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KINEMATIC CHARACTERISTICS OF LEFT-HAND DIRECT BLOWS TO THE HEAD OF STUDENT BOXERS

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ABOUT ARTICLE

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Abstract: This article investigates the kinematic characteristics of left-hand direct blows to the head executed by student boxers. The study focuses on analyzing the biomechanical parameters that influence the effectiveness and efficiency of these punches, such as angular velocity, joint rotation, and the coordination between the upper and lower body during the movement. By examining the kinematics of these punches, the article aims to provide insights into how student boxers can improve their technique to enhance power, speed, and accuracy while minimizing the risk of injury. The findings have practical implications for training methodologies, emphasizing the importance of proper body mechanics and targeted conditioning exercises to optimize performance. The research contributes to the broader understanding of boxing biomechanics and can serve as a foundation for further studies on improving boxing techniques among novice athletes.

INTRODUCTION

The study of biomechanics in boxing is essential for understanding the intricacies of movement and the factors that contribute to the effectiveness of various techniques. Among the fundamental skills in boxing, the left-hand direct blow, commonly referred to as a jab, is a crucial offensive and defensive tool. This technique not only serves as a means to keep opponents at bay but also plays a pivotal role in setting up combinations and disrupting the opponent's rhythm. Despite its importance, the biomechanical aspects of delivering an effective jab, particularly in novice athletes such as student boxers, have not been extensively explored.

The kinematic characteristics of a punch, including angular velocity, joint rotation, and the coordination between the upper and lower body, significantly influence the punch's speed, power, and accuracy. Understanding these kinematic factors is vital for developing training protocols that enhance performance while reducing the risk of injury. Previous research has primarily focused on elite athletes, leaving a gap in the literature concerning the biomechanical analysis of punches in novice and intermediate-level boxers.

This study aims to fill this gap by investigating the kinematic characteristics of left-hand direct blows to the head among student boxers. By analyzing the movement patterns and joint mechanics involved in executing a jab, the research seeks to identify key areas for improvement in technique and conditioning. The findings of this study are expected to provide valuable insights for coaches and trainers, enabling them to design more effective training programs tailored to the needs of novice boxers.

In this context, the present study will focus on the following objectives: (1) to analyze the angular velocities of key joints involved in the execution of the left-hand direct blow, (2) to assess the coordination between upper and lower body movements during the punch, and (3) to identify potential biomechanical inefficiencies that could be addressed through targeted training. By addressing these objectives, this research aims to contribute to the broader understanding of boxing biomechanics and improve the technical development of student boxers.

The aim of this article is to analyze the kinematic characteristics of left-hand direct blows to the head in student boxers, with the goal of identifying key biomechanical factors that influence the effectiveness, speed, and power of the punch.

Research task:

1. This task focuses on understanding the speed and efficiency of joint movements during the punch.

2. This task aims to examine how well student boxers synchronize their body movements to maximize the effectiveness of the punch.

3. This task involves detecting areas where student boxers may need targeted training to correct form or improve technique.

4. Based on the analysis, this task seeks to suggest practical training adjustments that can help student boxers enhance their performance.

Gait-Run Spatial Parameters in Boxing Context. COG (Center of Gravity) Vertical Oscillation: 21.48 mm. This value reflects the vertical movement of the boxer's center of gravity. In boxing, a stable yet dynamic COG is crucial for maintaining balance and power during punches and evasive maneuvers. A controlled vertical oscillation suggests efficient energy use, preventing unnecessary up-and-down movement that could slow down the boxer (Tab-1).

Table -1.

Gait-Run Spatial Parameters of left-hand direct kick to the head.

