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Review Article

The Mechanics of Speed: A Systematic Literature Review on Athletic Sprint Technique

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Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

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Abstract

Objectives. This study aimed to collect and analyze findings from research on athletic sprinting techniques through a biomechanics approach to provide an in-depth understanding of effective technique and biomechanical factors that influence sprint performance.

Materials and methods. This review inquiry adhered to the PRISMA guidelines for systematic reviews and meta-analyses. The studies should have been published between January 2020 and August 2025, which encompassed the previous five years. The following keywords were used in the search process: Techniques for Athletic Sprinting. The search was conducted using the ScienceDirect database.

Results. The search process showed the following results: set position – 2 articles, hip angle – 3 articles, shorter time – 2 articles, fascicle length – 1 article, knee flexor – 3 articles, and hamstring length – 2 articles.

Conclusions. The center of mass and contact time along with force application to the back block are critical to acceleration. Muscle properties, such as fascicle length, and joint motion (ankle, hip, and BCM), in addition to trunk, knee, and hip angles, define sprint mechanics.

Keywords: athletic sprint, biomechanics, technique.

Introduction

Sprinters exhibit unique characteristics that differentiate them from other athletes. Research shows that sprinters have specific body size and composition traits, with top performers displaying greater body mass index, muscle girths, fat-free mass, and strength than lower-performing sprinters (Barbieri et al., 2017). Additionally, sprinters possess inhomogeneous muscularity, impacting mass distribution and mechanical difficulty in movement, although their normalized moment of inertia is not significantly different from non sprinters (Sado et al., 2023). The development of sprinting speed is influenced by various factors such as morphological and physiological characteristics, energy mechanisms, coordination, and optimal biomechanics (Haugen et al., 2019). Understanding these characteristics is crucial for coaches and sports scientists to enhance sprinters' performance through tailored training programs and techniques.

Systematic literature evaluations help business executives make better judgments by offering a thorough overview of a subject covered in business literature and directing future research (Clark et al., 2021). According to (Foo et al., 2021), systematic reviews play a crucial role in synthesizing research findings and demystifying the search process. In systematic reviews, a search summary table enhances the reporting of search results and broadens the body of knowledge regarding information retrieval (Bethel et al., 2021).

Understanding effective and efficient movement in sports is essential to enhancing skill development in novice learners, improving performance efficiency in athletes and musicians, and facilitating patient recovery (Wulf & Lewthwaite, 2021). Understanding biomechanics and its application in sports helps athletes learn the correct way to execute skills and achieve correct mechanical technique, leading to success (Baudha, 2023). Understanding efficient movement in sport is important because it contributes to our understanding of how elite performers optimize their movements under competitive pressure (Burns et al., 2020).

Previous research limited generalizability due to small sample size and subjective nature of concept mapping technique (Kalema et al., 2022). Impedes application of results in track and field athletes (Moura et al., 2023). No evidence to suggest superiority of either technique (LeDune et al.,

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2012). The main gaps in this study are the limitations of the small sample size and the subjectivity of the concept mapping technique, which reduces the generalizability of the results and the accuracy of application in athletics. In addition, there was no clear evidence regarding the superiority of one technique over another, indicating the need for further research. The novelty of this study lies in the attempt to address such issues by integrating more objective methods and using a larger sample size, as well as providing a comprehensive analysis of the different techniques to determine the effectiveness of the better technique and its application in a broader athletic context.

This study aimed to collect and analyze findings from studies on athletic sprinting techniques through a biomechanics approach to provide an in-depth understanding of effective technique and biomechanical factors that influence sprint performance. The novelty of this study lies in using a systematic approach to review the literature on sprint technique, enabling the integration of various findings and the development of comprehensive, evidence-based recommendations, as well as identifying research areas that require further exploration in the context of sprint biomechanics.

Materials and Methods

Systematic literature review (SLR) is the research method that is employed; specifically, biomechanical analysis on sprinting is examined, studied, and interpreted. The term "SLR research" refers to a group of studies that deal with data gathering techniques or research subjects that are investigated using a variety of library resources (books, encyclopedias, scientific journals, magazines, and documents). According to Baker (2016), the stages that the systematic literature review goes through are as follows:

1. Create inquiries for your research.
2. Ascertain search terms, databases, and inclusion and exclusion standards.
3. Search the literature.
4. Article identification and screening.
5. Evaluating the literature's viability and quality.
6. Review of the literature.
7. Synthesis and analysis of qualitative data.

