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OPTIMIZATION OF TRAINING LOADS BASED ON INTENSITY ZONES USING THE BIOMECHANICAL INDICATORS OF ATTACK TECHNIQUE IN ELITE KICKBOXERS

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ABOUT ARTICLE

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Abstract: This article analyzes the mechanism for optimal planning and control of training load in sport based on intensity zones. The possibilities of scientifically grounded management of athletes' physical loads were examined based on exercise duration, heart rate, intensity level, and the number of repetitions. It was found that distributing training loads according to individual functional capacities optimizes the activity of the cardiovascular system and increases the effectiveness of the training process. The proposed mechanism plays an important role in planning athletes' preparation and in the scientific management of the training process.

Introduction. In recent years, increasing attention has been paid in global sports science to the scientific organization of athletes' training, the optimal planning of training loads, and the improvement of the effectiveness of sports techniques. Particularly in combat sports, including kickboxing, the effectiveness of competitive performance largely depends on the technical proficiency of athletes in executing attacking actions, the coordinated movement of body segments during striking, and the high level of development of strike force and speed.

Therefore, an in-depth study of the biomechanical indicators of attacking techniques has significant scientific and practical importance for improving the system of athletes' training.

Achieving high sports performance in kickboxing depends not only on the level of technical preparation but is also closely related to the scientific planning and management of training loads during the training process. In modern sports theory, the optimal distribution of training loads according to intensity zones is considered an important factor in improving athletes' functional capacities, ensuring the stability of technical movements, and preventing excessive load and injuries. At the same time, basing the planning of training loads on the biomechanical indicators of sports movements makes it possible to further increase the effectiveness of the training process.

Currently, scientific studies in kickboxing are focused on investigating the biomechanical characteristics of attacking techniques, particularly the kinematic and kinetic parameters of striking movements, the coordination mechanisms between body segments, and the force and speed indicators generated during the striking process. However, the issue of optimizing training loads according to intensity zones based on the biomechanical indicators of attacking techniques in elite kickboxers has not yet been sufficiently studied.

Therefore, conducting scientific research aimed at determining the biomechanical indicators of attacking techniques in elite kickboxers and optimizing training loads according to intensity zones based on these indicators has important scientific and practical significance for improving the system of athletes' training, increasing the effectiveness of attacking techniques, and ensuring high performance in competitive activities.

Materials and methods. During the research process, the biomechanical indicators of elite kickboxers while performing attacking techniques were analyzed, particularly the kinematic and kinetic parameters of striking movements. The obtained results showed that the effectiveness of attacking techniques mainly depends on the sequential movement of body segments during the striking process, the angular velocities, and the coordinated transfer of impulse from the lower body segments to the upper body segments.

The analysis revealed that athletes who demonstrated optimal coordination among the leg, thigh, trunk, and shoulder segments during the execution of striking movements exhibited higher levels of strike speed and force. It was also observed that the stability of the supporting leg and the optimal displacement of the body's center of mass during the striking process are important biomechanical factors ensuring the effectiveness of attacking techniques.

When the striking technique of qualified and highly qualified kickboxers was evaluated based on 3D kinematic analysis criteria, clear differences were observed according to the level of qualification in the spatial control of the spine (trunk stabilization and the mechanism of strike impulse transmission). In particular, in qualified kickboxers the minimum value of the forward–backward flexion movement of the spine was −17±1.13° (forward flexion), while the maximum backward extension reached 23±2.49°, with a total angular range of 30±3.28°. These indicators show that during the strike there is a relatively “large-amplitude” forward displacement of the trunk, meaning that the athlete moves the trunk center further forward in order to maintain balance while executing the strike (see Table 1).

In contrast, these movement indicators were manifested in a more rational form in highly qualified kickboxers: the minimum forward flexion was −5±2.24°, while the maximum backward extension was recorded at 38±2.55°. The range value was 33±1.57°, which indicates the effective functioning of the kinetic chain between trunk segments and the optimal control of impulse transmission during the striking process in highly qualified athletes. In other words, a highly qualified athlete more actively utilizes the elastic–potential capacity of the trunk in the “rear phase” to increase strike force, thereby enhancing both the speed and the power component of the strike.

