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INDIVIDUAL BIOMECHANICAL CHARACTERISTICS OF COMBAT MANEUVER FOOTWORK IN ELITE AMATEUR BOXERS: A QUICK BOARD ASSESSMENT

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ABOUT ARTICLE

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Abstract: The purpose of this study was to evaluate the individual neuromuscular and biomechanical characteristics of elite boxer Iqboljon Kholdorov using the Quick Board system. The assessment focused on lower-limb reaction time, ground contact time, movement accuracy, bilateral symmetry, and agility performance. The athlete underwent a standardized Quick Board testing protocol consisting of Stagger Step, Double Leg React, and Foot Fire tasks. The results demonstrated excellent agility performance, with an overall Agility Rating of 3135 and outstanding Foot Fire performance (109 repetitions without errors). Bilateral analysis revealed a considerable asymmetry in reaction time, whereas movement accuracy and symmetry remained high. These findings indicate that Quick Board technology provides valuable objective information for identifying individual neuromuscular characteristics, detecting functional asymmetries, and optimizing sport-specific footwork performance. The obtained results may contribute to the development of individualized biomechanics-based training programs for elite boxers and facilitate the transition from amateur to professional boxing.

Introduction. Boxing is a complex combat sport in which successful performance depends on the effective integration of technical, tactical, physiological, biomechanical, and neuromuscular factors. Among these, lower-limb movement plays a fundamental role in

maintaining balance, controlling fighting distance, creating favorable attacking angles, and transferring force efficiently through the kinetic chain during punching actions (Walilko et al., 2005; Lenetsky et al., 2015; Turner et al., 2011). Consequently, combat maneuver footwork has become one of the most important determinants of competitive success in both amateur and professional boxing.

Although amateur and professional boxing share similar technical foundations, important differences exist in competition format, bout duration, tactical demands, movement tempo, and scoring systems. Professional boxing requires greater movement economy, continuous positional control, efficient footwork, and the ability to maintain neuromuscular performance over longer contest durations. Therefore, understanding the individual biomechanical characteristics of combat maneuver footwork is essential for optimizing performance and facilitating the transition from amateur to professional boxing (Lenetsky et al., 2015; Loturco et al., 2016).

Recent advances in sports biomechanics have significantly improved the objective evaluation of athletic performance through three-dimensional motion analysis, wearable technologies, force platforms, and computerized neuromuscular assessment systems (Preatoni et al., 2023). Among these technologies, the Quick Board® system provides a practical field-based method for assessing reaction time, ground contact time, movement accuracy, bilateral symmetry, and sport-specific agility under dynamic conditions. These variables are directly associated with lower-limb neuromuscular function and may provide valuable information for monitoring athlete readiness and optimizing movement performance.

Interlimb asymmetry has become an important topic in contemporary sports science because differences between the dominant and non-dominant limbs may influence force production, movement efficiency, reactive agility, and injury risk (Bishop et al., 2018; Bishop et al., 2021; Maloney, 2019). Although moderate asymmetry may represent sport-specific adaptation, excessive neuromuscular imbalance can negatively affect athletic performance, particularly in sports requiring rapid multidirectional movements such as boxing. Efficient footwork depends on symmetrical lower-limb function to ensure rapid acceleration, deceleration, directional changes, and stable punching mechanics.

Previous investigations have primarily focused on punching biomechanics, impact force production, and upper-limb kinematics (Walilko et al., 2005; Piorkowski et al., 2011; Beattie & Ruddock, 2022). Other studies have demonstrated strong associations between lower-limb strength, explosive power, and punching performance (Loturco et al., 2016; Loturco et al., 2019). Nevertheless, relatively few studies have comprehensively evaluated the individual

neuromuscular characteristics of elite boxers using practical field-based technologies such as Quick Board. Furthermore, there is limited evidence describing bilateral reaction characteristics and agility profiles in internationally successful boxers.

