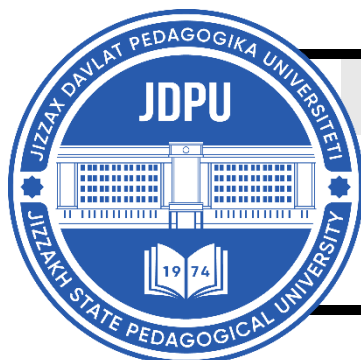


MENTAL ENLIGHTENMENT SCIENTIFIC –
METHODOLOGICAL JOURNALMENTAL ENLIGHTENMENT SCIENTIFIC –
METHODOLOGICAL JOURNAL<http://mentaljournal-jspu.uz/index.php/mesmj/index>PRELIMINARY KINEMATIC ANALYSIS OF MAXIMUM
ANGULAR VELOCITY IN RIGHT-HAND UPPERCUT PUNCH AMONG STUDENT
BOXERS**Davron Omonov***Doctoral student at the Uzbek State University of Physical Education and Sports**E-mail: omondavr717@gmail.com**Chirchik, Uzbekistan*

ABOUT ARTICLE

Key words: Boxing, sports biomechanics, impact, angular velocity, body joints, biomechanical analysis, impact technique, defense, body movement, kinematics.**Received:** 10.08.25**Accepted:** 12.08.25**Published:** 14.08.25**Abstract:** In this article, the maximum angular velocities of the body joints during the execution of the uppercut technique with the right hand of student boxers were studied in depth based on kinematic analysis. During the special motion analysis, the angular velocities of the joints participating in each impact component were determined using the Motion Analysis system. The results of the analysis showed that high angular velocities were recorded in the right shoulder, elbow, hip, knee and ankle joints. In particular, the central role of the pelvis and torso movement in directing the impact force upward was determined, and the left hand was observed to actively participate in performing the protective task. The results obtained showed that intersegmental connectivity, lower body strength and core stability are decisive factors in increasing the impact efficiency. This study serves to develop highly effective training methods in the training of athletes, optimize technical movements biomechanically and increase the individual capabilities of the athlete to a high level.

Introduction. Boxing is a complex and dynamic combat sport characterized by asymmetrical, explosive movements that require precise coordination of multiple body segments. Effective punch delivery in boxing, particularly techniques such as the right-hand

uppercut, demands seamless integration of rotational mechanics, angular velocity optimization, and kinetic chain efficiency from the lower to upper limbs [1,2]. The success of these strikes hinges not only on upper-body strength but also on the efficient transference of force initiated from the ground up, involving the legs, pelvis, and trunk before reaching the fist [12,13,15].

Rotational movement generated by the inward turn of the supporting foot has been identified as a key contributor to enhancing angular velocity during punch execution, especially for complex punches like the uppercut [2,11]. In this biomechanical sequence, the proximal-to-distal coordination—where force is initiated by the legs and transferred sequentially through the pelvis, torso, and arm—is crucial for maximizing punch velocity and power [13,15,30]. Furthermore, the precise timing and synchronization of each body segment play a pivotal role in ensuring efficient energy transmission and punch accuracy [16].

Recent research emphasizes the role of lower-body strength, particularly in the glutes, quadriceps, and calf muscles, in generating sufficient propulsion for forward motion and explosive strikes [6,14]. Plyometric training and explosive strength development have also been shown to significantly contribute to improving punching performance through the stretch-shortening cycle of muscles [25,26].

Kinematic studies of various punching techniques have revealed notable differences in angular velocity, reaction time, and joint angle dynamics across skill levels and punch types. For instance, jab and hook punches show differing velocity profiles in the shoulder and wrist, as well as in elbow flexion-extension movements [5,27]. Similarly, in taekwondo and karate, optimal kick and strike execution is achieved by accelerating limb movements and timing the strike at the peak of velocity, a principle that equally applies to upper-body strikes in boxing [9,22,23].

Training models based on movement kinematics have highlighted the importance of step-by-step learning and targeted exercises to develop technically sound punch mechanics [3,4]. Such approaches are particularly valuable for amateur boxers, where biomechanical inefficiencies often stem from poor intermuscular coordination and a lack of segmental synchronization [7,8]. Vestibular loading and aerobic conditioning also influence neuromuscular stability and punch accuracy, reinforcing the need for comprehensive and structured training interventions [7,26].