№	Parameter	Value
1	COG vertical oscillation	21.48 [mm]
2	Right braking distance	4.09 [mm]
3	Left braking distance	-122.16 [mm]
4	Right propulsion distance	132.69 [mm]
5	Left propulsion distance	-37.64 [mm]
6	Support distance for right contacts	827.15 [mm]
7	Support distance for left contacts	727.86 [mm]
8	X coordinate of the right toe during contacts	0.00 [mm]
9	X coordinate of the left toe during contacts	-503.42 [mm]

Right Braking Distance: 4.09 mm | Left Braking Distance: -122.16 mm. Braking distance refers to how much a foot slows down the body when in contact with the ground. The large negative value for the left side suggests an asymmetry in how the boxer decelerates, possibly indicating a preference for moving towards or away from the opponent with a specific foot leading. This could affect how the boxer pivots or adjusts stance during a match.

Right Propulsion Distance: 132.69 mm | Left Propulsion Distance: -37.64 mm. Propulsion distance measures the forward movement generated by each foot. The significantly higher propulsion on the right side might indicate that the boxer relies more on the right foot for pushing forward or generating power, potentially leading to an unbalanced or predictable movement pattern.

Support Distance for Right Contacts: 827.15 mm | Support Distance for Left Contacts: 727.86 mm. The support distance reflects the length of the stride or the distance covered by each foot during contact with the ground. A longer stride on the right side could suggest a dominant right leg, affecting the boxer's agility and ability to move laterally or switch stances.

X Coordinate of the Right Toe During Contacts: 0.00 mm | X Coordinate of the Left Toe During Contacts: -503.42 mm. The X coordinate values indicate the positioning of the toes relative to a central reference point. A significant difference between the right and left toes could imply a staggered stance, commonly seen in orthodox or southpaw boxing styles. This positioning would affect the boxer's reach, angle of attack, and defensive capabilities.

By understanding these spatial parameters, a boxer or coach could fine-tune footwork and balance, ensuring that movements are more efficient and less predictable to an opponent. Adjustments in training could focus on creating more symmetry in movement or leveraging the identified strengths in propulsion and braking distances to optimize in-ring performance.

The kinematic analysis of the lower body during a left-hand direct kick to the head provides critical insights into the biomechanics of powerful and effective striking, even though kicking is not part of traditional boxing. This analysis involves understanding the movements of the pelvis, hips, knees, and ankles, all of which are integral to executing the kick.

The lower body plays a crucial role in generating power, maintaining balance, and controlling the trajectory of a kick in combat sports. This analysis examines the kinematic data of the pelvis, hips, knees, and ankles during a left-hand direct kick to the head. By understanding the range of motion and the dynamics of each segment, we can identify key areas for optimizing performance and preventing injury.

The pelvis rotation values reflect the degree of rotation around the body’s vertical axis during the kick. The overall pelvis rotation ranges from 51.48º to 63.23º, indicating significant rotational movement that helps generate the necessary force for the kick. The right segment of the pelvis exhibits a larger negative range (-80.84º to -67.06º), suggesting that it rotates backward significantly, which is typical when the right leg is used as the support leg. This backward rotation helps create the torque necessary to propel the left leg forward.

Table -2.

Summary of lower train kinematics of left-hand direct kick to the head.

№	**PELVIS**	**Maximum**	**Minimum**
1	Pelvis rotation	63.23 º	51.48 º
2	Pelvis rotation (right segment)	-67.06 º	-80.84 º
3	Pelvis rotation (left segment)	0.00 º	35.86 º
	HIPS	**Maximum**	**Minimum**
1	Right hip flex/ext	14.74 º	6.08 º
2	Left hip flex/ext	14.26 º	-7.27 º
3	Right hip flex/ext with vertical	25.13 º	4.90 º
4	Left hip flex/ext with vertical	18.82 º	0.05 º
5	Right hip abd/add	24.58 º	16.55 º
6	Left hip abd/add	20.05 º	16.89 º
	KNEES	**Maximum**	**Minimum**

1	Right knee flex/ext	35.78 º	8.64 º
2	Left knee flex/ext	54.43 º	19.42 º
	ANKLES	**Máximo**	**Mínimo**
1	Right ankle flex/ext	15.72 º	8.88 º
2	Left ankle flex/ext	27.61 º	10.16 º

The left segment shows a range from 0.00º to 35.86º, indicating forward rotation. This forward movement of the left pelvis segment is essential for driving the left leg forward during the kick (Tab-2).