Individual biomechanical profiling has recently emerged as an important approach in high-performance sport because it allows coaches to identify athlete-specific strengths and functional deficits, thereby facilitating individualized training interventions instead of generalized conditioning programs (Preatoni et al., 2023). Such an approach is particularly relevant for elite boxing, where even small improvements in reaction time, movement efficiency, and bilateral coordination may determine competitive success.

Iqboljon Kholdorov is one of Uzbekistan's most accomplished elite boxers, having won the gold medal at the 2017 Asian Amateur Boxing Championships, the silver medal at the 2017 AIBA World Boxing Championships, and the gold medal at the 2018 Asian Games. In addition to his amateur achievements, he has maintained an undefeated professional boxing record, making him an appropriate model for investigating the neuromuscular and biomechanical characteristics associated with elite boxing performance.

Therefore, the aim of the present study was to evaluate the individual biomechanical and neuromuscular characteristics of Iqboljon Kholdorov using the Quick Board assessment system. Specifically, the study analyzed lower-limb reaction time, ground contact time, movement accuracy, bilateral symmetry, and agility performance to establish an objective biomechanical profile that may support individualized training, optimize combat maneuver footwork, and contribute to evidence-based preparation for elite boxing performance.

Materials and Methods. This study employed a descriptive case-study design to evaluate the individual neuromuscular and biomechanical characteristics of an elite boxer using the Quick Board assessment system. The investigation focused on lower-limb reaction time, ground contact time, movement accuracy, bilateral symmetry, and agility performance. Case-study methodology is considered appropriate for examining high-performance athletes because it allows comprehensive biomechanical profiling while preserving the ecological validity of elite sport performance (Halperin, I. 2018).

The participant was Iqboljon Baxodirjon o'g'li Kholdorov, an elite Uzbek boxer competing in the 64-kg weight category. He is a 2017 Asian Amateur Boxing Champion, 2017 AIBA World Championship silver medalist, and 2018 Asian Games champion. At the time of testing, the athlete was 29 years old, 179 cm in height, weighed 64 kg, and competed in a left-handed (southpaw) stance. He also maintained an undefeated professional boxing record of 7 victories (6 by knockout and 1 by decision).

Prior to participation, the athlete was informed about the objectives and procedures of the study and voluntarily provided written informed consent. The study complied with the ethical principles of the Declaration of Helsinki for research involving human participants (World Medical Association, 2013).

Neuromuscular performance was evaluated using the Quick Board® system (Quick Board LLC, USA), a computerized assessment platform designed to measure sport-specific agility and lower-limb neuromuscular performance. The system has previously been used to evaluate reaction time, movement frequency, bilateral coordination, and agility in elite athletes (Bishop et al., 2021).

The Quick Board software automatically calculated the following variables:

- Ground contact time (s);
- Reaction time (s);
- Movement accuracy (%);
- Bilateral symmetry (%);
- Agility Rating score.

Testing was conducted under standardized laboratory conditions at the Sports Biomechanics Laboratory. Before data collection, the athlete completed a standardized 15-minute warm-up, consisting of light jogging, dynamic stretching, mobility exercises, and sport-specific footwork drills.

Following familiarization with the Quick Board system, the participant performed four standardized testing protocols:

- Stagger Step 3134
- Stagger Step 3235
- Double Leg React
- Foot Fire

Each protocol lasted 10 seconds and was completed according to the manufacturer's testing guidelines. The athlete performed each test with maximal effort while maintaining proper movement technique. The software automatically recorded all performance variables immediately after each trial.

The primary outcome variables included:

- Reaction Time (s): the elapsed time between the visual stimulus and initiation of movement.
- Ground Contact Time (s): the duration of foot contact with the board during each movement cycle.

- Accuracy (%): the percentage of correctly executed foot placements.
- Symmetry (%): the degree of functional balance between the left and right lower limbs.
- Agility Rating: a composite score generated by the Quick Board software reflecting overall neuromuscular performance and movement efficiency.