Study Participants

Articles from international publications that were indexed by science direct, a very reliable database, made up the study's population. We looked through published publications from Science Direct from 2020 to 2024 for the term "Athletic Sprint Techniques." Articles published between 2020 and 2024 made up the sample. Primary and secondary data sources are the two categories of research data sources used in this study. A data coding sheet is the tool employed in this study. This information is helpful in explaining the exclusion of specific studies from the synthesis in addition to acting as an internal audit.

Data Collection Techniques and Instruments

Planning

Forming a review panel including experts and practitioners to formulate a review question is the first step in initiating the systematic review process. The review questions will lead to the synthesis and analysis of data. The problem formulation chapter includes a discussion of review questions.

Data Collection

The stage of gathering data for study is known as data collecting. The information gathered for this study is secondary information taken from primary scientific reports published in primary scientific publications, which were the findings of earlier academics' research. This study searched a number of reliable online databases, including Science Direct. The keywords "Athletic AND Sprint AND Techniques" were used in the article search. To boost the number of article searches, the author also looked through the references of the articles that were searched.

Criteria for Inclusion and Exclusion

This step determines whether the discovered data can be used or not for SLR research. SLR investigation or not. The following conditions must be met for this study to be included, or for a study to be chosen:

1. Only keyword-related data was used.
2. The article "Data" is original.
3. Only articles written in English that are indexed using preset standards.
4. nformation utilized between 2020 and 2024

However, the following are the exclusion criteria:

1. Information unrelated to sprinting biomechanics.
2. Review articles and data are not the same thing.
3. Not an English-language article that is indexed based on preset standards.
4. Data not from the 2020–2024 time frame.

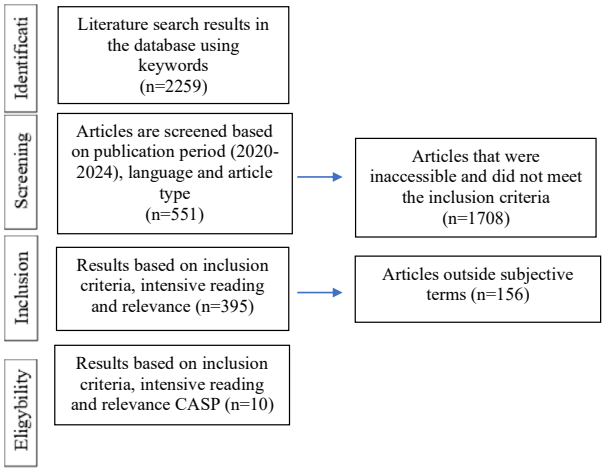

Fig. 1. PRISMA scheme in the literature selection process

Study Instrument

The researcher employed analysis of annotated bibliographies. A journal article or other textual source's annotations are just a brief synopsis of the content. A list of sources on a single subject is called a bibliography. Analyzing the an-

notated bibliography requires taking into account a number of factors, including:

1. The name of the cited source
2. The author's background and goals
3. A brief synopsis of the material
4. The significance of the sources mentioned in addressing the posed question.

Results

Table 1. Evolution of the number of publication at year

Year of Publication	Number of article
2024	110
2023	118
2022	106
2021	104
2020	113

Table 2. Source from languages

Languages	Number of article
English	546
French	5

Five studies were deemed eligible to advance to the next stage based on the articles that satisfied the inclusion criteria, thorough reading, and relevance to address the research issues. The mixed methods appraisal tool (MMAT), which was modified from Hong (2018), was then used to analyze the gathered studies. Of the eleven quantitative studies in Table 4, nine employed random sampling with a control or comparison group, according to the results of the MMAT analysis.

Discussion

The trunk angle at takeoff and the thigh separation angle at takeoff explain almost 90 % of the variation in initial acceleration performance in sprinters (Walker et al., 2021). A shorter front block starting line distance (up to 50 % reduction in leg length) results in improved sprint start performance through greater power production against the rear block (Cavedon et al., 2022). Placing the stance foot further behind the body's center of mass at touchdown and a more anterior orientation of the (King et al., 2022).

