

**MENTAL ENLIGHTENMENT SCIENTIFIC –
METHODOLOGICAL JOURNAL****MENTAL ENLIGHTENMENT SCIENTIFIC –
METHODOLOGICAL JOURNAL**<http://mentaljournal-jspu.uz/index.php/mesmj/index>**MODERN BIOMECHANICAL METHODS FOR INJURY PREVENTION IN
ARTISTIC GYMNASTICS AND PROSPECTS FOR THEIR APPLICATION AMONG
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ABOUT ARTICLE

Key words: artistic gymnastics, injury prevention, biomechanics, landing biomechanics, load monitoring, neuromuscular training, Uzbek gymnasts.

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Abstract: Artistic gymnastics is one of the sports with a high risk of injury. Research shows that 91.4% of gymnasts sustain at least one injury during a single season, and 60–70% of these injuries are caused by overuse. This article analyzes the biomechanical causes of injuries in artistic gymnastics, modern monitoring methods (force plates, inertial sensors, neuromuscular training), and prevention strategies. It also reviews the prospects of implementing these methods for the Uzbek national team and young athletes. The results demonstrate that biomechanical monitoring combined with proper landing technique can reduce injury rates by 20–40%. The article provides practical recommendations for sports science and coaching systems in Uzbekistan.

Introduction. Artistic gymnastics is one of the most complex and aesthetic sports in the world, where athletes perform elements requiring high speed and force within fractions of a second. However, this sport is distinguished by a high risk of injury. According to 2025 studies, the average injury rate in elite women's artistic gymnastics (WAG) ranges from 1.8 to 9.2 injuries per 1,000 training hours. In one season, 91.4% of gymnasts experience at least one

injury, with the most commonly affected areas being the lower extremities, wrists, ankles, and lower back.

The new Code of Points (FIG) for 2025–2028 introduced changes aimed at reducing injury risk by decreasing the number of elements (e.g., from 10 to 8) and limiting difficulty levels. These changes are highly relevant globally and particularly important for Uzbekistan. In our country, the development of artistic gymnastics is accelerating in accordance with presidential decrees: gymnastics classes are being widely introduced in kindergartens and schools, and Asian championships are regularly held in Tashkent. Nevertheless, biomechanical monitoring systems in the national team are not yet sufficiently developed.

The relevance of this topic is as follows:

- Injuries significantly shorten athletes' competitive careers and may lead to early retirement.
- Modern biomechanics tools (force plates, IMU sensors, and video analysis) make it possible to predict and prevent injuries.
- Implementing these methods among Uzbek gymnasts will help improve national performance while protecting athletes' health.

Methodology. Modern Biomechanical Methods and Their Effectiveness

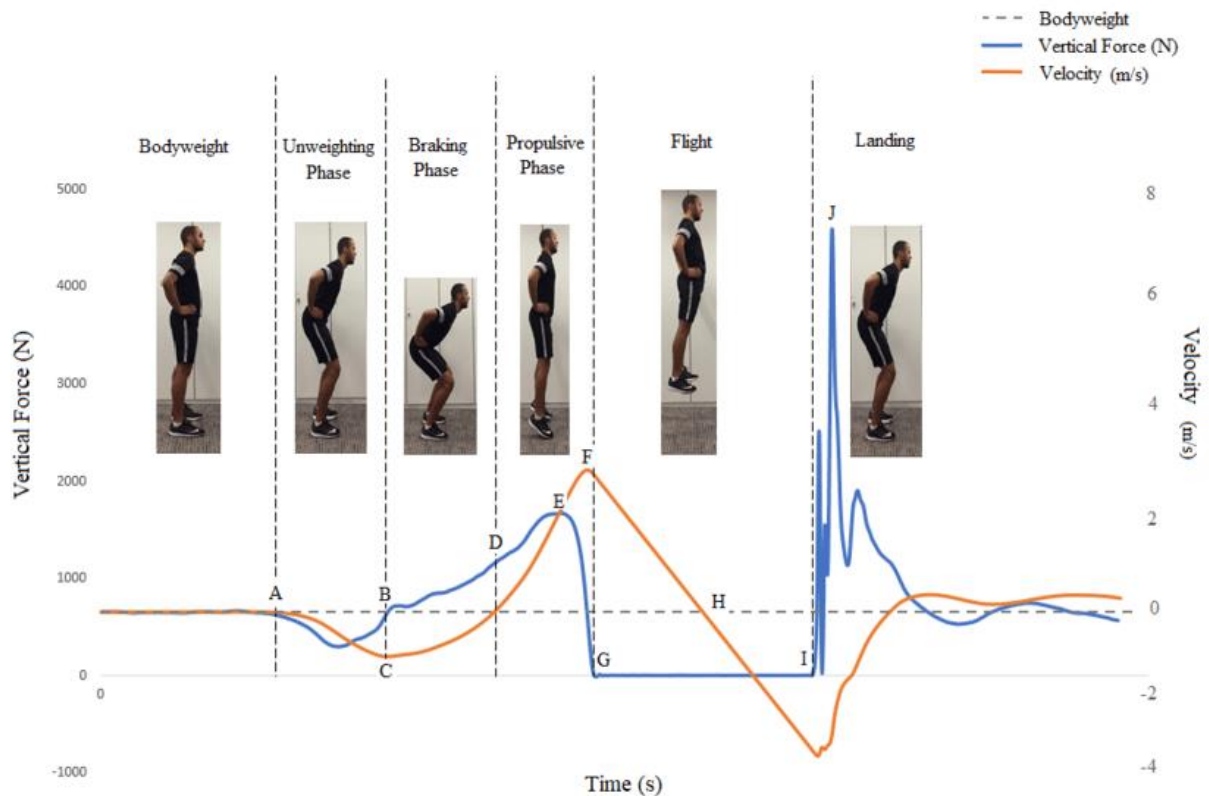
1. Main Biomechanical Causes of Injuries