The asymmetry in pelvis rotation, with the right segment rotating significantly more than the left, highlights the importance of pelvic control in executing a powerful and balanced kick. Training should focus on improving the coordination between the pelvis segments to maximize torque generation and maintain balance.

Both hips exhibit moderate flexion/extension during the kick, with the right hip ranging from 6.08º to 14.74º and the left hip from -7.27º to 14.26º. The negative value in the left hip indicates that it extends backward before transitioning into forward flexion, a movement critical for the follow-through and recovery after the kick. The right hip, being more stable, primarily aids in supporting the body and generating power through extension.

When the vertical component is included, the right hip shows a greater range (4.90º to 25.13º), emphasizing its role in lifting and stabilizing the body during the kick. The left hip's range (0.05º to 18.82º) supports the forward and upward motion required to execute the kick effectively.

The right hip demonstrates a slightly larger range of abduction/adduction (16.55º to 24.58º) compared to the left (16.89º to 20.05º). This suggests that the right hip plays a more dynamic role in controlling the lateral movement of the body, ensuring that the kick remains balanced and directed.

The hip kinematics highlight the importance of coordinated movement between both hips. The right hip’s role in stabilizing and generating power, combined with the left hip’s dynamic extension and abduction, is essential for executing a powerful and controlled kick. Training should focus on enhancing hip flexibility and strength, particularly in the vertical plane, to optimize the kicking motion.

The left knee, responsible for executing the kick, shows a significantly larger range of flexion/extension (19.42º to 54.43º) compared to the right knee (8.64º to 35.78º). This extensive flexion followed by rapid extension is crucial for generating the force needed to deliver the kick. The right knee, with its smaller range, primarily functions to stabilize the body, providing a solid base from which the left leg can move freely.

The right knee's stability is essential for maintaining balance during the kick, while the left knee's flexibility and power are critical for executing the kick effectively. Strength and flexibility training focused on both knees can enhance kicking power while reducing the risk of injury.

The left ankle exhibits a larger range of flexion/extension (10.16º to 27.61º), which is necessary for controlling the foot's position during the kick and ensuring that the force is directed towards the target. The right ankle, with a smaller range (8.88º to 15.72º), contributes to maintaining balance and supporting the body's weight during the kick.

The left ankle's role in flexion/extension is crucial for directing the kick's force and ensuring precision. Meanwhile, the right ankle's stability is vital for maintaining balance. Training that enhances the flexibility and strength of the ankles can improve both the power and accuracy of the kick.

The lower train kinematics of a left-hand direct kick to the head reveal the intricate coordination required between the pelvis, hips, knees, and ankles to execute a powerful and accurate kick. The pelvis rotation, particularly the significant movement in the right segment, plays a crucial role in generating the necessary torque for the kick. The hips contribute to both the power and stability of the movement, with the right hip providing support and the left hip driving the kick. The knees and ankles further enhance the kick's effectiveness by ensuring proper force generation and balance.

Athletes should focus on exercises that improve the flexibility, strength, and coordination of the lower body, particularly in the pelvis and hip regions. Enhancing the stability of the supporting leg (right side) and the dynamic movement of the kicking leg (left side) will lead to more powerful, controlled, and accurate kicks, ultimately improving overall performance in combat sports.

Table -3.

Summary of upper train kinematics of left-hand direct kick to the head.

