one of the important problems in MMA related to the search for the optimal set of technical elements of special striking and wrestling training for each athlete. An important criterion for the effectiveness of applying technical elements in athletes of the striking or wrestling style of fighting is the correspondence of the adaptation body reserves to the volume and intensity of training loads. The developed mechanisms for correcting load regimes and sets of training exercises will contribute to the maximum realization of the functional potential of athletes in competitive activities depending on the style of fighting.

Conflicts of interest - There is no conflict of interest.

References:

- Alzhanov, H., Ivanov D., Sagiev, T., Kladov, E., Matyunina, N. (2021). A comparative analysis of the competitive fights of fighters in mixed martial arts. *Journal of Physical Education and Sport*, 21(6), 3405–3410. <https://doi.org/10.7752/jpes.2021.06461>
- Antonietto, N., Bello, F., Queiroz, A., Carvalho, P., Brito, C., Amtmann, J., Miarka, B. (2023). Suggestions for Professional Mixed Martial Arts Training With Pacing Strategy and Technical-Tactical Actions by Rounds. *J Strength Cond Res*, <https://doi.org/10.1519/JSC.0000000000003018>.
- Barley, O., & Harms, C. (2021). Profiling Combat Sports Athletes: Competitive History and Outcomes According to Sports Type and Current Level of Competition. *Sports Med Open*, 7(1), 63. <https://doi.org/10.1186/s40798-021-00345-3>.
- Beranek, V., Stastny, P., Novacek, V., Votapek, P., Formanek, J. (2020). Upper Limb Strikes Reactive Forces in Mix Martial Art Athletes during Ground and Pound Tactics. *Int J Environ Res Public Health*, 17(21), 7782. <https://doi.org/10.3390/ijerph17217782>.