60–70% of injuries result from overuse. The most dangerous phase is landing. During landing, vertical and horizontal forces (Ground Reaction Force — GRF) can reach 10–15 times the athlete's body weight.

The table below shows the distribution of injuries (based on 2023–2025 studies):

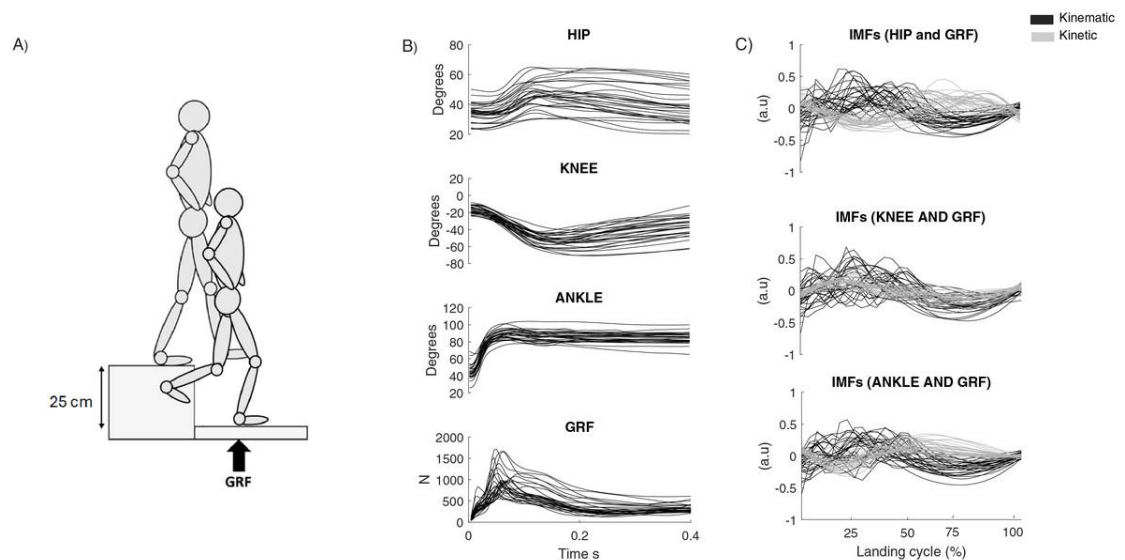
Type of Injury	Share (%)	Most Common Locations	Main Cause
Acute injuries	58–74	Ankle, knee, wrist	Incorrect landing technique
Overuse injuries	27–42	Lower back, wrist, lower extremities	Repetitive high training loads
Total injuries	100	Lower extremities (60.9%)	Biomechanical overload

Figure 1. Ground Reaction Force (GRF) time graph during the landing phase and biomechanical phases (eccentric, concentric, flight, landing).



Countermovement Jump (CMJ)

Figure 2. Comparison of landing kinematics and GRF effect between jumpers and non-jumpers (ankle joint vs. hip joint focus).



