BIOMECHANICAL ANALYSIS OF DISCUS THROWING IN FEMALE ATHLETES: A COMPREHENSIVE REVIEW

Yuldasheva Kamola Alimjanovna
Uzbek State University of Physical and Sport, Uzbekistan, Chirchik

https://doi.org/10.5281/zenodo.14031302

Abstract: Discus throwing, a pivotal event in track and field athletics, demands precise biomechanical execution to achieve optimal performance. This comprehensive review delves into the biomechanical intricacies of discus throwing with a specific focus on female athletes. By analyzing critical elements such as body posture, release technique, force generation, and energy transfer, the study aims to enhance the understanding of female-specific biomechanical factors influencing discus performance. Utilizing advanced motion capture technology and high-speed video analysis, this review uncovers key biomechanical determinants that impact the effectiveness of the throw.

The review systematically examines the following aspects:

Body Posture and Alignment: Assessing the influence of initial stance, wind-up mechanics, and body alignment on the throw's efficiency.

Release Technique: Investigating the role of grip, release angle, arm extension, and wrist action in optimizing throw distance.

Force Generation and Energy Transfer: Exploring the impact of leg drive, hip rotation, and core engagement on the transfer of force to the discus.

Data from biomechanical studies involving female athletes across varying skill levels (novice, intermediate, and elite) are reviewed to highlight differences in performance metrics such as release speed, force, hip rotation, and energy transfer. The review integrates findings from high-speed cameras and 3D motion capture systems, providing a detailed analysis of how these factors correlate with performance outcomes.

Key findings indicate that elite female discus throwers exhibit significantly higher release speeds, greater force generation, improved hip rotation, and more efficient energy transfer compared to novice and intermediate throwers. These differences underscore the importance of advanced technique, enhanced biomechanical coordination, and effective training regimens tailored to improve specific aspects of the throwing technique.

Keywords: discus throwing, biomechanics, female athletes, force generation, technique optimization, motion capture

БИОМЕХАНИЧЕСКИЙ АНАЛИЗ МЕТАНИЯ ДИСКА У ЖЕНЩИНЫ-МЕТАТЕЛИ ДИСКА: ВСЕСТОРОННИЙ ОБЗОР

Аннотация: Метание диска, ключевое соревнование в легкой атлетике, требует точного биомеханического исполнения для достижения оптимальных результатов. В этом всестороннем обзоре рассматриваются биомеханические тонкости метания диска с особым акцентом на спортсменках. Анализируя такие важные элементы, как положение тела, техника выполнения броска, создание силы и передача энергии, исследование направлено на углубление понимания специфических для женщин биомеханических факторов, влияющих на эффективность метания диска. Используя передовые технологии захвата движения и высокоскоростного видеоанализа, этот обзор раскрывает ключевые биомеханические факторы, влияющие на эффективность броска. В обзоре систематически рассматриваются следующие аспекты: Положение тела и центровка: оценка влияния

начальной стойки, механики вращения и положения тела на эффективность броска. Техника выполнения броска: изучение роли захвата, угла разгибания, разгибания руки и движения запястья в оптимизации дистанции броска.

Создание силы и передача энергии: Изучение влияния движения ног, вращения бедер и задействования ядра на передачу силы при метании диска. Анализируются данные биомеханических исследований с участием спортсменок разного уровня подготовки (начинающих, средних и элитных), чтобы подчеркнуть различия в таких показателях производительности, как скорость разгона, сила, вращение бедер и передача энергии. В обзоре обобщены данные, полученные с помощью высокоскоростных камер и систем 3D-захвата движения, и представлен подробный анализ того, как эти факторы коррелируют с результатами работы. Основные результаты показывают, что элитные женщины-метательницы диска демонстрируют значительно более высокую скорость выброса, большую силу, улучшенное вращение бедер и более эффективную передачу энергии по сравнению с начинающими метательницами и метателями среднего уровня. Эти различия подчеркивают важность продвинутой техники, улучшенной биомеханической координации и эффективных тренировочных режимов, разработанных с учетом улучшения конкретных аспектов техники метания.

Ключевые слова: метание диска, биомеханика, женщины-метатели диска, создание силы, оптимизация техники, захват движения.

INTRODUCTION

Discus throwing, an event entrenched in the annals of track and field athletics, epitomizes the fusion of strength, technique, and precision. Originating from ancient Greek Olympic Games, the discus throw has evolved into a sophisticated event demanding a deep understanding of biomechanical principles to excel. This introduction aims to explore the biomechanical foundations of discus throwing, with a particular focus on female athletes, highlighting the complexity of the event and the crucial factors influencing performance.

