The importance of kinematic analysis in shaping kickboxers' striking technique

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Abstract

Purpose: In the process of an in-depth study of kickboxers' striking techniques, important biomechanical factors influencing the effectiveness of strikes are determined by identifying kinematic (speed, angular motion, acceleration) and kinetic (force, moment, pressure) indicators. Based on these analyses, the main goal of the study is to improve striking technique, establish a scientific approach to the training process, and develop effective training methods tailored to the individual characteristics of athletes.

Methods: Analysis of scientific and methodological literature, pedagogical tools, pedagogical observation, mathematical and statistical analysis.

Results: According to the kinematic analysis, the range of motion of the left knee is 16°, while that of the right knee is 27°. A wider range of motion in the right knee provides an advantage in the process of delivering strikes and making rapid changes in stance. Simultaneously, the limitation in the left knee indicates that it serves more of a supporting function. Overall, the role of the knees in generating strike power is of particular importance.

Conclusion: The activity of the hip joint is one of the decisive biomechanical factors in the process of impact force generation. At the same time, the limitation of abduction to only the right side indicates that it may restrict the athlete's dynamic balance and optimal force production mechanisms. From this perspective, an in-depth study of the kinematic characteristics of the elbow, wrist, and hip joints is crucial for increasing the energy efficiency of striking techniques in kickboxers, improving motor control, and scientifically optimizing defense strategies.

Keywords: striking technique, kinematic indicators, kinetic indicators, skilled athletes, biomechanics, sports analysis, impact force, movement coordination, muscle activity, athlete's technical preparation.

Introduction

Achieving high results in modern kickboxing is closely linked to the athlete's level of technical preparedness. The accuracy, power, and speed of striking movements (such as hand and foot strikes) are among the main factors determining an athlete's superiority in competition. Effective execution of these technical actions is accomplished not only through traditional training but also through scientifically-based biomechanical analyses. Specifically, kinematic and kinetic indicators allow for in-depth analysis of the mechanical properties of strikes, identification of existing shortcomings, and their elimination. Consequently, the training process is organized based on an individualized approach between the coach and athlete, increasing effectiveness. Therefore, studying striking techniques in kickboxing based on kinematic and kinetic parameters is important both theoretically and practically. The conclusions drawn from such research are of great significance for developing athletes' technical skills, fully realizing their potential, and achieving high sporting accomplishments.

Methods

Analysis of scientific and methodological literature, pedagogical instruments, pedagogical observation, mathematical and statistical analysis.

Results and discussion

In kickboxing, body bending (flexion/extension) plays a crucial role not only in increasing strike power but also in ensuring defense, speed, and balance. Studies have shown that forward and backward bending (5-6°) and lateral bending (-3° to -2°) indicators demonstrated an almost stationary state (Range = 0°). This suggests insufficient body engagement during strikes, resulting in a decrease in the impact's inertial force. Neck movements in various directions (flexion, extension, lateral bending, and rotation) provide kickboxers with four main advantages: protection from strikes, effective counterattack opportunities, increased punch power and accuracy, and maintenance of vestibular stability. For instance, a 15-20° lateral bend ("slip") neutralizes an opponent's straight punches within 0.25-0.4 seconds, and when combined with neck rotation ("roll"), defensive effectiveness increases by 68%. In a hook punch, rotating the neck by 8-12° enhances strike power by 15-20%.

Additionally, vestibular stabilization is of great importance: the ability to rotate the neck

up to 45° provides the athlete with a full 360° view in the ring, reducing fatigue. When bending sideways, the vestibular system restores balance in 0.08 seconds. Measurements have determined the neck's flexion (17°), rotation (-17°), and lateral flexion (4°) capabilities. While these indicators are positively assessed for protecting the head from impacts and observing movement direction, the fact that rotation occurs only to the right (max = 0° on the left side) indicates movement asymmetry. Thus, kinematic analysis plays a crucial role in developing punching techniques in kickboxers, improving defensive actions, and considering individual biomechanical characteristics.

during punching, technical deficiencies, or muscle limitations.

Raising the shoulders to ear level (elevation) and bringing them forward (protraction) increases the area of facial protection by 65%. Specifically, the forward movement of the left shoulder at a 45° angle serves as a "shield" for the body, while lowering the right shoulder allows the athlete to evade blows directed at the torso. Therefore, kinematic analysis plays a crucial role in assessing the effectiveness of shoulder movements, determining their impact force, accuracy, and role in defensive functions, as well as in identifying and correcting technical flaws.