The effect of countermovement on sprinter acceleration depends on the speed of movement, sport, and level of the athlete (Cross et al., 2021). The decrease in hip flexion and extension velocity during changes in running technique during sprinting caused by fatigue allows athletes to maintain their acceleration despite the shift in joint moments, forces, and positive work from the hip joint to the knee joint (Vial et al., 2023). Greater synchronization between blind runners and guides may be important for better blind sprint performance (Gleadhill & Nagahara, 2020).

A narrower stride width in a sprint start does not provide any advantage in muscle contribution to supporting or propelling the body's center of mass (Wang et al., 2021). Interlimb coordination during the initial sprint acceleration is primarily anti-phase and dominant on the trailing leg, with ankle flight and final stance driven by the leg (Donaldson et

Tabel 3. Mixed method apparaisal tool (MMAT) 2018

Author, year	Screening Questions		Quantitative randomized controlled trial				
	Is question research questions clear?	Is collection data collection can answer questions research question?	2.1. Was randomization carried out appropriately?	2.2. Are the groups comparable from the beginning?	2.3. Is there is result data complete?	2.4. What is the intervention given confidentially (blind) to the results assessor?	2.5. Is participant obey intervention Which given?
Valamatos et al., 2022	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Moura et al., 2023	Yes	Yes	Yes	Yes	Yes	Yes	Yes
LIN & PANDY, 2022	Yes	Yes	Yes	Yes	Yes	Yes	Yes
de Andrade et al., 2021	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Romero et al., 2022	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Esposito et al., 2023	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Van Wouwe et al., 2023	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Alt et al., 2021	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Walker et al., 2021	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pleša et al., 2022	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 4. Review of research results

Title	Method	Finding
Valamatos et al., 2022	Sistematic Literature Review	"Set" position, rapid hip extension at push-off, shorter flight times, and greater propulsive forces after block exit.
Moura et al., 2023	Sistematic Literature Review	Center of mass, contact time, force applied to the back block, and the athlete's ability to generate a large amount of force.
Lin & Pandy, 2022	Observasional Study	Muscle fascicle length than by the muscle's intrinsic maximum shortening velocity.
de Andrade et al., 2021	Observasional Study	Ankle, hip, and BCM motion.
Romero et al., 2022	Observasional Study	Trunk, knee, and hip angles influencing hamstring length and tension.
Esposito et al., 2023	Observasional Study	Forefoot bending stiffness influences sprint performance. Non-linear bending stiffness profiles, like carbon fiber plates, may mitigate negative effects during sprint acceleration, impacting sprinter biomechanics and performance.
Van Wouwe et al., 2023	Observasional Study	Biomechanical factors affecting sprinter performance include optimized hip musculature, increased knee flexor strength, and enhanced ankle plantarflexion capacity, as revealed by musculoskeletal simulations.
Alt et al., 2021	Observasional Study	Biomechanical factors affecting sprinter performance include knee extension velocity, hip mean power in the swing phase, and eccentric hamstring strength, crucial for sprint mechanics and velocity.
Walker et al., 2021	Observasional Study	Kinematic factors, such as start performance, play a crucial role in sprinter performance according to the study on World-class male sprinters.
Pleša et al., 2022	Sistematic Literature Review	Eccentric utilization ratio, force-velocity relationship, reactive strength index, and bilateral deficit are biomechanical factors that impact sprinter performance by providing detailed insights into neuromuscular capabilities.

al., 2022). Placing the stance foot further behind the center of mass at touchdown and a more anterior orientation of the foot and calf segments are associated with a greater force ratio during the initial sprint acceleration (King et al., 2022)

Muscle fascicles shorten during sprint acceleration, contributing to positive joint work and reusing elastic strain energy (Werkhausen et al., 2021). Muscles act synergistically to generate ground force impulses and maximize forward momentum changes during sprinting, with the ankle plantarflexors, soleus, gastrocnemius, broadi, hamstrings, and gluteus medius playing key roles (Pandy et al., 2021).