The growing utilization of motion capture technologies—both marker-based and markerless systems—has enabled more precise quantification of joint kinematics and motion patterns. Marker-based systems, though accurate, present limitations in real-time training

scenarios due to their dependence on anatomical palpation and laboratory constraints [17]. Alternatively, innovations such as Theia 3D now allow for high-resolution, markerless motion analysis in real-world environments, enhancing the ecological validity of kinematic assessments [18,19].

Furthermore, the effectiveness of strikes has been found to correlate with factors such as the mass and acceleration of the striking limb, segment orientation, and the biomechanical alignment during the attack phase [24,29]. Newton's second law reinforces this observation, as increasing force output or reducing unnecessary mass enhances acceleration—thereby increasing punch velocity [21]. Studies using instrumented dummies have also confirmed that accurate, forceful strikes rely on optimized force pathways and reaction times [32,33].

Despite numerous studies on straight punches, limited attention has been given to the biomechanics of the uppercut punch, particularly in amateur boxers. The right-hand uppercut presents unique challenges due to its upward trajectory, increased dependence on pelvic rotation, and vertical force generation. Moreover, most existing research either generalizes across punch types or focuses predominantly on elite athletes, leaving a gap in the understanding of how to systematically develop angular velocity in uppercut punches among developing boxers.

Therefore, this study aims to perform a kinematic analysis and exercise-based intervention to improve the maximum angular velocity of the right-hand uppercut punch in amateur boxers. By leveraging 3D motion capture technologies and biomechanically-informed training protocols, this research seeks to enhance technical performance, optimize intersegmental coordination, and provide evidence-based recommendations for boxing training. The results are expected to contribute to the advancement of boxing biomechanics by offering practical insights into the kinematic determinants of uppercut effectiveness.

The present study aims to fill this gap by conducting a detailed kinematic analysis of the right-hand uppercut punch in amateur boxers and implementing a targeted exercise-based intervention to enhance the maximum angular velocity of the key joints involved. It is hypothesized that the application of a biomechanically-informed training program can significantly improve angular performance in the shoulder, elbow, pelvis, and hip joints, leading to better punching efficiency and technical precision.

The aim of this article is to conduct a preliminary kinematic analysis of the maximum angular velocity generated in the body joints of student boxers during the execution of a right-hand uppercut punch

Research Tasks:

1. To record and analyze the angular velocity of the main body joints during the execution of the right-hand uppercut punch in student boxers using 3D motion capture technology.
2. To identify the most active joint segments contributing to maximum angular velocity in the punch.
3. To examine the coordination between lower and upper body segments during the strike.
4. To develop biomechanically grounded recommendations for improving technical training in amateur boxers.

Materials and methods

The study was conducted at the “Hi-Tech Sports Lab° 3D MA Biomechanics Laboratory” under the Uzbekistan State University of Physical Education and Sport. The kinematic data were recorded using 12 high-speed 3D cameras (240 frames per second) integrated with STT motion capture software. Participants included student boxers from the university (mean age: 19.11 ± 2.1 years, body mass: 69.60 ± 2.83 kg, height: 172 ± 4.9 cm). All participants signed informed consent forms before participation. A total of 19 sensor markers were attached to specific anatomical points across the boxers' bodies for accurate 3D tracking. All kinematic analyses were carried out by standard protocols to ensure data reliability.

Result and discussion

The preliminary findings of this study indicate that the execution of the right-hand uppercut punch among student boxers is heavily influenced by the biomechanical coordination of multiple body joints, particularly those on the dominant (right) side. The high angular velocity in the right shoulder and elbow joints supports existing literature emphasizing the proximal-to-distal sequencing of striking techniques in boxing [13,15,27]. This sequence ensures that the kinetic energy generated by the lower body and trunk is effectively transmitted to the fist.