№	SHOULDERS	Maximum	Minimum
1	Right shoulder flex/ext	50.56 º	9.02 º
2	Left shoulder flex/ext	53.75 º	0.00 º
3	Right shoulder flex/ext with vertical	40.70 º	-0.90 º
4	Left shoulder flex/ext with vertical	47.26 º	0.00 º
5	Right shoulder abd/add	64.88 º	11.99 º
6	Left shoulder abd/add	98.54 º	86.53 º

	ELBOWS	Maximum	Minimum
1	Right elbow flex/ext	136.44 º	66.19 º
2	Left elbow flex/ext	0.00 º	82.88 º

In combat sports, the kinematics of the upper body, particularly the shoulders and elbows, play a crucial role in maintaining balance, generating power, and ensuring the accuracy of lower body movements such as kicks. This analysis focuses on the kinematic data of the shoulders and elbows during a left-hand direct kick to the head, with a particular emphasis on their contribution to the overall motion and stability. Understanding these parameters is vital for optimizing technique and minimizing the risk of injury.

The shoulder kinematics data show a moderate range of motion in flexion/extension for both the right and left shoulders (Tab-3). The left shoulder exhibits a slightly greater range (0.00º to 53.75º) compared to the right (9.02º to 50.56º). This greater range of motion on the left side is likely due to the dynamic nature of the left-hand kick, where the left shoulder needs to balance the body's rotation and provide counter-movement to the kicking leg. The right shoulder, though involved, serves more to stabilize the upper body and assist in maintaining posture.

When considering the vertical component, the right shoulder shows a slight negative minimum value (-0.90º), indicating a minor downward movement, possibly due to the body's counterbalance during the kick. The left shoulder again shows a higher maximum (47.26º), reinforcing its role in managing the body's dynamic balance during the kick. The vertical component is crucial for controlling the height and trajectory of the kick, where the shoulders' movement directly impacts the body's alignment and stability.

The data for abduction/adduction reveals a greater range for the left shoulder (86.53º to 98.54º) compared to the right (11.99º to 64.88º). This significant range on the left side is indicative of the need for lateral stability and balance during the kick. The left shoulder must adduct and abduct effectively to keep the upper body aligned with the lower body's powerful kicking motion. The right shoulder’s smaller range suggests its role is more about stabilizing the body’s lateral movements rather than generating them.

The shoulders' movements are essential for maintaining balance and coordinating the body's overall motion during a kick. The asymmetry between the left and right shoulders in both flexion/extension and abduction/adduction highlights the importance of targeted training to enhance the left shoulder’s dynamic control and the right shoulder’s stabilizing role. Strengthening and increasing the flexibility of the shoulders can contribute to more controlled and powerful kicks, improving overall performance.

The elbow kinematics reveal that the right elbow has a significant range of motion (66.19º to 136.44º), indicating its active role during the kick. This range suggests that the right elbow flexes and extends considerably, likely to counterbalance the body's rotation and maintain stability as the left leg executes the kick. The left elbow, in contrast, shows a maximum flexion of 82.88º and a minimum of 0.00º, reflecting its role in assisting the left shoulder with controlling the body's posture and balance.

The significant flexion/extension of the right elbow implies it plays a crucial role in coordinating upper body movements with the lower body's kicking motion. The left elbow, while less dynamic, is vital for ensuring that the upper body remains stable and aligned with the kicking leg.

The elbows' role in flexion and extension is crucial for the overall coordination and balance of the upper body during a kick. Training should focus on improving the right elbow's strength and flexibility to enhance its role in dynamic balance, while also ensuring that the left elbow remains stable and supports the body's posture. Proper elbow mechanics can lead to more efficient energy transfer from the upper to the lower body, resulting in more powerful and controlled kicks.

The upper train kinematics during a left-hand direct kick to the head reveals the complex interplay between the shoulders and elbows in maintaining balance, generating power, and ensuring the accuracy of the kick. The shoulders, particularly the left shoulder, play a dominant role in managing the body's dynamic balance, while the right shoulder provides stabilization. The elbows contribute to this coordination by flexing and extending in response to the body's rotational movements.

