



دراسة حول العلاقة بين الميكانيكا الحيوية والإصابات الرياضية لدى الرياضيين الأطفال

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الكلمات المفتاحية: الميكانيكا الحيوية ، الإصابات ، الرياضيين ، الاطفال  
مستخلص البحث :

البايوميكانيكا المختلفة، مع التركيز على توجهات بحثية جديدة مثل استخدام التكنولوجيا القابلة للارتداء في تقييم البايوميكانيكا الرياضية.

## Study on the Relationship between Biomechanics and Sports Injuries in Pediatric Athletes

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### Abstract:

This research explores the relationship between biomechanics and sports injuries in young athletes, focusing on how biomechanical factors influence the risk of sports injuries and methods for prevention and rehabilitation. The literature review

هذا البحث يستكشف العلاقة بين البايوميكانيكا والإصابات الرياضية في الرياضيين الصغار، مركزاً على كيفية تأثير العوامل البايوميكانيكية في خطر الإصابات الرياضية وطرق الوقاية منها وإعادة التأهيل. يُظهر الاستعراض الأدبي تنوع الإصابات الشائعة بين الأطفال الرياضيين، بما في ذلك الإصابات الحادة مثل الالتواءات والكسور، وإصابات الإفراط في الاستخدام مثل التهاب الأوتار، والمشاكل المتعلقة بالنمو. يُسلط الضوء على عدة عوامل بايوميكانيكية مثل القوى العالية الأثر، الحركة المتكررة، وفترات الراحة غير الكافية كعوامل خطر للإصابات. تُبيّن الدراسة أهمية التقييمات البايوميكانيكية في تحديد هذه العوامل وتطوير استراتيجيات الوقاية والتأهيل القائمة على الدليل، بما في ذلك تعديل التقنيات، برامج التقوية والتكييف، واستخدام المعدات الواقية. يُشير البحث أيضاً إلى الحاجة إلى مزيد من الدراسات حول آثار التخصص الرياضي المبكر وفعالية تدخلات

optimize rehabilitation protocols tailored to the pediatric population. The importance of this research lies not only in safeguarding the health and well-being of young athletes but also in fostering a foundation for lifelong physical activity and sports participation without the setback of injuries.

**1.1 Research Objectives:** The primary aim of this study is to systematically explore the relationship between biomechanics and sports injuries in pediatric athletes. Specific objectives include:

- To identify biomechanical factors that contribute to the risk of sports injuries in children.
- To evaluate the impact of biomechanical assessments in the prevention and management of sports injuries in pediatric athletes.
- To synthesize current knowledge on effective biomechanical interventions aimed at reducing injury rates among young athletes.

**1.2 Research Questions or Hypotheses:**

- What biomechanical factors are most strongly associated with an increased risk of sports injuries in pediatric athletes?
  - How do biomechanical assessments contribute to the prevention and management of sports injuries in this population?
  - What evidence-based biomechanical interventions can effectively reduce the incidence of sports injuries in pediatric athletes?
- These questions aim to guide the research through a comprehensive examination of biomechanics as a critical component in the prevention,

reveals a diversity of common injuries among pediatric athletes, including acute injuries such as sprains and fractures, overuse injuries like tendinitis, and growth-related issues. Several biomechanical factors, such as high-impact forces, repetitive motion, and insufficient rest periods, are highlighted as risk factors for injuries. The study underscores the importance of biomechanical assessments in identifying these factors and developing evidence-based prevention and rehabilitation strategies, including technique modifications, strength and conditioning programs, and the use of protective equipment. The research also points to the need for further studies on the effects of early sports specialization and the effectiveness of various biomechanical interventions, with a focus on new research directions such as the use of wearable technology in the biomechanical assessment of sports activities.

**Keywords: Biomechanics, Injuries, Athletes, Children**

## 1- Introduction

The intersection of biomechanics and sports injuries, particularly within the context of pediatric athletes, represents a pivotal area of inquiry within sports science and pediatric health. This research area garners significant attention due to the unique physiological and developmental characteristics of children, which influence their susceptibility to sports-related injuries. The application of biomechanical principles offers a promising avenue to enhance our understanding of injury mechanisms, inform preventive strategies, and

Adolescent Sports Injuries: Specific Considerations in the Young Athlete." Their work underscores the importance of recognizing biomechanical patterns that predispose young athletes to injuries [2].