Fig 1. Comparative results based on the kinematic analysis of arm and leg movement indicators of kickboxers

Body parts	Joints	Types of movements	Sides	Min (°)	Max (°)	Range (°)
Trunk	Bending	Front/Back	-	5	6	0
	Lateral bend	Right/Left	-	-3	-2	0
Neck	Bending	Flexion/Extension	-	0	17	17
	Lateral bend	Right/Left	-	4	9	4
	Rotation	Right/Left	-	16	0	-17
Shoulders	Bending	Flexion/Extension	Left	30	45	14
			Right	-1	20	21
	Elevation	Abduction	Left	78	82	3
			Right	0	0	0
Elbows	Bending	Flexion/Extension	Left	130	137	6
			Right	110	146	35
Hips	Bending	Flexion/Extension	Left	-7	5	12
			Right	14	27	12
	Lateral movement	Abduction	Left	0	0	0
			Right	25	34	8
Knees	Bending	Flexion/Extension	Left	21	38	16
			Right	26	54	27
Ankles	Bending	Dorsiflexion/Plantar Flexion	Left	5	17	11
			Right	-13	0	12

In kickboxing, the shoulders play a key role in transmitting punch power, defending, and maintaining balance. Shoulder rotation serves as a decisive link in transmitting impulses originating from the rear leg. For example, in a right cross punch, a 25-30° backward rotation of the left shoulder increases punch force by 40%. Analysis shows that shoulder movement is asymmetrical: in the left shoulder, flexion is 30-45°, while in the right it's -1-20°; in abduction, the left shoulder moves by 3°, and the right shoulder doesn't move at all (0°). This indicates insufficient use of the right shoulder

In kickboxing, elbows and forearms are important components of striking technique, playing a key role in defense, attack, maintaining balance, and energy transfer. The attacking functions of the elbows are manifested through various mechanisms: for example, in a cross punch, the elbow bends at a 90° angle, providing an optimal distance of 25-30 cm and increasing the strike force by 12%; in an uppercut, a 110-120° bend acts as a "piston" mechanism, effectively transferring energy. In a jab, bending the elbow at 45-60° maintains speed and reduces the return time from the strike by 0.2 seconds, while in a hook, a tightly held el-

bow at 75-85° reduces radial vibrations by 17%. The range of motion is also important: the left elbow has only 6° of very limited movement, while the right elbow actively works up to 35°. This asymmetry may reduce the effectiveness of the left elbow in defense or counter-attack. At the same time, bringing the elbows 20-30° closer to the body increases the effectiveness of rib protection by 40%. This asymmetry may reduce the effectiveness of the left elbow in defense or counter-attack.

The role of the wrists is particularly important in transmitting the accuracy and power of strikes. Keeping them in a 15-20° dorsal flexion position increases the accuracy of a jab by 25%, while a 25-30° palmar flexion in an uppercut allows for proper force direction. A 5-10° ulnar deviation at the point of impact increases force by 12-15%, and forearm pronation in a cross punch increases penetration by 18%. Wrists also perform crucial functions in defense: a 30° radial deviation ensures effective protection with the inner part of the arm, while bending the wrist 10-12° during impact reduces arm vibration by 40%.

Hip joint movement is also considered one of the main sources of strike force. However, the fact that abduction is observed only on the right side indicates certain limitations in the athlete's stability and power generation capabilities. Thus, kinematic analysis of the elbow, wrist, and hip joints is important for improving striking technique in kickboxers, increasing power and accuracy, and optimizing defensive movements.

In kickboxing, knees are crucial for generating strike power, movement, maintaining balance, and evading strikes. During footwork (sliding technique), keeping the knees bent at 25-30° is optimal for quick lateral movements. In an Orthodox stance, pulling the left knee back 5-10° enhances preparation for forward attacks, while rotating the knees 15-20° aids in turning the body 45°, creating favorable conditions for hook strikes.

According to kinematic analysis results, the left knee has a 16° range of motion, while the right knee has 27°. The wider range of motion in the right knee is beneficial for push-offs and quick platform changes, whereas the limited left knee indicates its primary support function. Knees play a vital role in generating strike force. For instance, in a cross strike, the right knee of the rear leg straightens from a 35-40° bend to 5-10°, completing the kinetic chain and transmitting 60% of the strike force. The left knee of the front leg increases speed by bending from 25° to 15° in a jab, while a 30° lateral bend in a hook generates additional force. Therefore, studying the kinematic properties of knees is crucial for improving striking technique, increasing speed, and stabilizing balance in kickboxers.

Conclusion

This study demonstrated that kinematic and kinetic indicators are of crucial importance in the in-depth analysis of striking techniques in kickboxers. According to the results of biomechanical analysis, the effectiveness of a strike directly depends on the balanced and harmonious functioning of the athlete's body parts, particularly the synchronous movements of the neck, shoulders, elbows, wrists, and lower body joints (hips, knees, ankles). The range of motion of each joint, as well as the angles of rotation and flexion in the direction of the strike, significantly affect the force and speed of the impact.

The study revealed that the asymmetry between the movements of the right and left sides plays a significant role in the athlete's technical capabilities and defensive strategies. Therefore, kinematic analysis is of great practical importance in further improving athletes' striking techniques, organizing the training process on a scientific basis, and developing effective training programs based on individual characteristics. These results serve as an important resource for coaches in developing methodological recommendations aimed at increasing striking force, reducing unnecessary movements, and maximizing the biomechanical potential of athletes. Overall, studying striking techniques based on kinematic analysis establishes a solid scientific foundation for implementing a scientific approach to kickboxing training and provides a robust basis for future research.

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