

Biomechanics: Movement, Injury, Performance, Prevention

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Introduction

This review discusses how running shoes influence biomechanics and, consequently, injury risk. It highlights the complex interaction between shoe characteristics, individual running patterns, and ground reaction forces, emphasizing that a universal 'best' shoe for injury prevention likely doesn't exist. Instead, shoe choice should consider individual needs and biomechanical profiles to optimize comfort and load distribution[1].

This systematic review identifies significant sex differences in lower extremity biomechanics during landing tasks, with females often exhibiting greater knee valgus moments and reduced knee flexion. These findings are crucial for understanding the higher incidence of Anterior Cruciate Ligament (ACL) injuries in female athletes and for developing targeted injury prevention programs[2].

This paper investigates age-related changes in neuromuscular control and their biomechanical implications for lower limb function in older adults. It emphasizes how alterations in muscle activation patterns and sensory feedback contribute to decreased balance, gait instability, and increased fall risk, suggesting targeted interventions could improve mobility and safety[3].

This meta-analysis examines how saddle height impacts cycling biomechanics and power output. It concludes that an optimal saddle height exists to maximize power and minimize injury risk by influencing joint angles, muscle activity, and pedaling efficiency. Extreme deviations from this optimum can reduce performance and increase strain on the musculoskeletal system[4].

This review examines the growing use of wearable sensors for gait analysis in clinical settings. It highlights the potential of these devices to provide objective, real-world data on gait parameters, aiding in the assessment, monitoring, and rehabilitation of various clinical populations by offering insights into movement patterns outside of traditional lab environments[5].

This meta-analysis investigates how the biomechanical properties of the Achilles tendon change with age. It reveals that older adults exhibit reduced tendon stiffness and increased slack, which can impair force transmission and contribute to gait alterations and a higher risk of tendon injuries. Understanding these changes is critical for developing age-appropriate exercise and rehabilitation strategies[6].

This review analyzes the biomechanical impact of standing desk workstation designs on upper extremity posture and muscle activity. It suggests that while standing desks offer benefits over prolonged sitting, specific design elements, such as keyboard and monitor height, are crucial for optimizing ergonomic posture and reducing muscle fatigue, thus preventing musculoskeletal disorders[7].

This meta-analysis synthesized data on gait biomechanics in individuals with Parkinson's disease (PD), revealing characteristic alterations such as reduced step length, velocity, and increased variability. Understanding these specific gait deficits is critical for developing targeted rehabilitation strategies to improve mobility and reduce fall risk in PD patients[8].

This meta-analysis investigated how foot orthoses impact lower limb biomechanics in people with flat feet (pes planus). It concluded that orthoses can significantly alter foot kinematics and kinetics, reducing pronation and influencing joint moments up the kinetic chain. This biomechanical modification helps alleviate pain and improve function, supporting their use in conservative management[9].

This review explores the force-velocity relationship of muscle contractions, discussing its fundamental principles, measurement techniques, and practical implications in sports and exercise. It highlights how understanding this relationship can optimize training protocols for power development, assess muscle function, and inform rehabilitation strategies, while also acknowledging its methodological limitations[10].

Description

This body of work investigates various biomechanical aspects crucial for injury prevention and performance optimization. The role of running shoes in preventing injuries is complex; it highlights that a universal 'best' shoe doesn't exist, and instead, shoe choice should align with individual needs and biomechanical profiles to optimize comfort and load distribution [1]. In cycling, saddle height critically influences both biomechanics and power output. An optimal height maximizes power while minimizing injury risk by affecting joint angles, muscle activity, and pedaling efficiency, with extreme deviations leading to reduced performance and increased musculoskeletal strain [4]. Additionally, a review of the force-velocity relationship of muscle contractions provides fundamental principles, measurement techniques, and practical implications in sports and exercise science, demonstrating how understanding this relationship can optimize training protocols for power development, assess muscle function, and inform rehabilitation strategies [10].