#### **2.4 Prevention and Rehabilitation Strategies**

Emery and Meeuwisse (2010) discuss the effectiveness of neuromuscular training programs in "The Effectiveness of a Neuromuscular Prevention Strategy to Reduce Injuries in Youth Soccer: A Cluster-Randomised Controlled Trial," showcasing how biomechanical interventions can mitigate injury risks in pediatric sports populations [3].

#### **2.5 Gaps in Current Knowledge**

DiFiori et al. (2014) in "Overuse Injuries and Burnout in Youth Sports: A Position Statement from the American Medical Society for Sports Medicine" call attention to the need for more research on the long-term effects of early sports specialization. They highlight a significant gap in understanding how early, intensive training impacts the biomechanics and overall health of pediatric athletes.

By integrating these real studies, this Literature Review not only provides a comprehensive overview of the field but also underscores the critical role of biomechanical understanding in enhancing the safety and performance of pediatric athletes. Each study contributes to a broader comprehension of how biomechanical factors influence sports injury risks and prevention strategies, setting the stage for further investigation into unexplored areas [4].

diagnosis, and treatment of sports injuries among children engaged in athletic activities.

### **2. Literature Review**

The Literature Review section synthesizes existing research on biomechanics, sports injuries among pediatric athletes, and preventive strategies. This section reviews the interplay between biomechanical factors and injury risks in young athletes, drawing on a range of studies to map the current landscape.

#### **2.1 Overview of Biomechanics in Pediatric Sports**

Biomechanics is critical in enhancing athletic performance and injury prevention. Myers et al. (2017) in "The Role of Biomechanics in Maximizing Distance and Accuracy of Golf Shots in Young and Senior Golfers" offer insights into the application of biomechanical assessments for optimizing performance, which can be extrapolated to pediatric sports for injury risk identification and performance enhancement [1].

#### **2.2 Common Sports Injuries in Pediatric Athletes**

Straccolini et al. (2015), in their study "Pediatric Sports Injuries: An Age Comparison of Children Versus Adolescents," provide a comprehensive overview of the types and prevalence of sports injuries, emphasizing the impact of age and developmental stages on injury types and recovery.

#### **2.3 Biomechanical Risk Factors for Sports Injuries**

Meehan and Straccolini (2012) highlight biomechanical risk factors such as improper landing techniques and overuse, leading to ACL injuries and stress fractures in "Pediatric and

mitigating injury risks, emphasizing the need for biomechanically informed training and equipment design tailored to young athletes' developmental stages [6].

**Stress-Strain Injury Model:** This model explains how biomechanical stress (force per unit area) and strain (deformation in response to stress) on tissues can lead to sports injuries, according to this model, injuries occur when the stress and strain on the body's tissues exceed their capacity to withstand and adapt to these forces. For pediatric athletes, whose musculoskeletal systems are still developing, the balance between stress, strain, and tissue capacity is delicate. Understanding the biomechanical properties of pediatric athletes' tissues and the forces they encounter during sports activities is crucial for developing preventive strategies that reduce the risk of exceeding these biomechanical thresholds [7].

**Integration into Research Questions:** Grounded in DST and the Stress-Strain Injury Model, the research questions explore how biomechanical assessments can identify risk factors for injuries in pediatric athletes and how tailored interventions based on these assessments can mitigate such risks. The framework hypothesizes that interventions addressing the biomechanical imbalances or deficiencies identified through these assessments can effectively reduce the incidence of sports injuries among pediatric athletes [8].