Data obtained from the Quick Board system were exported directly from the proprietary software and analyzed descriptively. Continuous variables are presented as absolute values and percentages where appropriate. Bilateral differences between the left and right lower limbs were calculated using percentage difference:

$$\text{Bilateral Difference (\%)}=\frac{|\text{Right}-\text{Left}|}{\frac{\text{Right}+\text{Left}}{2}}\times100$$

The results were interpreted from a biomechanical perspective by comparing reaction time, contact time, movement accuracy, and symmetry between the dominant and non-dominant lower limbs. Because this investigation represents a single-athlete case study, no inferential statistical analyses were performed. Instead, emphasis was placed on identifying individual neuromuscular characteristics and functional asymmetries relevant to elite boxing performance (Bishop et al., 2018; Preatoni et al., 2023).

Results and Discussion. The Quick Board assessment revealed a comprehensive neuromuscular profile of the elite boxer, highlighting both superior agility performance and measurable bilateral functional asymmetry. The results of the bilateral comparison are presented in Table 1 and Figure 1.

Ground contact time differed between the lower limbs, with the left limb recording 0.118 s and the right limb 0.137 s, corresponding to a 16.1% bilateral difference. The longer contact duration observed in the right lower limb suggests a movement strategy emphasizing greater stability and force application during ground support. Conversely, the shorter contact time on the left side indicates a more reactive push-off mechanism, which is advantageous for explosive foot repositioning during combat maneuvers.

Table 1. Quick Board Neuromuscular Performance and Bilateral Symmetry Assessment in an Elite Boxer

Variable	Left	Right	Mean	Bilateral Difference (%)	Interpretation

Contact Time (s)	0.118	0.137	0.128	16.1	Longer ground contact on the right limb
Reaction Time (s)	1.123	0.746	0.934	50.5	Faster neuromuscular response on the right limb
Accuracy (%)	78.8	82.6	80.7	4.8	Comparable movement accuracy between limbs
Symmetry (%)	90.9	100.0	—	9.1	Mild functional asymmetry

The most pronounced inter-limb difference was observed in reaction time. The left lower limb demonstrated a reaction time of 1.123 s, whereas the right limb responded in 0.746 s, representing a 50.5% bilateral difference. This substantial asymmetry indicates faster neuromuscular activation of the right lower extremity and suggests that movement initiation is more efficient on that side. Since rapid lower-limb activation represents the initial phase of force generation in boxing, delayed neuromuscular response in one limb may reduce movement efficiency during offensive and defensive footwork.

Movement accuracy remained relatively balanced between limbs. The left and right limbs achieved 78.8% and 82.6% accuracy, respectively, with only a 4.8% bilateral difference, indicating consistent motor control during task execution. Likewise, symmetry values reached 90.9% for the left limb and 100% for the right limb, demonstrating generally well-preserved bilateral coordination despite the reaction-time imbalance.

These findings indicate that the athlete possesses excellent neuromuscular control while simultaneously exhibiting functional asymmetry in lower-limb responsiveness. Similar observations have been reported by Bishop et al. (2018, 2021), who demonstrated that elite athletes frequently develop sport-specific inter-limb asymmetries as a consequence of repetitive unilateral loading and technical specialization. Although moderate asymmetry may represent functional adaptation rather than dysfunction, excessive reaction-time imbalance may negatively influence movement efficiency and increase injury susceptibility.

Performance outcomes obtained from the four Quick Board protocols are summarized in Table 2 and Figure 1D.

Table 2. Quick Board Agility Test Performance

Test	Duration	Result	Errors
Stagger Step 3134	10 s	31	19
Stagger Step 3235	10 s	31	21
Double Leg React	10 s	8	2

Foot Fire	10 s	109	0
Overall Agility Rating	—	**3135**	—

The athlete completed 31 successful repetitions in both the Stagger Step 3134 and Stagger Step 3235 tests. Despite identical performance scores, the second protocol produced a slightly greater number of execution errors (21 vs. 19), suggesting increased motor complexity and higher coordination demands.