- Brechney, G., Chia, E., & Moreland, A. (2021). Weight-Cutting Implications for Competition Outcomes in Mixed Martial Arts Cage Fighting. *Journal of Strength and Conditioning Research*, 35(12), 3420–3424. <https://doi.org/10.1519/JSC.0000000000003368>.
- Bueno, J., Faro, H., Lenetsky, S., Gonçalves, A., Dias, S., Ribeiro, A., Silva, Filho, B., Vasconcelos, B., Serrão, J., Andrade, A., Souza-Junior, T., Claudino, J. (2022). Exploratory Systematic Review of Mixed Martial Arts: An Overview of Performance of Importance Factors with over 20,000 Athletes. *Sports (Basel)*, 10(6), 80. <https://doi.org/10.3390/sports10060080>.
- Camarco, N., Neto, I., Ribeiro, E., & Andrade, A. (2022). Anthropometrics, Performance and Psychological Outcomes in Mixed Martial Arts Athletes. *Biology (Basel)*, 11(8), 1147. <https://doi.org/10.3390/biology11081147>.
- Chernozub, A., Korobeynikov, G., Mytskan, B., Korobeynikova, L., & Cynarski, W. (2018). Modelling Mixed Martial Arts Power Training Needs Depending on the Predominance of the Strike or Wrestling Fighting Style, Ido movement for culture. *Journal of Martial Arts Anthropology*, 18(3), 28–36. doi:10.14589/ido.18.3.5
- Chernozub, A., Danylchenko, S., Imas, Y., Kochina, M., Ieremenko, N., Korobeynikov, G., Korobeynikova, L., Potop, V., Cynarski, W., Gorashchenko, A. (2019) Peculiarities of correcting load parameters in power training of mixed martial arts athletes. *Journal of Physical Education and Sport*. 19(2), 481–488. <https://doi.org/10.7752/jpes.2019.s2070>.
- 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. *PeerJ*, 10, 13827. <https://doi.org/10.7717/peerj.13827>
- Dunn, E., Humberstone, C., Franchini, E., Iredale, F., Blazevich, A. (2022). The effect of fatiguing lower-body exercise on punch forces in highly-trained boxers. *Eur J Sport Sci*, 22(7), 964–972. <https://doi.org/10.1080/17461391.2021.1916085>.
- Fernandes, J., Bello F., Duarte, M., Carvalho, P., Queiroz, A., Brito, C., Miarka, B. (2018). Effect of rule changes on technical-tactical actions correlated with injury incidence in Professional Mixed Martial Arts. *Journal of Physical Education and Sport*, 18(3), 1713–1721. <https://doi.org/10.7752/jpes.2018.03250>
- Folhes, O., Reis, V., Marques, D., Neiva, H., Marques, M. (2022). Maximum Isometric and Dynamic Strength of Mixed Martial Arts Athletes According to Weight Class and Competitive Level. *Int J Environ Res Public Health*, 19(14), 8741. <https://doi.org/10.3390/ijerph19148741>.
- Folhes, O., Reis, V., Marques, D., Neiva, H., Marques, M. (2023). Influence of the Competitive Level and Weight Class on Technical Performance and Physiological and Psychophysiological Responses during Simulated Mixed Martial Arts Fights: A Preliminary Study. *J Hum Kinet*, 86, 205-215. <https://doi.org/10.5114/jhk/159453>.
- Giboin, L., & Gruber, M. (2022). Neuromuscular Fatigue Induced by a Mixed Martial Art Training Protocol. *J Strength Cond Res*, 36(2), 469–477. <https://doi.org/10.1519/JSC.0000000000003468>.
- Gottschall, J., & Hastings, B. (2023). A comparison of physiological intensity and psychological perceptions during three different group exercise formats. *Front Sports Act Living*, 5, 1138605. <https://doi.org/10.3389/fspor.2023.1138605>.
- Iglesias-Soler, E., Mayo, X., Rial-Vázquez, J., Haff, G. (2021). Inter-individual variability in the load-velocity relationship is detected by multilevel mixed regression models. *Sports Biomech*, 20(3), 304–318. <https://doi.org/10.1080/14763141.2018.1548640>.
- James, L., Connick, M., Haff, G., Kelly, V., Beckman, E. (2020). The Countermovement Jump Mechanics of Mixed Martial Arts Competitors. *Journal of Strength and Conditioning Research*, 34(4), 982–987. <https://doi.org/10.1519/JSC.0000000000003508>.
- Kirk, C., Clark, D., Langan-Evans, C., Morton, J. (2020). The physical demands of mixed martial arts: A narrative review using the ARMSS model to provide a hierarchy of evidence. *Journal of Sports Sciences*, 38(24), 2819–2841. <https://doi.org/10.1080/02640414.2020.1802093>.
- Kirk, C., Langan-Evans, Clark, D., C., Morton, J. (2021). Quantification of training load distribution in mixed martial arts athletes: A lack of periodisation and load management. *PLoS One*, 16(5), e0251266. <https://doi.org/10.1371/journal.pone.0251266>.
- Liu, Y., Evans, J., Wąsik, J., Zhang, X., Shan, G. (2022). Performance Alteration Induced by Weight Cutting in Mixed Martial Arts-A Biomechanical Pilot Investigation. *Int J Environ Res Public Health*, 19(4), 2015. <https://doi.org/10.3390/ijerph19042015>.
- Manolachi, V., Chernozub, A., Potop, V., Zoriy, Y., Kulbayev, A., Braniște, G., Savenko, A. (2022). Increasing the functional capabilities of Mixed Martial Arts athletes in the process of optimizing different regimes of power load. *Pedagogy of Physical Culture and Sports*, 26(6), 399–406. <https://doi.org/10.15561/26649837.2022.0606>
- Omcirk, D., Vetrovsky, T., Padecky, J., Vanbelle, S., Malecek, J., Tufano, J. (2021). Punch Trackers: Correct Recognition Depends on Punch Type and Training Experience. *Sensors (Basel)*, 21(9), 2968. <https://doi.org/10.3390/s21092968>.

- Pavelka, R., Třebický, V., Fialová, J., Zdobinský, A., Coufalová, K., Havlíček, J., Tufano, J. (2020). Acute fatigue affects reaction times and reaction consistency in Mixed Martial Arts fighters. *PLoS One*, 15(1), e0227675. <https://doi.org/10.1371/journal.pone.0227675>.
- Polechoński, J., Langer, A. (2022). Assessment of the Relevance and Reliability of Reaction Time Tests Performed in Immersive Virtual Reality by Mixed Martial Arts Fighters. *Sensors (Basel)*, 22(13), 4762. <https://doi.org/10.3390/s22134762>.
- Stellpflug, S., Menton, W., LeFevre, R. (2022). Analysis of the fight-ending chokes in the history of the Ultimate Fighting Championship™ mixed martial arts promotion. *Phys Sportsmed*, 50(1), 60–63. <https://doi.org/10.1080/00913847.2020.1866958>.
- Tota, Ł., & Wiecha, S. (2022). Biochemical profile in mixed martial arts athletes. *PeerJ*, 10, 12708. <https://doi.org/10.7717/peerj.12708>.
- Vecchio, L., Whitting, J., Hollier, J., Keene, A., Climstein, M. (2022). Reliability and Practical Use of a Commercial Device for Measuring Punch and Kick Impact Kinetics. *Sports (Basel)*, 10(12), 206. <https://doi.org/10.3390/sports10120206>.