#### **4.2 Linking Biomechanics to Injury Prevention and Rehabilitation**

Biomechanical assessments and interventions are grounded in the

#### **4. Theoretical Framework**

The Theoretical Framework for the study on "The Relationship between Biomechanics and Sports Injuries in Pediatric Athletes" builds upon conceptual models from sports science and pediatric exercise physiology. It integrates theoretical perspectives that elucidate the multifaceted influence of biomechanical factors on the risk and occurrence of sports injuries among pediatric athletes. This framework serves as the foundation for the study's hypotheses or research questions, grounding them in a blend of established theories and recent findings [5].

##### **4.1 Conceptualizing Biomechanical Influences**

Biomechanical factors play a crucial role in the incidence and prevention of sports injuries in pediatric athletes. The theoretical framework draws on two main models: the Dynamic Systems Theory (DST) in motor development and the Stress-Strain Injury Model specific to sports injuries.

**Dynamic Systems Theory (DST):** DST posits that human movement emerges from the interaction of various subsystems, including the individual's biomechanics, environment, and task at hand (Thelen, 1989). In the context of pediatric athletes, this theory suggests that the risk of sports injuries is not solely determined by the child's physical attributes (e.g., muscle strength, flexibility) but also by environmental factors (e.g., playing surface, footwear) and the specific demands of the sports activity (e.g., jumping, running). This perspective underlines the importance of a holistic approach to understanding and

activities, making biomechanical assessments and interventions crucial for safely navigating these developmental stages [10].

#### **4.4 Identifying Research Gaps and Emerging Trends**

While significant strides have been made in understanding biomechanics and pediatric sports injuries, gaps in knowledge persist. For example, there is limited research on the long-term effects of biomechanical interventions on injury rates and performance in pediatric populations. Additionally, the biomechanical differences between genders and across various stages of development are not fully understood, representing an area ripe for further investigation. Emerging trends in biomechanics and pediatric sports science include the use of wearable technology to monitor athletes in real-time, offering new opportunities for personalized and immediate feedback on movement patterns. The integration of machine learning algorithms with biomechanical data presents another frontier, potentially enabling predictive models of injury risk based on individual biomechanical profiles, these trends highlight the dynamic and evolving nature of the field, emphasizing the need for ongoing research to fully leverage biomechanics in enhancing the safety and performance of young athletes [11].

### **3. Methodology**

**3.1 Research Approach:** This study employs a descriptive literature review methodology, aiming to compile and synthesize existing research on the relationship between biomechanics and sports injuries in pediatric athletes.

theoretical basis that understanding the mechanical aspects of movement can significantly prevent or mitigate sports injuries in young athletes. Motor learning theories suggest that through biomechanical assessments, athletes can be taught optimal movement patterns that reduce the risk of injury by enhancing coordination and efficiency, Physical adaptation theories, such as the SAID principle (Specific Adaptation to Imposed Demands), further support the notion that targeted biomechanical interventions can strengthen musculoskeletal structures, making them more resilient to the stresses encountered in sports, Injury mechanics theories provide insight into how injuries occur from a biomechanical perspective, offering a framework for designing interventions that specifically address these mechanisms[9]

#### **4.3 The Role of Pediatric Development**

The developmental aspects of pediatric athletes play a critical role in their susceptibility to sports injuries, necessitating tailored prevention and rehabilitation strategies. Growth patterns and developmental biomechanics highlight the importance of considering the anatomical and physiological changes that occur during childhood and adolescence. For instance, the concept of growth-related vulnerability posits that rapid periods of growth can temporarily weaken joints and increase the risk of, Theories of neuromuscular control development emphasize that younger athletes may not yet have fully developed the motor control necessary for certain sports

sports injuries, preventive biomechanics, and rehabilitation strategies.

**3.5 Quality Assessment:** Although this study does not involve empirical data analysis, it will assess the quality and reliability of included studies using established criteria, such as study design, methodology, and the impact of findings on the field.

**3.6 Ethical Considerations:** As this research relies on previously published studies, direct ethical concerns related to human subjects are minimal. However, the research will adhere to ethical standards of academic integrity and proper citation to acknowledge the original authors.

This methodology enables a comprehensive examination of existing literature on biomechanics and sports injuries in pediatric athletes, providing a solid foundation for understanding the current landscape, identifying best practices, and suggesting areas for future research.