Shoulder Joint Dynamics: The right shoulder flexion/extension produced the highest angular velocity among all joints (685.28 ± 40.43 deg/s in the control group and 681.12 ± 38.15 deg/s in the experimental group). This reinforces the shoulder's critical role in generating final acceleration of the fist. Notably, flexion/extension movements in the vertical plane also demonstrated high values, confirming the vertical vector trajectory of the uppercut. In contrast, the left shoulder showed significantly lower velocities, supporting the role of the non-dominant arm in stabilization rather than force generation (Tab-1).

Table-1

The kinematic indicators of the maximum angular velocity of body joints during the execution of the Uppercut punch (right-handed) in the technical movements of boxers from the Experimental and Control groups before and after the experiment (n=24).

PARAMETERS		Stages	CG	V%	EG	V%
SHOULDERS	Right shoulder flex/ext	<u>BE</u>	685.28 ± 40.43	5.90%	681.12 ± 38.15	5.67%
	Left shoulder flex/ext	<u>BE</u>	79.83 ± 4.36	5.47%	75.84 ± 4.12	5.43%
	Right shoulder flex/ext with vertical	<u>BE</u>	606.81 ± 30.72	5.06%	598.45 ± 29.03	4.85%
	Left shoulder flex/ext with vertical	<u>BE</u>	181.52 ± 10.69	5.95%	176.39 ± 10.15	5.75%
	Right shoulder abd/add	<u>BE</u>	105.84 ± 7.00	5.86%	100.55 ± 6.65	6.03%
	Left shoulder abd/add	<u>BE</u>	52.52 ± 7.92	15.08%	49.89 ± 3.52	7.5.%
ELBOWS	Right elbow flex/ext	<u>BE</u>	364.76 ± 28.90	7.92%	356.52 ± 21.45	6%
	Left elbow flex/ext	<u>BE</u>	29.88 ± 4.85	16.23%	28.39 ± 3	10.56%
PELVIS	Pelvis rotation	<u>BE</u>	321.12 ± 20.23	5.93%	314.06 ± 14.22	5%
	Pelvis rotation (right segment)	<u>BE</u>	357.93 ± 31.49	8.45%	354.28 ± 22.92	6.47%
	Pelvis rotation (left segment)	<u>BE</u>	322.49 ± 17.23	5.18%	315.87 ± 12.36	4%
HIPS	Right hip flex/ext	<u>BE</u>	84.28 ± 9.42	11.17%	80.07 ± 7	8.74%
	Left hip flex/ext	<u>BE</u>	101.76 ± 9.14	8.98%	96.67 ± 5	5.27%
	Right hip abd/add	<u>BE</u>	59.71 ± 4.99	8.37%	56.72 ± 4.74	8.35%
	Left hip abd/add	<u>BE</u>	62.27 ± 7.44	11.94%	59.16 ± 4.11	7%
KNEES	Right knee flex/ext	<u>BE</u>	86.24 ± 9.27	10.75%	81.93 ± 6	7.32%
	Left knee flex/ext	<u>BE</u>	122.96 ± 11.33	8.79%	128.51 ± 8	6.22%
ANKLES	Right ankle flex/ext	<u>BE</u>	93.92 ± 7.38	7.86%	89.22 ± 6.45	7.22%
	Left ankle flex/ext	<u>BE</u>	50.90 ± 5.38	10.56%	48.36 ± 3	6.20%

Note: BE - Before experience, CG- control group, EG – experimental group

Elbow Joint Function: The right elbow flexion/extension also exhibited high angular velocity (Control: 364.76 ± 28.90 deg/s; Experimental: 356.52 ± 21.45 deg/s), underlining its importance in the terminal phase of the punch. However, left elbow movements (below 30

deg/s) confirmed that it contributes minimally during the uppercut, acting mainly as a counterbalancing component.

Pelvis and Trunk Contribution: The pelvic rotation (321.12 ± 20.23 deg/s in control, 314.06 ± 14.22 deg/s in experimental) illustrates the engagement of core musculature. The involvement of both right and left pelvic segments with comparable velocities (around 315–357 deg/s) demonstrates symmetrical engagement of the hips for torque generation and body alignment during rotational transfer.

Hip and Knee Involvement: The hip joint angular velocity was moderate (Right: 84 deg/s; Left: 101 deg/s), suggesting its role in maintaining postural base and vertical push during the punch. The left knee showed slightly greater angular velocity in the experimental group, indicating possible enhanced rear-leg drive—a critical component in amateur boxers for balance and thrust.

