RANGE OF MOTION INDICATORS IN THE MAJOR BODY JOINTS DURING THE EXECUTION OF THE FORWARD JUMP TECHNIQUE WITH THE LEFT LEG IN BOXERS

F.Qo'chqorov
Andijan State University
E-mail: quchkarov@gmail.com

https://doi.org/10.5281/zenodo.16758054

Abstract: This article presents a kinematic analysis of the implementation of the left-foot stepping technique in boxing, and the movement of the body joints and the stepping trajectory in this process. As a result of this analysis, the necessary instructions and recommendations will be developed for improving the stepping technique of boxers.

Keywords: boxing, left foot, stepping, kinematics, sliding, technique, exercise.

BOKSCHILARDA CHAP OYOQ BILAN OLDINGA SAKRASH TEXNIKASINI BAJARISHDA ASOSIY TANA BO'G'IMLARIDAGI HARAKAT KO'RSATKICHLARI DIAPAZONI

Annotatsiya: ushbu maqolada boks sport turida chap qoyoq yordamida qadam tashlash texnikasini amalga oshirish va bu jarayonida tana bog'imlarining harakati va qadam tashlash treaktoriyasi bo'yicha kinematic tahlil amalga oshirilgan. Ushbu tahlil natijasida bokschilarning qadam tashlat texnikasini takomillashtirish yuzasidan kerakli ko'rsatma va tavsiyalar ishlab chiqiladi.

Kalit so'zlar: boks, chap oyoq, qadam tashlash, kinematika, siljib yurish, texnika, mashq.

ПОКАЗАТЕЛИ АМПЛИТУДЫ ДВИЖЕНИЙ В ОСНОВНЫХ СУСТАВАХ ТЕЛА ПРИ ВЫПОЛНЕНИИ ТЕХНИКИ ПРЫЖКА ВПЕРЕД ЛЕВОЙ НОГОЙ У БОКСЕРОВ

Аннотация: В статье представлен кинематический анализ реализации техники шага левой ногой в боксе, а также движения суставов тела и траектории шага при этом. В результате анализа будут разработаны необходимые указания и рекомендации по совершенствованию техники шага боксеров.

Ключевые слова: бокс, левая нога, шаг, кинематика, скольжение, техника, упражнение.

INTRODUCTION

Boxing distinguishes itself from other combat sports through its high-intensity movements, complex technical and tactical decisions, and the demand for advanced physical conditioning. In particular, a boxer's movement style in the ring—along with their speed, agility, and ability to maintain balance—are key factors in gaining an advantage over an opponent. From this perspective, the boxer's ability to reposition through forward jumping, adopt a favorable stance for striking, or transition from defense to offense must be technically precise.

In the forward jumping movement performed with the left leg, the coordination of motion amplitudes in the body's major joints—such as the ankle, knee, hip, waist, and shoulder—is crucial. The balanced and synchronized kinematic functioning of these joints serves as a key indicator of movement efficiency [1,2,3].

Biomechanical analyses show that studying the amplitude of athletes' movements helps improve technique, enhance energy efficiency, and reduce unnecessary physical strain. In turn, this plays a vital role in injury prevention and maintaining performance stability during competition. Specifically, in the forward jumping technique using the left leg, a detailed understanding of joint movements provides a foundation for improving technical and tactical preparation systems [4,5,6,7,8,9,10].

This study aims to identify and analyze the range of motion in major joints during the execution of the forward jump with the left leg in boxing, and to draw scientifically grounded conclusions for optimizing athletes' techniques. The research also explores the practical implementation of biomechanical approaches in boxing training.

Research Objective: To improve footwork technique by analyzing the range of motion in the main body joints during the execution of the forward jump with the left leg in boxers.

Research Tasks: To study the technique of forward stepping with the left leg;

To determine the involvement of joints during this movement and conduct a kinematic analysis; To develop relevant guidelines and recommendations based on the obtained results.

Research Methods: Pedagogical observation, video analysis, pedagogical testing, and mathematical-statistical analysis.

RESULTS AND DISCUSSION

The precision and effectiveness of athletes' movements are closely linked to their level of technical preparation, and in boxing, the accurate and balanced execution of every technical action is of critical importance. In modern boxing trends, the speed, dynamics, and accuracy of both defensive and offensive movements are directly related to the performance of the athlete's musculoskeletal system. One such essential technical movement is the forward double jump performed using the left leg, which plays a key role in enabling the boxer to quickly approach the opponent or change position while maintaining speed and balance.

One of the main factors ensuring the efficiency of movement is the range of motion in the body's major joints. By analyzing the angular range of joint motion, it becomes possible to evaluate how correctly and in how coordinated a manner the technique is being performed. From this standpoint, a kinematic analysis of the hip, knee, ankle, and pelvic joints during the execution of the forward double jump with the left leg serves as an important methodological basis for assessing the athlete's technical proficiency and movement coordination.