## 4. Results

**4.1 Overview of Biomechanics in Pediatric Sports:** Biomechanics plays a pivotal role in enhancing athletic performance and preventing injuries among pediatric athletes. Fundamental principles such as kinematics and kinetics are applied to understand and optimize movement patterns, with biomechanical assessments frequently used to identify potential risk factors like improper technique or muscle imbalances. These evaluations are crucial for tailoring training and prevention strategies to the unique needs of young athletes, aiming to

This approach facilitates an in-depth understanding of the current state of knowledge, identifies key theories and findings, and highlights gaps in the literature without the necessity for statistical analysis.

**3.2 Data Sources:** The research will systematically search electronic databases, including PubMed, Scopus, and Google Scholar, for relevant literature. Keywords related to biomechanics, sports injuries, and pediatric athletes will guide the search. The review will consider peer-reviewed journal articles, conference proceedings, and authoritative reports published in English over the last two decades.

### 3.3 Inclusion and Exclusion Criteria:

- **Inclusion Criteria:** Articles that focus on biomechanics and sports injuries in pediatric athletes, including both observational studies and reviews. The literature should provide insights into biomechanical risk factors, preventive measures, and rehabilitation strategies.

- **Exclusion Criteria:** Studies focusing on adult populations, non-sports-related injuries, or lacking a clear focus on biomechanical aspects will be excluded.

### 3.4 Literature Review Process:

- **Screening:** Initial screening of titles and abstracts to identify potentially relevant articles.

- **Eligibility:** Full-text review of screened articles to determine their relevance based on the inclusion and exclusion criteria.

- **Synthesis:** Summarizing findings from the selected articles, categorizing them into themes such as biomechanical risk factors, types of

athlete's specific needs, promoting a safer return to sport.

#### **4.5 Gaps in Current Knowledge:**

Despite significant advancements, gaps remain in our understanding of the biomechanics of pediatric sports injuries. Notably, the long-term effects of early sports specialization on biomechanics and injury risk are not well-documented. Additionally, the effectiveness of certain biomechanical interventions requires further investigation, particularly across diverse pediatric populations and various sports disciplines.

**4.6 Emerging Trends:** Emerging trends in the field include the adoption of new technologies for biomechanical assessment, such as wearable sensors and motion capture systems, which offer insights into real-time athletic performance and injury risk. Furthermore, innovative training methodologies that incorporate biomechanical principles are being developed, alongside evolving concepts in injury prevention and rehabilitation, pointing towards a future where sports participation is safer and more efficient for pediatric athletes.

This comprehensive synthesis provides a clear overview of the current state of knowledge on biomechanics and sports injuries in pediatric athletes, laying the groundwork for future research and interventions aimed at enhancing the safety and performance of young athletes in sports.

improve efficiency and safety in sports participation.

#### **4.2 Common Sports Injuries in Pediatric Athletes:**

The literature reveals a variety of sports injuries common among pediatric athletes, including acute injuries (e.g., sprains and fractures), overuse injuries (e.g., tendinitis), and growth-related issues. The prevalence of these injuries varies significantly across different sports and is influenced by factors such as age, sex, and competitive level. This variation underscores the importance of sport-specific injury prevention and management strategies.

#### **4.3 Biomechanical Risk Factors for Sports Injuries:**

Analysis of existing research highlights several biomechanical risk factors associated with sports injuries in pediatric athletes. These include high-impact forces during play, repetitive motion leading to overuse injuries, and inadequate recovery periods. Additionally, biomechanical misalignments or deficiencies, such as imbalances in muscle strength or flexibility, have been identified as contributing factors to the injury risk.

#### **4.4 Prevention and Rehabilitation Strategies:**

The review points to evidence-based biomechanical strategies effective in preventing and rehabilitating sports injuries. These strategies encompass technique modifications to reduce injury risk, strength and conditioning programs to address biomechanical imbalances, and the use of protective equipment designed from biomechanical insights. Rehabilitation approaches leveraging biomechanical analysis ensure recovery protocols are customized to address the

development, affecting their biomechanical characteristics and injury susceptibility. For instance, implementing plyometric training that focuses on improving neuromuscular control can significantly reduce the risk of lower limb injuries. The success of such preventive measures relies on a thorough understanding of biomechanical principles and their application in creating age-appropriate, sport-specific training regimens.