Performance in the Double Leg React task was comparatively lower, with 8 successful reactions and 2 execution errors. Unlike repetitive stepping tasks, this protocol primarily evaluates reactive agility and neuromuscular decision-making in response to unpredictable visual stimuli. Consequently, the reduced score most likely reflects the greater cognitive demands associated with stimulus recognition and rapid movement execution.

The most outstanding performance was observed during the Foot Fire assessment. The athlete completed 109 successful foot contacts within 10 seconds without committing a single error, indicating exceptional lower-limb movement frequency, coordination, and neuromuscular efficiency. Such performance reflects an advanced capacity for rapid cyclic movement, which is essential for maintaining optimal fighting distance and executing rapid positional adjustments during boxing competition.

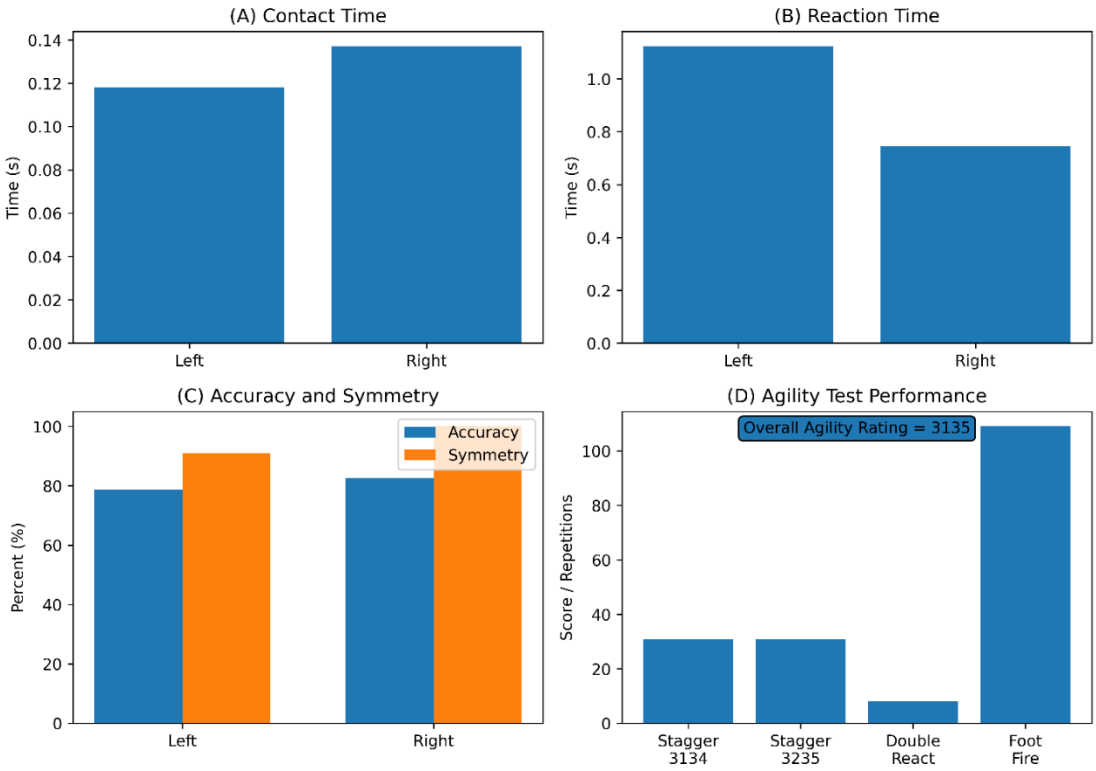

Figure 1. Neuromuscular Performance Profile Obtained from the Quick Board Assessment

The athlete achieved an Overall Agility Rating of 3135, confirming an exceptionally high level of sport-specific agility and neuromuscular readiness.