Table 1

Kinematic indicators of forward–backward and lateral bending of the spine

Spinal segment	Type of movement	Technical movement indicators of qualified kickboxers			Technical movement indicators of highly qualified kickboxers		
		Minº	Maksº	Rangeº	Minº	Maksº	Rangeº
	Forward–backward flexion	-17±1,13	23±2,49	30±3,28	-5±2,24	38±2,55	33±1,57
	Lateral flexion	-27±2,03	3±0,96	30±2,37	-53±5,26	14±0,81	67±5,79

A significant biomechanical difference between qualification levels was also identified in the lateral flexion movement of the spine. In qualified kickboxers, the minimum value of lateral flexion was −27±2.03°, while the maximum value was 3±0.96°, with a total movement range of 30±2.37°. This indicates that the stability of the trunk in the frontal plane during strike execution is not sufficiently developed; in other words, during the strike the athlete maintains trunk inclination within a relatively limited range in order to compensate for the coordination between the supporting leg and the pelvic segments.

Based on the biomechanical indicators obtained during the research, a mechanism for optimizing training loads according to intensity zones was developed. According to this mechanism, training loads were planned across low, moderate, and high intensity zones and were directed toward improving strike speed, force indicators, and movement coordination during the execution of attacking techniques. The results of the experimental training sessions confirmed that planning training loads based on biomechanical indicators has a positive effect on increasing the accuracy of athletes' technical movements as well as the force and speed of strikes.

Result and discussion. It was determined that the scientifically based distribution of training loads according to intensity zones contributes to the effective development of athletes' functional capacities, reduces the risk of excessive load, and ensures the stable execution of attacking techniques (see Figure 1).

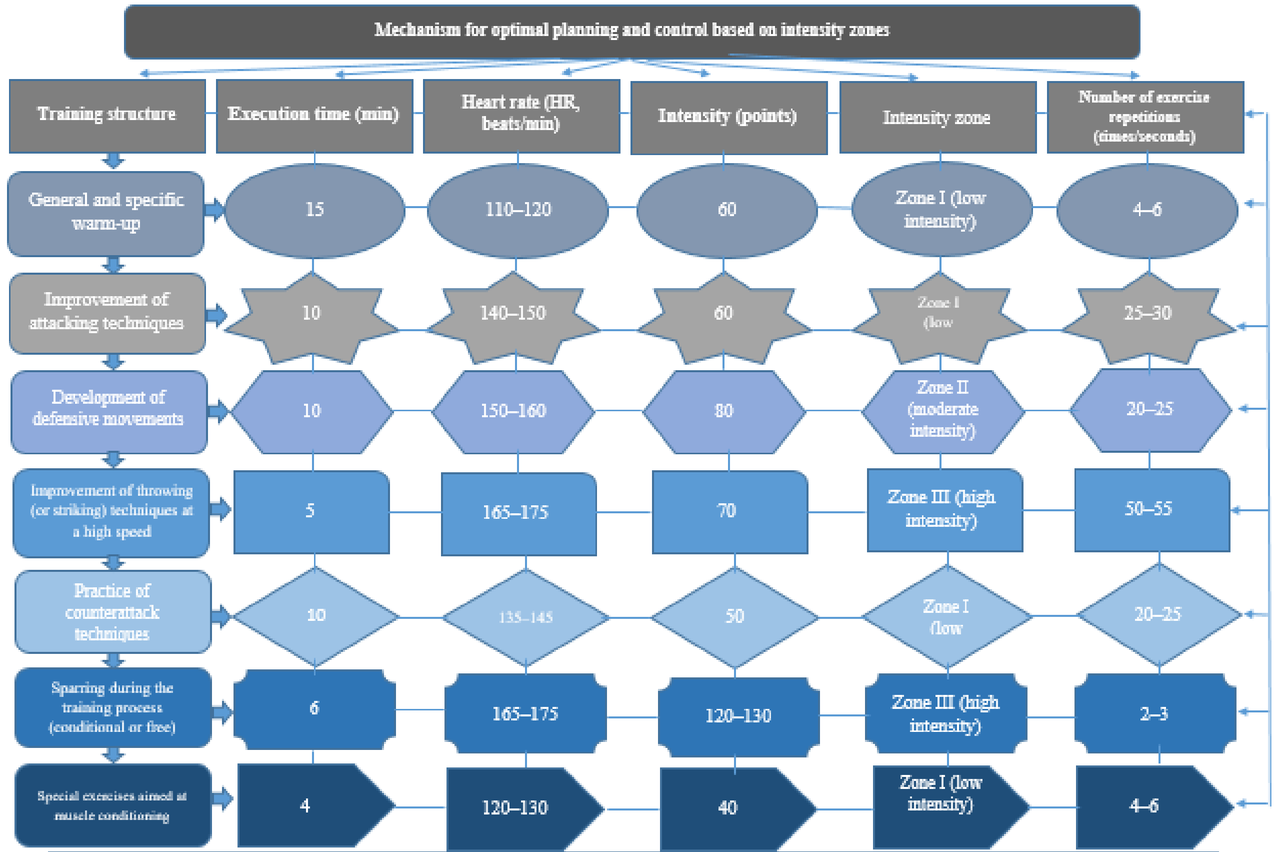

Figure 1. Mechanism for optimal planning and control of training loads based on intensity zones

The results of this study make it possible to develop a mechanism for planning and controlling training loads based on the biomechanical indicators of attacking techniques in the training system of elite kickboxers.