### **5.3 Rehabilitation Strategies**

The role of biomechanical evaluations extends into the rehabilitation process, where they inform the development of personalized recovery plans. These plans, grounded in biomechanical insights, aim to address the specific deficits and needs of injured pediatric athletes, facilitating more effective and efficient rehabilitation outcomes. For example, research has highlighted the effectiveness of biomechanically based rehabilitation protocols in addressing post-ACL reconstruction deficits in young athletes, emphasizing the restoration of proper knee mechanics and neuromuscular control. Such strategies underscore the importance of incorporating biomechanical analysis into the rehabilitation process, ensuring that recovery plans are not only personalized but also conducive to the long-term health and performance of pediatric athletes. The integration of biomechanical strategies into rehabilitation protocols represents a significant advancement in sports medicine, offering promising prospects for enhancing recovery outcomes in pediatric sports injuries [13].

### **In conclusion**

## **5. Discussion**

### **5.1 Interpretation of Findings**

The findings from this research underscore the pivotal role of biomechanical factors in the occurrence and prevention of sports injuries among pediatric athletes. Biomechanical assessments have emerged as crucial tools in identifying risk factors such as improper technique or muscle strength imbalances. These assessments enable the development of targeted injury prevention strategies by offering insights into the unique physical dynamics of young athletes. For example, studies have shown that specific biomechanical patterns, like those related to landing mechanics in jump sports, significantly contribute to the risk of anterior cruciate ligament (ACL) injuries. By pinpointing such risk factors, interventions can be tailored to address the specific needs of pediatric athletes, thereby enhancing their safety and performance in sports [12].

### **5.2 Biomechanical Principles and Injury Prevention**

Biomechanical principles form the foundation of designing effective preventive measures for sports injuries. Training modifications, equipment adjustments, and the introduction of biomechanically informed exercises aim to mitigate injury risks by improving athletic performance and safety. The application of these principles allows for the customization of prevention strategies to fit the biomechanical profiles of individual athletes. This approach is vital in pediatric sports, where athletes undergo various stages of physical growth and

- Adoption of injury prevention strategies that are informed by biomechanical analysis, including technique modification, strength and conditioning exercises, and the use of appropriate protective equipment.

#### **Suggestions for Future Research:**

- Further studies are needed to examine the long-term effects of early sports specialization on the biomechanics and overall health of young athletes.
- There is a significant opportunity for research into the effectiveness of various biomechanical interventions across different pediatric populations and sports disciplines.
- Investigating the potential of emerging technologies, such as wearable sensors and motion capture systems, in enhancing the biomechanical assessment and monitoring of young athletes in real-time sports environments.

This research contributes to the growing body of knowledge on sports biomechanics and pediatric athlete health, offering a foundation for future investigations aimed at optimizing sports participation safety and performance among young athletes.

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In conclusion, this research, which explored the relationship between biomechanics and sports injuries in young athletes, has led to several key findings that highlight the importance of biomechanical factors in determining the risk of sports injuries and in developing effective methods for injury prevention and rehabilitation.

#### **Findings:**

- The results indicate that biomechanical assessments provide essential insights into risk factors such as improper technique or muscle imbalances, which are crucial for devising targeted injury prevention strategies.
- A diverse range of sports injuries common among pediatric athletes, including acute injuries, overuse injuries, and growth-related issues, underscores the need for sport-specific and age-appropriate prevention and rehabilitation protocols.
- The study also reveals the critical role of biomechanical principles in designing preventive measures and rehabilitation strategies, emphasizing the benefits of personalized assessments and interventions.

#### **Recommendations:**

- Sports organizations and coaching staff should incorporate regular biomechanical assessments into their training programs to identify and mitigate potential injury risks among young athletes.
- Development and implementation of comprehensive educational programs for coaches, parents, and athletes on the importance of biomechanics in sports safety and performance.

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