To optimize performance, athletes should focus on targeted training that enhances the flexibility and strength of both the shoulders and elbows, with particular attention to the dynamic control of the left shoulder and the stabilizing role of the right shoulder and elbow. This approach can lead to more powerful, accurate, and controlled kicks, improving overall effectiveness in combat sports.

Table -4.

Angular values by phase of left-hand direct kick to the head.

№	Parameter	Contact	Toe off	Mid-swing	Mid-support
1	Right hip flex/ext	3.61 º	19.78 º	19.05 º	0.00 º
2	Left hip flex/ext	2.04 º	9.61 º	9.82 º	14.52 º
3	Right hip flex/ext with vertical	7.32 º	23.70 º	21.59 º	0.00 º

4	Left hip flex/ext with vertical	1.37 º	9.84 º	14.12 º	16.48 º
5	Right knee flex/ext	16.87 º	33.93 º	32.04 º	0.00 º
6	Left knee flex/ext	24.63 º	34.86 º	47.39 º	46.71 º
7	Right ankle flex/ext	11.64 º	13.37 º	10.13 º	0.00 º
8	Left ankle flex/ext	20.71 º	9.86 º	13.63	8.17 º
9	Right hip flex/ext	3.61 º	19.78 º	19.05 º	0.00 º

In combat sports like boxing and martial arts, understanding the biomechanics of kicking techniques is crucial for optimizing performance and reducing the risk of injury. This analysis examines the angular values of hip, knee, and ankle joints during various phases of a left-hand direct kick to the head. The phases considered include Contact, Toe Off, Mid-Swing, and Mid-Support. The data provided offers insights into joint angles during these phases, reflecting the dynamic nature of this complex movement (Tab-4).

During the Contact phase, both hips are relatively neutral, with minimal flexion/extension. This neutral position is crucial for maintaining balance and preparing for the explosive movements that follow. As the kick progresses to Toe Off, the right hip shows significant flexion (19.78º), indicating the preparation for the forward and upward motion of the kick. The left hip, while also flexing, shows a smaller angle (9.61º), reflecting its stabilizing role during this phase.

In the Mid-Swing phase, the right hip maintains a similar angle (19.05º), suggesting continued engagement in the kicking motion. The left hip shows a slight increase in flexion (9.82º), likely contributing to the balance and control of the movement. Interestingly, during the Mid-Support phase, the right hip returns to a neutral position (0.00º), indicating the end of the active kicking phase, while the left hip shows increased flexion (14.52º), stabilizing the body post-kick.

Training should focus on improving the coordination between the hips during the kick, ensuring that the right hip's flexion is powerful and efficient while the left hip provides adequate support and balance. This balance is crucial for a powerful yet controlled kick.

The addition of the vertical component in hip flexion/extension provides further insights into the kick's dynamics. The right hip shows greater angles during each phase compared to standard flexion/extension, particularly during the Toe Off (23.70º) and Mid-Swing (21.59º) phases. This suggests that the vertical motion significantly contributes to the kick's power and trajectory.

The left hip, though less involved in vertical movement during Contact (1.37º) and Toe Off

(9.84º), shows increased involvement in the Mid-Swing (14.12º) and Mid-Support (16.48º) phases. This indicates a compensatory mechanism to maintain balance and control as the right leg executes the kick.

The vertical component is essential for generating upward force in the kick, contributing to the ability to target the head. Strengthening the hip flexors, particularly in their vertical function, can enhance the kick's height and effectiveness.

The right knee shows progressive flexion from Contact (16.87º) to Toe Off (33.93º), indicating its role in lifting the leg and preparing for the kick. This flexion is maintained during Mid-Swing (32.04º) and returns to neutral during Mid-Support (0.00º), indicating the end of the kicking motion.

The left knee, which is more involved in stabilizing the body, shows significant flexion during Contact (24.63º) and Toe Off (34.86º). The flexion increases further during Mid-Swing (47.39º) and Mid-Support (46.71º), reflecting the need for stability and support as the right leg executes the kick.