Ankle Mobility: Ankle flexion/extension velocities (90–93 deg/s right; 50 deg/s left) support the concept that the rear foot (right) pushes off more forcefully than the lead (left) foot. The lower value in the left ankle may reflect a stabilizing function (Tab-1).

The preliminary kinematic analysis of the right-hand uppercut punch revealed a biomechanically synchronized contribution of both upper and lower body joints. The right arm segments, especially the right shoulder and elbow, demonstrated the highest angular velocities, confirming their primary role in force generation and acceleration during punch execution. The pelvis and hip joints served as critical rotational bases, enabling effective transmission of momentum from the lower limbs toward the striking arm.

Notably, the left arm, particularly the left shoulder and elbow, exhibited significantly lower angular velocities, supporting their role as stabilizers during the strike. This defensive positioning is typical in orthodox stance, where the non-dominant arm maintains guard while the dominant arm executes the attack.

The ankle, knee, and hip joints, especially on the rear (right) side, contributed to ground reaction force and upward drive, enabling explosive body extension during the uppercut. The movement sequence followed a proximal-to-distal pattern, consistent with effective kinetic chain mechanics.

Overall, these results confirm that the efficiency of a right-hand uppercut depends not only on arm speed, but also on the synchronized activation of the pelvis, hips, and legs, along with the stabilizing role of the opposite arm, which supports balance, control, and counterforce.

Biomechanically-Based Methodological Recommendations (For Amateur Boxers)

To improve the execution of the right-hand uppercut punch in amateur boxers, the following

biomechanically grounded methodological approach is recommended. Mastery of the punching technique requires special attention to factors such as intersegmental force transfer, lower-body strength, hip and trunk rotation, shoulder-elbow mechanics, defensive posture, and overall body stability.

1. Developing intersegmental coordination is of crucial importance. In effective punching mechanics, force should be transferred not from top to bottom, but from the ground up—i.e., from the feet through the hips and torso to the arm. To instill this principle, exercises such as upward medicine ball throws with rotational motion and trunk rotation drills using resistance bands are suggested.

2. The power and explosiveness of the punch are directly related to the strength of the lower-body muscles—namely the hips, knees, and ankles. Therefore, plyometric exercises (e.g., jumping from inclines or onto boxes) and squats with added weight are necessary to develop explosive lower-limb strength.

3. Effective force transmission during the uppercut punch depends on activating the rotation of the hips and torso. Recommended exercises include hip rotation drills using resistance bands and trunk rotation exercises performed with weights.

4. The mechanics of shoulder and elbow movement play a significant role in determining the accuracy and speed of the punch. To improve shoulder-elbow coordination, athletes should perform shadowboxing at different speeds and practice uppercut punch combinations on the bag.

5. During the execution of the punch, the body's overall posture should remain stable—meaning the head, pelvis, and legs must be aligned along a centralized axis. Segment-by-segment drills, where each body part's movement is practiced independently, and vestibular-load balance exercises (e.g., punching while standing on one leg) are beneficial.

This methodological approach is aimed at improving the technical quality, speed, and power of the punch and supports the step-by-step development of technical training for amateur boxers.

Conclusion

This preliminary kinematic analysis of the right-hand uppercut punch among student boxers revealed the key role of angular velocity in both the upper and lower limb joints. The dominant right-side joints (shoulder, elbow, hip, knee, and ankle) exhibited significantly higher angular velocities compared to the non-dominant side, indicating a coordinated kinetic chain from the ground up. The pelvis and trunk rotation emerged as central to transferring

momentum from the lower limbs to the striking arm, while the left arm acted as a stabilizer during execution.

The findings emphasize that effective uppercut execution relies not only on arm speed but also on intersegmental synchronization, lower-limb propulsion, and core stability. The use of 3D motion analysis technology allowed for detailed measurement of joint-specific angular velocities, providing a scientific basis for assessing punch mechanics in amateur boxers.

These results can guide the development of training programs focused on improving rotational mechanics, lower-body explosiveness, and coordinated punching technique. In future studies, a comparative analysis of post-intervention data will offer deeper insights into the effectiveness of kinematics-based interventions.

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