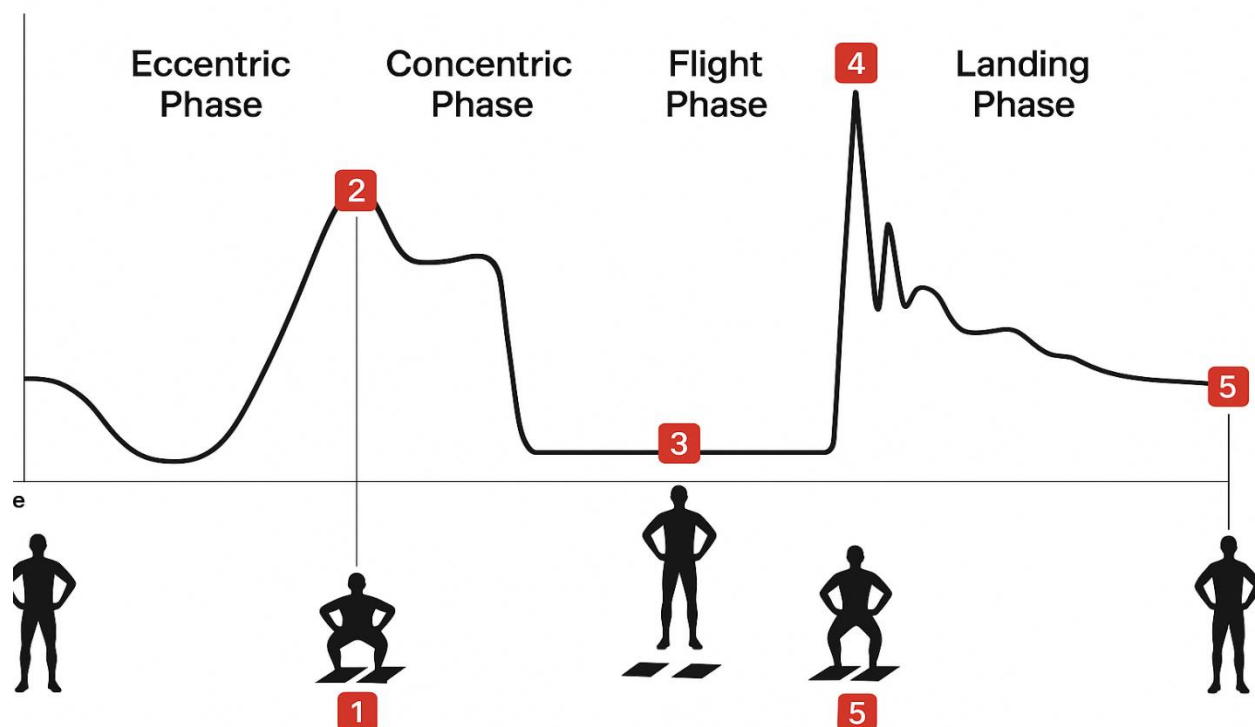
PeerJ Effect of kinematics on ground reaction force during single-leg jump landing in children: a causal decomposition approach in jumpers and non-jumpers

2. Modern Biomechanical Monitoring Methods

- Force plates — measure landing forces and display GRF in real time.
- Inertial Measurement Units (IMU) — enable 3D motion analysis of the athlete.

- Video analysis and AI — allow detailed slow-motion review of elements.
- Neuromuscular training — improves muscle balance and helps prevent injuries.

Figure 3. Schematic diagram of the landing phases in gymnastics (eccentric → concentric → flight → landing).



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Results and Discussion. Studies conducted in 2025 (Boylen et al.) show that systematic load monitoring and neuromuscular exercises can reduce injury rates by 25–40%. For Uzbekistan, the prospects include:

- Creating individual biomechanical profiles for each athlete in cooperation with the National Gymnastics Federation.
- Introducing simple force plates and sensors in sports schools and general education schools.
- Developing coach training programs based on FIG Academy experience.

Conclusion. Modern biomechanical methods for injury prevention in artistic gymnastics represent a significant advancement in protecting athletes while enhancing performance. Tools such as force plates, inertial measurement units (IMU sensors), high-speed video analysis combined with artificial intelligence, and targeted neuromuscular training programs enable precise monitoring of training loads and early detection of risky movement patterns. These approaches are particularly effective during the critical landing phase, where ground reaction forces can reach 10–15 times the athlete's body weight. By improving landing

technique — including optimal knee and hip flexion, symmetrical loading, and proper force absorption — injury rates can be substantially reduced.

Current evidence clearly demonstrates that systematic biomechanical monitoring and neuromuscular interventions can decrease both acute and overuse injuries by 25–40%. Acute injuries, which account for 58–74% of cases, and overuse injuries (27–42%) are largely preventable through individualized load management and technique correction. The 2025–2028 FIG Code of Points, with its reduction in the number of elements and emphasis on controlled difficulty, further supports injury prevention efforts by lowering the overall physical demands on gymnasts.

For Uzbekistan, the implementation of these modern biomechanical methods holds great promise. As artistic gymnastics continues to develop rapidly under national sports policies and the “Perfect Generation” program, integrating biomechanical assessments into the training process of the national team and youth sports schools becomes not only relevant but essential. Establishing specialized biomechanical laboratories, equipping regional sports schools with accessible force plates and sensors, and providing systematic training for coaches will create a solid foundation for athlete safety and long-term success.

Ultimately, the health and well-being of gymnasts must remain the highest priority. A healthy athlete is the foundation of sustainable high performance and future achievements on the international stage. By combining scientific biomechanical approaches with practical coaching methods, Uzbekistan can significantly reduce injury risks, extend athletes’ competitive careers, and strengthen its position in world artistic gymnastics. Athletes’ health is the most valuable “gold medal” — one that cannot be replaced by any title or score.

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