In this study, the angular amplitudes of flexion, abduction, and rotation in the major joints of the body during the execution of the forward double lunge technique with the left leg were examined. Differences between the control and experimental groups were statistically analyzed. The results of this analysis have important practical value for optimizing training processes, improving technique, and developing individualized training approaches.

Pelvic flexion is a key biomechanical parameter that defines body flexibility and the amplitude of movement. In the double lunge technique, the pelvic flexion angle is one of the main factors determining the optimal positioning of the rear leg. This movement is crucial for ensuring the effective transfer of force through the lower body and maintaining overall stability.

According to the analysis results, the average pelvic flexion range was 4±0.5° in the control group and 4±0.7° in the experimental group. These identical values indicate a technically consistent execution of flexion in both groups (see Table 1). The coefficient of variation was 12.5% in the control group and 17.5% in the experimental group, suggesting slightly greater individual variability in the experimental group. This difference may be attributed to the training methodology, individual movement strategies, or differences in muscle elasticity.

Moreover, statistical analysis showed that the difference between the groups was not significant ($p > 0.05$), indicating that there was no meaningful difference in pelvic flexion range between the control and experimental groups.

Table 1. Range of Motion Indicators (°) in the Major Body Joints During the Execution of the Forward Double Jump Technique with the Left Leg in Boxers

№	Indicators	Control Group (n = 14)	CV, %	Experimental Group (n = 14)	CV, %	t	p
1	Pelvic flexion range (°)	4 ± 0.5	12.5	4 ± 0.7	17.5	0.62	>0.05
2	Pelvic abduction range (°)	2 ± 0.2	10.0	2.03 ± 0.2	9.85	0.21	>0.05
3	Pelvic rotation range (°)	20 ± 3.4	17.0	21.3 ± 3.2	15.02	0.85	>0.05
4	Hip flexion range (°)	18 ± 2.4	13.33	17.2 ± 2.7	15.70	0.61	>0.05

5	Hip abduction range (°)	19.1 ± 2.8	14.66	19.45 ± 3.1	15.94	0.67	>0.05
6	Hip rotation range (°)	8 ± 0.9	11.25	8.4 ± 0.9	10.71	0.34	>0.05
7	Knee flexion range (°)	36 ± 4.5	12.5	35 ± 4.2	12.0	0.82	>0.05
8	Knee abduction range (°)	14 ± 2.7	19.29	14.1 ± 2.8	19.86	0.14	>0.05
9	Knee rotation range (°)	5.24 ± 0.9	17.18	5.48 ± 0.9	16.42	0.85	>0.05
10	Ankle flexion range (°)	25 ± 3.4	13.6	26.4 ± 3.4	12.88	0.54	>0.05
11	Ankle abduction range (°)	7.4 ± 0.8	10.81	8.7 ± 1.48	17.01	1.63	>0.05
12	Ankle rotation range (°)	9 ± 0.8	8.89	10.12 ± 2.7	26.68	0.34	>0.05
13	Foot direction range (°)	9 ± 0.7	7.78	10.2 ± 1.8	17.65	0.74	>0.05

Note: The table presents the range of motion for each joint in terms of flexion, abduction, and rotation, along with their coefficients of variation (V, %), and the statistical differences (t, p) between the control and experimental groups.

RESULTS AND DISCUSSION

Pelvic abduction is an important biomechanical factor in maintaining balance in the frontal plane, controlling the jump direction, and distributing load optimally on the left leg. In the "double lunge" technique, this phase directly affects movement coordination and postural stability.

According to the analysis results, the average pelvic abduction range was 2±0.2° in the control group and 2.03±0.2° in the experimental group. These values are nearly identical, indicating that the angle of abduction was stable and consistent in both groups. The coefficient of variation was 10.0% in the control group and 9.85% in the experimental group, showing low variability and good repeatability across athletes. Statistical analysis confirmed that the differences between the groups were not significant ($P > 0.05$), suggesting that training conditions or methodological differences had no meaningful effect on this joint's movement (see Table 1).

Pelvic abduction range is one of the main components ensuring stability in technical movement structure. Stable values of this parameter reflect a well-formed and functionally effective double lunge technique.

Pelvic rotation plays a crucial role in axial plane movement, especially in effectively linking the kinetic chain between upper and lower body segments. In the double lunge technique, this component is essential for proper weight transfer to the left leg, maintaining balance, and controlling movement direction.

The analysis showed that the average pelvic rotation range was 20±3.4° in the control group and 21.3±3.2° in the experimental group. Although numerically different, statistical analysis did not find this difference to be significant ($P > 0.05$). The coefficient of variation was 17.0% in the control group and 15.02% in the experimental group, indicating a relatively consistent execution with slightly higher stability in the experimental group. These values suggest that the pelvic rotation movement was performed similarly in both groups and that training methodology did not exert a statistically significant influence.

Hip flexion is a major dynamic link in lower-body movement, especially during jumping with the left leg in the double lunge technique. It facilitates forward displacement, lowers the center of gravity, and initiates force-generating movement.