Significant biological differences impact biomechanics, notably between sexes and across age groups. Systematic reviews show that females often exhibit greater knee valgus moments and reduced knee flexion during landing tasks, findings crucial for understanding their higher incidence of Anterior Cruciate Ligament (ACL) injuries and for developing targeted prevention programs [2]. Age-related changes also profoundly affect lower limb function. Alterations in neuromuscular control contribute to decreased balance, gait instability, and increased fall risk in older

adults, suggesting targeted interventions could improve mobility and safety [3]. Similarly, the Achilles tendon's biomechanical properties, such as reduced stiffness and increased slack, change with age, impairing force transmission and contributing to gait alterations and a higher risk of tendon injuries. Recognizing these changes is critical for developing age-appropriate exercise and rehabilitation strategies [6].

The analysis of gait is a prominent theme, particularly its application in clinical contexts. Wearable sensors are increasingly used for gait analysis in clinical settings, demonstrating their potential to provide objective, real-world data on gait parameters. These devices offer crucial insights into movement patterns outside traditional lab environments, assisting in the assessment, monitoring, and rehabilitation of various clinical populations [5]. This objective data is especially valuable for identifying specific pathologies. For instance, individuals with Parkinson's disease (PD) exhibit characteristic gait alterations, including reduced step length, velocity, and increased variability. Understanding these specific gait deficits is critical for developing targeted rehabilitation strategies to improve mobility and reduce fall risk in PD patients [8].

Specific interventions targeting foot biomechanics are also explored. A meta-analysis on foot orthoses in people with flat feet (pes planus) found that orthoses significantly alter foot kinematics and kinetics. By reducing pronation and influencing joint moments up the kinetic chain, these biomechanical modifications help alleviate pain and improve function, thereby supporting their use in conservative management [9].

Lastly, ergonomic considerations for workstation design are addressed. A review analyzes the biomechanical impact of standing desk workstation designs on upper extremity posture and muscle activity. It suggests that while standing desks offer benefits over prolonged sitting, specific design elements, such as keyboard and monitor height, are crucial for optimizing ergonomic posture and reducing muscle fatigue, ultimately preventing musculoskeletal disorders. This highlights the importance of thoughtful design in promoting health in occupational settings [7].

Conclusion

This collection of reviews and meta-analyses delves into diverse aspects of biomechanics, examining its influence on human movement, injury risk, and performance. Several studies focus on lower extremity biomechanics, exploring how running shoes affect injury prevention, emphasizing individualized shoe choice rather than a universal best option [1]. Sex differences in lower extremity biomechanics during landing tasks reveal higher knee valgus moments in females, which is vital for understanding Anterior Cruciate Ligament (ACL) injury rates and developing targeted prevention programs [2]. Age-related changes in neuromuscular control significantly impact lower limb function, leading to decreased balance, gait instability, and increased fall risk in older adults [3]. Similarly, the Achilles tendon's biomechanical properties, such as stiffness and slack, also change with age, affecting force transmission and increasing injury susceptibility [6]. Gait analysis is a recurring theme, with research on wearable sensors demonstrating their potential for objective, real-world data collection in clinical populations, aiding assessment and rehabilitation [5]. Specific gait alterations, like reduced step length and velocity, are observed in individuals with Parkinson's disease, necessitating targeted rehabilitation strategies [8]. Other topics include the optimization of cycling biomechanics through saddle height adjustments to maximize power and minimize injury [4], and the impact of foot orthoses on lower limb biomechanics in those with flat feet, which can alleviate pain and improve function [9]. Ergonomic considerations extend to workstation design, where standing desks are analyzed for their effect on upper extremity posture and muscle activity, highlighting the importance

of proper setup to prevent musculoskeletal disorders [7]. Finally, the fundamental force-velocity relationship of muscle contractions is explored, outlining its applications and limitations in sports science for optimizing training and rehabilitation [10]. Collectively, these studies underscore the complex interplay of intrinsic and extrinsic factors influencing human biomechanics across different populations and activities, providing critical insights for injury prevention, performance enhancement, and clinical intervention.

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Conflict of Interest

None.

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