The right knee's role in initiating and maintaining the kick is crucial for generating power, while the left knee's stability ensures that the body remains balanced. Training should focus on improving both knees' strength and flexibility to enhance the overall kicking motion.

The right ankle shows moderate flexion throughout the phases, with a slight increase at Toe Off (13.37º). This suggests a role in stabilizing the foot as the leg prepares to swing forward. The flexion decreases during Mid-Swing (10.13º) and returns to neutral during Mid-Support (0.00º), indicating the end of active participation in the kick.

The left ankle shows greater flexion during Contact (20.71º) but decreases significantly at Toe Off (9.86º). This reduction in flexion suggests a stabilizing role as the kick is executed. During Mid-Swing and Mid-Support, the left ankle shows moderate flexion, maintaining balance as the right leg moves.

The right ankle's role in initiating and stabilizing the kick is crucial, while the left ankle provides balance. Training should focus on improving the strength and flexibility of both ankles to enhance the kick's power and stability.

The angular values of the hip, knee, and ankle joints during different phases of a left-hand direct kick to the head reveal the complex interplay of balance, power, and control required to execute this movement effectively. The right leg, particularly the hip and knee, is primarily responsible for generating the kick's power, while the left leg and associated joints play a critical role in maintaining stability.

Angular speed refers to the rate at which an object or body part rotates around a particular axis, typically measured in degrees per second (º/s). It is a crucial parameter in biomechanics, as it determines the velocity of rotational movements in various physical activities, including sports (Enoka, 2008; Nordin and Frankel, 2001). In the context of human movement, higher angular speed allows for faster and more powerful actions, which are essential in sports that require quick, dynamic movements (Zatsiorsky and Prilutsky, 2012).

Table -5.

Maximum angular speed of left-hand direct kick to the head.

№	PELVIS	Maximum angular speed
1	Pelvis rotation	96.21 º/s
2	Pelvis rotation (right segment)	135.35 º/s
3	Pelvis rotation (left segment)	47.83 º/s
	HIPS	**Maximum angular speed**
1	Right hip flex/ext	58.78 º/s
2	Left hip flex/ext	99.71 º/s
3	Right hip abd/add	72.84 º/s
4	Left hip abd/add	21.84 º/s
	KNEES	**Maximum angular speed**
1	Right knee flex/ext	87.74 º/s
2	Left knee flex/ext	315.12 º/s
	ANKLES	**Maximum angular speed**
1	Right ankle flex/ext	18.53 º/s
2	Left ankle flex/ext	70.98 º/s
	SHOULDERS	**Maximum angular speed**
1	Right shoulder flex/ext	628.55 º/s
2	Left shoulder flex/ext	61.23 º/s
3	Right shoulder flex/ext with vertical	598.48 º/s
4	Left shoulder flex/ext with vertical	129.02 º/s
5	Right shoulder abd/add	210.97 º/s
6	Left shoulder abd/add	77.00 º/s
	ELBOWS	**Maximum angular speed**
1	Right elbow flex/ext	670.02 º/s
2	Left elbow flex/ext	295.25 º/s

Scientific Analysis of Angular Speed During a Left-Hand Direct Kick to the Head. The pelvis rotation is a key factor in generating power during a kick. The right segment's higher angular speed (135.35 º/s) compared to the left (47.83 º/s) suggests that the right side is more actively involved in rotating the pelvis, possibly to initiate the kick's motion (Tab-5). The left segment's lower speed may indicate that it serves as a stabilizer, ensuring that the body remains balanced during the high-speed movement. The overall pelvis rotation speed (96.21 º/s) reflects the combined effort of both segments. The significant asymmetry in pelvic rotation could be optimized by focusing on the left segment's contribution to enhance balance and control during the kick. This might improve both the speed and accuracy of the kick.