The figure illustrates the mechanism for optimal planning and control of training loads according to intensity zones, showing that the training process is managed through a multi-stage system of exercises. Each type of exercise is characterized by execution time, heart rate (HR), intensity level (points), intensity zone, and the number of exercise repetitions. These indicators serve to scientifically optimize training loads in accordance with the athlete's functional capacities and the activity of the body's energy supply systems.

In the first stage, exercises aimed at developing general and specific endurance are applied. These exercises are performed for approximately 15 seconds, with the heart rate maintained at 110–120 beats per minute. The intensity level averages 60 points, and the load is carried out within Zone I (low intensity), with the exercise repeated 4–6 times. These exercises mainly activate the aerobic energy supply mechanism, contributing to the stabilization of cardiovascular system activity, improving muscle adaptation to prolonged work, and strengthening the athlete's overall physical preparedness.

In the second stage, exercises aimed at developing specific speed endurance are performed. In this stage, the exercise duration is approximately 10 seconds, and the heart rate is observed at around 140–150 beats per minute. The intensity level is 60 points, and the exercise is carried out in Zone I (low intensity), with 25–30 repetitions. This type of load helps to improve the muscles' ability to work quickly, ensure the rhythmic stability of striking movements, and enhance the ability to generate force within a short period of time.

The exercises in the third stage are aimed at developing speed–strength qualities and are performed for 10 seconds. The heart rate reaches 150–160 beats per minute, the intensity level is 80 points, and the exercises are carried out within Zone II (moderate intensity). The number of repetitions ranges from 20 to 25. This type of load develops the athlete's ability to rapidly express muscular strength, improves strike force and impulse transmission mechanisms, and increases the efficiency of energy transfer along the kinetic chain.

In the next stage, exercises aimed at developing speed qualities are applied. These exercises last approximately 5 seconds, with the heart rate reaching 165–175 beats per minute. The intensity level is 70 points, and the exercises are performed within Zone III (high intensity). The number of repetitions ranges from 50 to 55. These exercises primarily activate the anaerobic energy systems and improve the athlete's reaction speed, striking speed, and dynamic coordination of movements.

In the next stage, exercises aimed at developing specific speed and coordination abilities are performed. These exercises last for 10 seconds, with the heart rate maintained at 135–145 beats per minute. The intensity level is 50 points, and the load is carried out within Zone II (low-to-moderate intensity). The exercises are repeated 20–25 times. These exercises help to improve the athlete's technical movements, enhance the ability to consistently perform striking combinations, and improve movement coordination.

The exercises in the final stage include high-intensity speed–strength loads. These exercises last for 6 seconds, with the heart rate reaching 165–175 beats per minute. The intensity level ranges from 120 to 130 points, and the exercises are performed within Zone III (high intensity). The number of repetitions is limited to 2–3. These exercises are aimed at demonstrating maximum strength and speed, developing explosive muscle power, increasing strike force, and improving the ability to perform high-intensity movements.

In addition, the final-stage exercises last for 4 seconds, with the heart rate maintained at 120–130 beats per minute. The intensity level is 40 points, and the load is performed within Zone I (low intensity). The exercises are repeated 4–6 times. These exercises help activate recovery processes in the body, stabilize the functional state of the muscles, and accelerate post-training rehabilitation.

The mechanism for planning training loads according to intensity zones presented in the figure enables the comprehensive development of athletes' physical qualities, the scientific management of training loads during the training process, and the optimal organization of energy system activity to achieve high sports performance.

Conclusion. The conducted analysis shows that planning training loads according to intensity zones allows for the systematic and scientifically grounded development of athletes' physical qualities. Managing exercises through execution time, heart rate, intensity level, and the number of repetitions increases the effectiveness of the training process. Low-intensity exercises primarily activate the aerobic energy supply system and contribute to the development of general and specific endurance. Moderate-intensity exercises improve the speed–strength capabilities of the muscles and enhance the stability of striking techniques. High-intensity exercises activate anaerobic energy systems, thereby increasing speed, explosive power, and striking efficiency. The step-by-step organization of exercises makes it possible to provide training loads that correspond to the athlete's functional capacities. At the same time, it supports the optimal functioning of the cardiovascular system and promotes efficient energy metabolism in the muscles. Such an approach prevents excessive strain during the training process and accelerates recovery processes.

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