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Biomechanical Analysis of Throwing Techniques in Kurash: Implications for Performance Optimization and Injury Prevention

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Abstract. *This study investigates the biomechanical characteristics of major throwing techniques in Kurash to identify performance-enhancing factors and injury risk mechanisms. Three commonly used throws – galtaq (leg sweep throw), yelka ortidan otish (shoulder throw), and bel otar (hip throw) – were analyzed using 3D motion capture and force plate systems. Results showed that optimal technique execution required coordinated triple extension, precise center of mass manipulation, and balanced ground reaction forces. Identifying biomechanical inefficiencies can guide coaches in refining technique and implementing injury prevention strategies for Kurash athletes.*

Key words: *Kurash, biomechanics, throwing techniques, injury prevention, performance optimization.*

Introduction. Kurash is an ancient form of grappling originating from Uzbekistan, characterized by explosive throws executed with precise technique and optimal leverage. Unlike other grappling sports, Kurash prohibits groundwork, placing greater emphasis on the effectiveness of standing throwing techniques to secure victory.

The biomechanical efficiency of throwing techniques determines both performance success and injury risk. Throws in Kurash require **complex multi-joint coordination**, high levels of **neuromuscular control**, and **force generation**. Inefficient biomechanics may lead to ineffective throws or predispose athletes to overuse or acute injuries, particularly in the lower back, hips, and knees.

Literature gap.

Although judo and wrestling have been extensively studied biomechanically to improve technique and reduce injuries, **scientific analysis of Kurash throwing techniques is scarce**. Most Kurash coaching remains based on traditional pedagogy rather than objective biomechanical evidence.

Aim of the study.

Therefore, this study aims to:

1. **Analyze** the kinematic and kinetic characteristics of three common Kurash throws.
2. **Identify** biomechanical factors contributing to throw effectiveness.
3. **Provide recommendations** for injury prevention strategies in Kurash training.

Such research will bridge the gap between traditional coaching and evidence-based practice, enhancing athlete safety and performance.

2. Methods

2.1 Participants

Eight elite male Kurash athletes (mean age 22.5 ± 2.4 years; height 174.6 ± 4.9 cm; weight 76.2 ± 6.7 kg; Kurash experience ≥ 6 years) volunteered. All were national-level competitors with regular training of at least 4 sessions per week.

Inclusion criteria:

- Minimum 5 years of competitive Kurash experience
- No musculoskeletal injuries in the previous 6 months
- Provided written informed consent.

The study was approved by the Ferghana State University Research Ethics Committee (Approval No. FSU-REC-2025-07).

2.2 Procedures

Throws analyzed:

1. **Galtaq (Leg Sweep Throw):** Uses a sweeping leg motion to unbalance and throw the opponent sideways.
2. **Yelka ortidan otish (Shoulder Throw):** Involves pivoting under the opponent's center of mass and throwing over the shoulder.
3. **Bel otar (Hip Throw):** Utilizes hip rotation and lift to project the opponent over the hip.

Athletes performed each throw three times with maximal effort under laboratory conditions, with adequate rest between trials to minimize fatigue effects.

2.3 Biomechanical Data Collection

Instrumentation:

- **3D Motion Capture:** Vicon system with 8 infrared cameras (250 Hz) and 39 reflective markers placed on anatomical landmarks following Plug-in-Gait full-body model.
- **Force Plates:** Dual AMTI force platforms (1000 Hz) embedded under a regulation Kurash mat to record ground reaction forces (GRF).
- **High-speed video:** Two Phantom cameras (500 fps) for qualitative analysis and technique verification from sagittal and frontal planes.

Data were synchronized across devices for precise temporal alignment of kinematic and kinetic events.

2.4 Data Analysis

Variables analyzed:

- **Joint kinematics:** Hip, knee, and ankle angles during preparation, execution, and follow-through phases.
- **Joint kinetics:** Peak net joint moments (Nm) and power outputs (W).
- **Ground Reaction Forces (GRF):** Vertical and horizontal GRF normalized to body weight (BW).
- **Center of Mass (COM):** Displacement, velocity, and trajectory relative to the base of support.