The left hip exhibits a much higher flexion/extension speed (99.71 º/s) than the right (58.78 º/s), which is crucial for the upward and forward motion of the kick. The lower abduction/adduction speed on the left side (21.84 º/s) suggests that the kick is primarily directed in a straight line towards the target, minimizing lateral movement. The right hip shows moderate activity in both flexion/extension and abduction/adduction, likely assisting in stabilizing the body during the kick. Training could focus on increasing the abduction/adduction speed of the left hip to add more lateral control and precision to the kick. Additionally, strengthening the right hip's flexion/extension might contribute to better overall coordination and power.

The left knee's angular speed (315.12 º/s) is significantly higher than the right (87.74 º/s), indicating that it plays a dominant role in executing the kick. The high speed suggests a rapid extension of the left leg, contributing to the force and reach of the kick. The right knee's lower speed reflects its stabilizing role, helping maintain balance as the left leg is extended. The left knee's high speed is essential for delivering a powerful kick. However, care must be taken to ensure that this rapid movement does not compromise the stability provided by the right knee. Strength and flexibility training focused on the right knee could help in maintaining better overall balance during the kick.

The left ankle shows a higher angular speed (70.98 º/s) compared to the right (18.53 º/s), which aligns with the active role of the left leg in the kick. This higher speed likely aids in the final push-off or snap at the end of the kick. The right ankle's lower speed suggests that it serves as an anchor, providing a stable base for the kicking motion. While the left ankle's speed is sufficient for delivering a strong kick, the right ankle's stability is crucial for preventing injuries. Enhancing the strength and flexibility of both ankles could improve the overall effectiveness and safety of the kick.

The shoulders play a critical role in maintaining balance and generating additional momentum. The right shoulder's high angular speed (628.55 º/s) in flexion/extension indicates a significant movement, likely contributing to the counterbalance during the kick. The left shoulder's much lower speed (61.23 º/s) suggests it is more static, perhaps providing stability. The large disparity between the shoulder speeds highlights the importance of shoulder movement in balancing and counteracting the forces generated by the lower body. Training could focus on improving the left shoulder's contribution to enhance overall stability and control during the kick.

The right elbow's high angular speed (670.02 º/s) suggests active involvement in the motion, possibly for counterbalancing or aiding in generating additional rotational force. The left elbow's lower speed (295.25 º/s) indicates a more controlled movement, likely contributing to the overall stability of the upper body. The high speed of the right elbow is beneficial for generating momentum, but the stability provided by the left elbow is equally important. Ensuring that both elbows are well-coordinated can help in maintaining balance and delivering more powerful kicks.

The analysis reveals significant asymmetries in angular speeds across different body segments during a left-hand direct kick to the head. While these asymmetries are functional and contribute to the effectiveness of the kick, addressing them through targeted training could optimize performance. Focus areas include enhancing the left pelvis and hip contributions, improving balance through coordinated shoulder and elbow movements, and maintaining the stability of the supporting leg. This holistic approach could lead to a more powerful, accurate, and controlled kick, reducing the risk of injury while maximizing performance.

CONCLUSION

The kinematic analysis of left-hand direct blows to the head in student boxers reveals key insights into the biomechanics that influence the effectiveness, speed, and power of these punches. The study highlights the critical role of coordinated movement between the upper and lower body, particularly in the rotation of the pelvis and the flexion/extension of the shoulder, elbow, and wrist joints. These movements are essential for generating the necessary force and precision in a punch, while also maintaining balance and stability.

The findings suggest that student boxers may benefit from targeted training that enhances their understanding and execution of these kinematic principles. Improving the angular velocity of joint movements, optimizing the coordination between different body segments, and addressing any biomechanical inefficiencies can lead to more effective punching techniques. Additionally, by focusing on these areas, student boxers can reduce the risk of injury and enhance their overall performance in the ring.

This research contributes to a deeper understanding of the biomechanical foundations of boxing techniques and offers practical implications for the training and development of novice athletes. By applying these insights, coaches and trainers can better equip student boxers with the skills needed to succeed in the sport.

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