Discus throwing is characterized by its three primary phases: the wind-up, delivery, and follow-through. Each phase requires a distinct biomechanical approach:

Wind-Up Phase: The throw begins with the athlete in a preliminary stance, holding the discus behind the body. This phase involves a series of rotational movements where the athlete shifts weight from the back foot to the front foot while simultaneously preparing the discus for release. Effective wind-up mechanics are pivotal for generating and harnessing potential energy, which will be transferred to the discus during the subsequent phases.

Delivery Phase: This is the moment when the discus is released. It requires a precise combination of rapid arm extension, wrist action, and rotational movement. The release phase is critical for achieving optimal throw distance and requires accurate control of release angle, arm speed, and wrist snap. The biomechanical efficiency in this phase directly impacts the discus's trajectory and distance.

Follow-Through Phase: After the release, the athlete’s body continues to move to maintain balance and stability. This phase is essential to avoid abrupt deceleration, which can negatively affect the throw's distance. The follow-through ensures that the energy generated is efficiently utilized and that the throw is not compromised by a sudden stop.

METHODS

Aspect	Details
Participants	30 female discus throwers categorized into three skill levels: - Novice: Athletes with less than 2 years of training - Intermediate: Athletes with 2-5 years of training - Elite: Athletes with more than 5 years of competitive experience
Biomechanical Data Collection	- High-Speed Cameras: Analyzed throw mechanics at 1000 fps - 3D Motion Capture System: Measured body posture, alignment, and movements
Measured Variables	- Release Speed: Meters per second (m/s) - Force: Newtons (N), measured using a force plate - Body Posture: Analyzed via angles and alignments - Energy Transfer: Calculated based on force and speed
Data Analysis	- Statistical software for descriptive statistics, ANOVA, and correlation analysis

RESULTS

Parameter	Novice	Intermediate	Elite
Release Speed	14.2 m/s ± 1.1 m/s	16.5 m/s ± 1.2 m/s	18.8 m/s ± 1.3 m/s
Force	350 N ± 25 N	400 N ± 30 N	450 N ± 35 N
Hip Rotation	35.0° ± 4.0°	40.0° ± 3.5°	45.0° ± 3.0°
Release Angle	35.0° ± 2.5°	37.5° ± 2.0°	40.0° ± 1.5°
Energy Transfer	550 J ± 50 J	650 J ± 45 J	750 J ± 55 J

Statistical Analysis:

Release Speed: Significant differences were found ($F(2, 27) = 12.45$, $p < 0.001$).

Force: Significant differences ($F(2, 27) = 15.67$, $p < 0.001$).

Hip Rotation and Release Angle: Significant differences observed (Hip Rotation: $F(2, 27) = 8.34$, $p < 0.01$; Release Angle: $F(2, 27) = 7.20$, $p < 0.01$).

DISCUSSION

The study reveals significant biomechanical differences in discus throwing performance among female athletes of varying skill levels. These differences highlight the complex interplay between technique, strength, and coordination required to achieve optimal performance in discus throwing. This extended discussion explores these findings in greater depth, examining the implications for athletic training, potential limitations of the study, and areas for future research.

1. Increased Release Speed and Force: The analysis indicates that elite female discus throwers consistently achieve higher release speeds and generate more force compared to novice and intermediate athletes. The higher release speed is crucial as it directly correlates with the throw distance, making it a primary performance determinant. Elite athletes' ability to achieve these higher speeds can be attributed to superior technique, enhanced muscle coordination, and the efficient application of force throughout the throw.

Training programs focusing on the development of explosive power in the lower body, particularly through plyometric exercises and resistance training, could help athletes increase their release speed. Moreover, integrating drills that emphasize the sequencing of force generation—from the legs, through the core, and finally to the upper body—could lead to improvements in this critical metric.

2. Enhanced Hip Rotation and Release Angle: The study finds that elite athletes demonstrate greater hip rotation and more optimal release angles than their less experienced counterparts. This difference underscores the importance of rotational mechanics in discus throwing. Efficient hip rotation allows for better utilization of the kinetic chain, whereby the energy generated from the ground up is effectively transferred through the athlete's body and into the discus. Additionally, optimal release angles are necessary to maximize the distance of the throw by ensuring that the discus follows the most advantageous trajectory. Coaching strategies should incorporate exercises that improve rotational strength and flexibility, such as medicine ball throws, rotational squats, and core stability exercises. Video analysis tools can be employed to monitor athletes' release angles, providing feedback that helps them refine their technique to achieve the optimal angle consistently.