From a biomechanical perspective, the present findings demonstrate that the athlete's lower-limb neuromuscular system is highly developed, allowing efficient execution of explosive footwork and rapid multidirectional movements. Efficient boxing performance depends on the coordinated interaction of the lower limbs, pelvis, trunk, and upper extremities through the kinetic chain (Walilko et al., 2005; Lenetsky et al., 2015). Therefore, even relatively small asymmetries in reaction time may influence punching mechanics and movement economy.

The outstanding Foot Fire performance indicates excellent motor unit recruitment, intermuscular coordination, and stretch-shortening cycle efficiency. These characteristics are fundamental for elite boxing, where rapid repositioning often determines both offensive success and defensive effectiveness.

Although the athlete demonstrated excellent overall agility, the substantial reaction-time asymmetry suggests that individualized neuromuscular training may further optimize performance. Unilateral plyometric exercises, reaction-based agility drills, proprioceptive training, and boxing-specific footwork emphasizing the slower limb may reduce functional imbalance and improve bilateral movement efficiency.

The present findings support the concept of individualized biomechanical profiling proposed by contemporary sports biomechanics research. Rather than relying solely on generalized performance measures, athlete-specific neuromuscular assessment enables coaches to identify subtle functional deficits that may otherwise remain undetected. Such information can be incorporated into individualized training programs aimed at maximizing performance while reducing injury risk.

Overall, the Quick Board assessment proved to be a practical and sensitive tool for evaluating lower-limb neuromuscular performance in elite boxing. The combination of reaction time, contact time, movement accuracy, symmetry, and agility measurements provides a comprehensive biomechanical profile that may assist coaches in evidence-based decision-making and long-term athlete development.

The findings of this assessment suggest that Quick Board testing can serve as a practical field-based tool for monitoring neuromuscular readiness and lower-limb asymmetry in elite boxers. Regular evaluation of reaction time, contact time, movement accuracy, and symmetry enables coaches to identify functional deficits, individualize training programs, and monitor rehabilitation progress. Integrating Quick Board assessments into routine performance testing

may contribute to improved footwork efficiency, enhanced explosive movement initiation, optimized kinetic chain function, and reduced injury risk during high-level boxing competition.

Conclusion. The present case study provides a comprehensive evaluation of the individual neuromuscular and biomechanical characteristics of elite boxer Iqboljon Kholdorov using the Quick Board assessment system. The findings demonstrated an exceptionally high level of sport-specific agility, lower-limb coordination, and neuromuscular performance, as reflected by the Overall Agility Rating of 3135 and outstanding Foot Fire performance.

Despite the athlete's excellent overall functional capacity, the assessment identified a substantial bilateral asymmetry in lower-limb reaction time, whereas movement accuracy and symmetry remained within a high-performance range. These findings indicate that elite athletic performance may coexist with functional neuromuscular imbalances that are not readily detectable through conventional performance testing.

The results confirm that the Quick Board system is an effective field-based tool for objectively assessing lower-limb reaction time, ground contact time, movement accuracy, bilateral symmetry, and agility in elite boxing. Such objective measurements provide valuable information for identifying individual neuromuscular characteristics and developing evidence-based, individualized training strategies.

From a practical perspective, regular biomechanical monitoring using Quick Board technology may assist coaches in optimizing boxing-specific footwork, improving movement efficiency, reducing bilateral asymmetry, and supporting injury prevention. The individualized neuromuscular profile established in this study may also serve as a reference model for monitoring elite boxers during different stages of training and for facilitating the transition from amateur to professional boxing.

Future research should include larger samples of elite amateur and professional boxers and integrate Quick Board assessments with three-dimensional motion analysis, force measurements, electromyography, and kinetic-chain biomechanics to develop comprehensive individualized performance models for high-performance boxing.

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