Processing.

Marker trajectories and force data were filtered using a low-pass Butterworth filter (cut-off frequency: 6 Hz for kinematics, 15 Hz for kinetics). Analyses were conducted in Visual3D software. Means ± SD were calculated for each variable.

Results

3.1 Kinematic Findings

- ✓ **Galtaq:**
- ➢ **Ankle plantarflexion:** Peak 35.2° ± 4.1° during sweep phase.
- ➢ **Knee extension:** Peak 167.5° ± 3.8° enabling efficient leg retraction and destabilization of opponent.
- ➢ **Hip flexion:** Maintained at ~42° to lower center of mass for stability.
- ✓ **Yelka ortidan otish:**
- ➢ **Hip flexion:** Peak 102.3° ± 5.6° for deep entry under opponent.
- ➢ **Trunk rotation:** Peak 87.4° ± 4.9° indicating strong rotational torque generation.
- ➢ **Knee flexion:** Peak ~115° allowing lower body drive during lift.
- ✓ **Bel otar:**
- ➢ **Hip extension:** Peak 176.8° ± 3.2°, crucial for elevating opponent.
- ➢ **Knee flexion:** Peak 95.1° ± 4.7° generating upward propulsion.
- ➢ **Trunk lateral flexion:** ~38°, stabilizing opponent over hip axis.

3.2 Kinetic Findings

- ✓ **Peak GRF:**
- ➢ Galtaq: 2.1 × BW
- ➢ Yelka ortidan otish: 2.4 × BW
- ➢ Bel otar: 2.6 × BW
- ✓ **Joint moments:**
- ➢ **Hip extension moment:** Highest in bel otar (260.4 Nm ± 22.8).
- ➢ **Knee extension moment:** Highest in yelka ortidan otish (201.3 Nm ± 18.7).
- ✓ **Power outputs:** Bel otar produced peak hip power output of 3220 W ± 210, highlighting its explosive nature.

3.3 Center of Mass Dynamics

- ➢ All throws demonstrated **forward and upward COM acceleration**.
- ➢ Faster COM displacement correlated with throw success.
- ➢ **Bel otar** showed greatest vertical COM elevation (mean peak 0.88 m ± 0.05).

4. Discussion

This biomechanical study provides novel insights into Kurash throwing techniques:

Performance optimization.

- ➢ **Triple extension coordination (ankle, knee, hip)** is essential for effective throw execution.
- ➢ **Trunk rotation and lateral flexion** enhance leverage and force transmission.
- ➢ **COM manipulation** determines opponent destabilization and projection trajectory.

These findings align with judo and wrestling biomechanics literature, confirming universal throwing mechanics across grappling sports. Coaches should emphasize technique drills focusing on joint synchronization, explosive hip drive, and trunk control.

Injury prevention.

High GRF and joint loading, particularly during bel otar, increase injury risk to the lumbar spine and hips. To mitigate these:

- Integrate posterior chain strengthening exercises (deadlifts, RDLs) into conditioning programs.
- Emphasize core stability and mobility training to protect lumbar structures.
- Ensure progressive technical mastery before maximal intensity application.

Limitations.

- Small sample size limits generalizability.
- Only male athletes were included; female biomechanics may differ.
- Laboratory analysis may not replicate competition-specific dynamics (e.g. psychological pressure, grip fighting).

Future directions.

- Investigate energy expenditure and metabolic demands of Kurash throws.
- Explore electromyography (EMG) to analyze muscle activation patterns.
- Study technique variations across weight categories to individualize training.

5. Conclusion.

Biomechanical analysis of Kurash throws demonstrates that effective technique execution relies on precise joint kinematics, optimal force generation, and COM manipulation. These insights can inform evidence-based coaching practices, enhancing throw effectiveness while reducing injury risks. Integrating biomechanical findings into Kurash training methodology can improve athlete performance and longevity in this traditional martial art.

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