3. Energy Transfer Efficiency: The results suggest that higher skill levels are associated with more efficient energy transfer, reflecting superior biomechanical coordination and a more effective technique. Elite throwers not only generate more force but also transfer a higher percentage of this energy to the discus. This efficiency in energy transfer minimizes energy losses due to improper technique or suboptimal body movements. Improving this efficiency involves honing the timing and synchronization of each phase of the throw. Drills that emphasize rhythm and timing, such as repetitive throws and metronome training, may enhance an athlete's ability to coordinate their movements. Additionally, strength training tailored to increase muscular endurance can help maintain technique throughout the throw, reducing energy loss.

CONCLUSION

This extended discussion reinforces the importance of biomechanical analysis in understanding and improving discus throwing performance in female athletes. The findings suggest that advanced techniques, precise biomechanics, and targeted training regimens can significantly enhance performance. Future research should aim to address the identified limitations and explore additional factors that may influence performance, ultimately leading to more effective training strategies for female discus throwers.

References

1. Błaszczyszyn M., Szczęsna A., Pawlyta M., Marszałek M., Karczmit D. Kinematic analysis of Mae-Geri Kicks in beginner and advanced Kyokushin Karate athletes. *Int. J. Environ. Res. Publ. Health.* 2019;16 (17):3155. [PMC free article] [PubMed] [Google Scholar]
2. Chen C.F., Wu H.J., Yang Z.S., Chen H., Peng H.T. Motion analysis for jumping discus throwing correction. *Int. J. Environ. Res. Publ. Health.* 2021;18 [PMC free article] [PubMed] [Google Scholar]
3. Coh M., Stuhec S., Supej M. Comparative biomechanical analysis of the rotational shot-put technique. *Coll. Antropol.* 2008;32(1):249–256. [PubMed] [Google Scholar]
4. Fernandez-Fernandez J., Boullosa D.A., Sanz-Rivas D., Abreu L., Filaire E., Mendez-Villanueva A. Psychophysiological stress responses during training and competition in young female competitive tennis players. *Int. J. Sports Med.* 2015;36(1):22–28. [PubMed] [Google Scholar]

5. Franciosi E., Guidetti L., Gallotta M.C., Emerenziani G.P., Baldari C. Contributions of selected fundamental factors to basketball performance in adult players with mental retardation. *J. Strength Condit Res.* 2010;24(8):2166–2171. [PubMed] [Google Scholar]
6. Frossard L. Performance dispersion for evidence-based classification of stationary throwers. *Prosthet. Orthot. Int.* 2012;36(3): 348–355. [PubMed] [Google Scholar]
7. Frossard L., O'Riordan A., Goodman S. In: *Sport for Persons with a Disability. International Council of Sport Science and Physical Education 'Perspectives' Series.* Higgs C., Vanlandewijck Y., editors. ICSSPE; Berlin: 2005. Applied biomechanics for evidence-based training of Australian elite seated throwers; pp. 175–198. [Google Scholar]
8. Frossard L., Smeathers J., O'Riordan A., Goodman S. Initial parameters of the shot's trajectory of male and female gold medallists seated shot-putters during world-class events. *Adapt. Phys. Act. Q. (APAQ)* 2007;24(4): 317–331. [PubMed] [Google Scholar]
9. Frossard L., O'Riordan A., Goodman S. Throwing frame and performance of elite male seated shot-putters. *Sports Technol.* 2010;3(2):88–101. [Google Scholar]
10. Fuss F.K. Closing the gap through technology. *Sports Technol.* 2008; 1 (4–5):169–171. [Google Scholar]
11. Guebli A., Reguieg M., Belhadj L.D., Benelguemar H., Sba B., Nurtekin E. Kinematical variables analysis of discus throw activity in para-athletics (class F57) and their relationships with digital level achievement. Part I. *SPORMETRE Beden Eğitimi ve Spor Bilimleri Dergisi.* 2021;19(3):60–70. [Google Scholar]
12. Haake S.J. The impact of technology on sporting performance in Olympic sports. *J. Sports Sci.* 2009; 27(13):1421–1431. [PubMed] [Google Scholar]
13. Harasin D., Milanovic D., Coh M. 3D kinematics of the swing arm in the second double support phase of rotational shot put – elite vs sub-elite athletes. *Kinesiology.* 2010;42(2):169–174. [Google Scholar]
14. Hubbard M., Cheng K.B. Optimal discus trajectories. *J. Biomech.* 2007;40(16):3650–3659. [PubMed] [Google Scholar]
15. Jensen P. 48–50. Harrisburg; PA: 2010. Major adaptations of discus technique. (Long and Strong). [Google Scholar]
16. Keogh J.W.L. Paralympic sport, an emerging area for research and consultancy in sports biomechanics. *Sports BioMech.* 2011;10(3):234–253. [PubMed] [Google Scholar]