In the control group, the average hip flexion range was 18±2.4°, and in the experimental group, it was 17.2±2.7°. These similar values indicate overall coordination across groups. The coefficient of variation was 13.33% in the control group and 15.70% in the experimental group, reflecting slightly more variability in the experimental group—likely due to differences in training approach or muscle flexibility. However, the difference was not statistically significant ($P > 0.05$), indicating no substantial effect of experimental factors on this parameter.

Knee flexion is a decisive biomechanical phase for lower-limb motion, especially during jump preparation and push-off in the double lunge. It reflects the athlete's power production, balance, and adaptability in the kinetic chain.

The average knee flexion range was 36±4.5° in the control group and 35±4.2° in the experimental group—very close values that indicate technical stability in both groups. The coefficient of variation was 12.5% for the control group and 12.0% for the experimental group, suggesting high accuracy in movement repetition and minimal individual differences. Statistical analysis confirmed that the difference was not significant (P > 0.05), implying that the training method did not notably influence knee flexion amplitude.

Knee rotation is vital for energy transfer between lower-body segments, coordination, and elasticity. In the double lunge, the knee's rotational angle is a functional movement that ensures correct leg positioning and balance.

In the control group, the average knee rotation was 14±2.7°, while in the experimental group, it was 14.1±2.8°. The similarity in these values indicates consistent technical performance and motor control across groups. The coefficient of variation was 19.29% in the control group and 19.86% in the experimental group, suggesting a relatively high level of individual variability—likely influenced by anatomical features such as joint shape and muscle attachment. Statistical analysis confirmed that the difference was not significant (P > 0.05). Despite high variability, the movement was biomechanically and functionally consistent in both groups, though an individualized approach may be necessary.

Ankle flexion (dorsal and plantar) plays a key role in ensuring stable movement of the lower leg and force production during ground contact. In the double lunge technique, this joint's flexion angle directly participates in balance, shock absorption, and propulsion.

The average ankle flexion range was 25±3.4° in the control group and 26.4±3.4° in the experimental group. The values were close, and although slightly higher in the experimental group, the difference was not statistically significant (P > 0.05). The coefficient of variation was 13.6% in the control group and 12.88% in the experimental group, indicating stable and consistent movement in both groups. Low variability suggests that the ankle flexion movement is well-established and biomechanically sound across both samples.

Ankle abduction (inversion and eversion) ensures frontal-plane stability and supports static and dynamic balance. In the double lunge, it helps stabilize movement and correctly position the foot during ground contact.

The average ankle abduction range was 7.4±0.8° in the control group and 8.7±1.48° in the experimental group. Although slightly higher in the experimental group, the difference was not statistically significant (P > 0.05). The coefficient of variation was 10.81% in the control group and 17.01% in the experimental group, indicating more variability in the latter. This may be due to individual training adaptations, joint flexibility, or neuromuscular response differences. Overall, the movement was technically similar in both groups, but greater individual variation in the experimental group suggests that tailored training could help standardize this movement further.

Ankle rotation is vital for adapting foot position relative to the ground, distributing body weight evenly, and quickly changing direction. In the double lunge, it is especially important during the jumping phase performed with the left leg.

In the control group, the average ankle rotation was 9±0.8°, while in the experimental group, it was 10.12±2.7°. Although slightly higher in the experimental group, statistical analysis showed this difference was not significant (P > 0.05). However, the coefficient of variation was 26.68% in the experimental group, much higher than the control group's 8.89%, indicating substantial individual variability in the experimental group. This may be due to differences in muscle elasticity, motor control, or training approach. While the average performance was similar, the execution consistency was notably lower in the experimental group, highlighting the need for individual corrective strategies and focused work on movement standardization.

CONCLUSION

During the study, the range of motion indicators in the major body joints during the execution of the forward double jump technique with the left leg were compared between the control and experimental groups. The analysis revealed that there were no statistically significant differences across all indicators (p

> 0.05). This indicates that the additional training conducted with the experimental group athletes did not have a significant impact on joint mobility.

The flexion, abduction, and rotation parameters of the pelvic joint were similar in both groups, confirming the stability and symmetrical functioning of this joint. Likewise, no significant differences were observed in the flexion, abduction, and rotation movements of the hip and knee joints between the groups, suggesting that movement coordination developed uniformly and that the musculoskeletal system functioned similarly during the technique executed with the left leg.

Although minor differences were found in the ankle and foot joints' range of motion, these were not statistically significant and may be explained by physiological individual characteristics. In particular, a slightly higher value was recorded in the foot direction range in the experimental group, which may indicate an improved adaptability in strike or movement direction; however, this too was not statistically significant.

Overall, in both groups, the movement of the major joints during the forward double jump performed with the left leg was stable, symmetrical, and biomechanically optimal. This suggests that coordinated body movement was achieved during the technical training phase, and based on these findings, recommendations for further technique improvement can be developed. The results of this research suggest that, in the future, it will be possible to design highly effective training systems that take into account athletes' individual biomechanical characteristics, and to further refine technique by optimizing joint range of motion parameters.

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