Loading caused significant changes in hip, knee, ankle, and trunk angles at touch-down and toe-off for both acceleration and maximum velocity phases (Osterwald et al., 2021). Greater forward trunk tilt and less neck flexion during the run-to-sprint transition predicted faster acceleration during the run-to-sprint transition (Jakeman et al., 2023). The superior performance of elite athletes in sprinting is primarily based on a larger hip angle range and smaller knee contact angle, which contribute to a greater horizontal velocity of the center of gravity during acceleration (Li & Ma, 2020).

Reactive and eccentric forces contribute to the ability to regulate leg spring stiffness during maximum speed running, resulting in faster running speeds in highly trained runners compared to team sport athletes (Douglas et al., 2020). Male sprinters had higher rear-leg starting block force, force development rate, F0, v0, and Pmax compared to females, but no differences in slope and ratio of horizontal force to resultant force (Mirkov et al., 2020).

The biomechanical analysis of sprinting reveals a complex interplay of factors that collectively define elite performance. Critical elements such as the initial setting position, rapid hip extension, and enhanced propulsive forces after exiting the blocks are fundamental for acceleration. The center of mass, contact time, and force application significantly influence sprint dynamics. Additionally, muscle properties, joint motions, and body angles are pivotal in optimizing sprint mechanics. Advanced materials like carbon fiber plates, along with variables such as knee extension velocity and hip mean power, further contribute to performance enhancement. Understanding eccentric hamstring strength, as well as biomechanical metrics like eccentric utilization ratio, force-velocity relationship, and bilateral deficit, provides deeper insights into the neuromuscular capabilities essential for achieving superior sprinting efficiency. Collectively, these factors underscore the intricate nature of sprint biomechanics and the importance of a multifaceted approach to improving sprint performance.

Conclusion

The biomechanical analysis of sprinting brings out many factors underlining what makes a good sprinter. Key elements comprise the setting position, quick hip extension on push-off, reduced flight times, and enhanced propulsive forces after exiting the blocks. Center of mass and contact time along with force application to the back block are critical in acceleration. Muscle properties — such as fascicle length — and joint motion (ankle, hip, and BCM),

in addition to trunk, knee, and hip angles, define sprint mechanics. Also, high-tech materials like carbon fiber plates and factors including knee extension velocity plus hip mean power as well as eccentric hamstring strength play a role in maximizing sprint performance. Insights on the eccentric utilization ratio, force-velocity relationship, and bilateral deficit help us understand the essential neuromuscular capabilities for optimal running economy: efficiency during sprinting. Future research should explore advancements in shoe materials, targeted training interventions, optimized starting positions and push-off techniques, biomechanical simulations, performance differences across athlete levels, the impact of fatigue and recovery, and injury prevention strategies to enhance sprint performance and technique.

Conflict of Interest

The authors state that they have no competing interests.

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Механіка швидкості: Систематичний огляд літератури щодо техніки легкоатлетичного спринту

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 4 табл., 1 рис., 35 джерел.

Мета дослідження. Мета цього дослідження полягала в збиранні та аналізі результатів наукових робіт з техніки легкоатлетичного спринту за допомогою біомеханічного підходу задля забезпечення поглибленого розуміння ефективної методики та біомеханічних факторів, що впливають на показники результативності в спринті.

Матеріали та методи. Представлений оглядовий аналіз проводився відповідно до рекомендацій PRISMA щодо систематичних оглядів та метааналізів. Дослідження мали бути опубліковані в період з січня 2020 року по серпень 2025 року, що охоплює попередні п'ять років. У процесі пошуку були використані наступні ключові слова: Техніка Легкоатлетичного Спринту. Пошук проводився за допомогою бази даних ScienceDirect.

Результати. Процес пошуку показав наступні результати: задане положення тіла – 2 статті, кут нахилу стегна – 3 статті, скорочений час – 2 статті, довжина пучка – 1 стаття, згинач колінного суглоба – 3 статті, довжина підколінного сухожилля – 2 статті.

Висновки. Центр маси тіла та час контакту, а також сила, що прикладається до спинного відділу, є критично важливими для прискорення. Властивості м'язів, як-от довжина пучка і рух суглобів (гомілковостопного, тазостегнового та показник центру маси тіла), у поєднанні з кутами нахилу тулуба, коліна і стегна, визначають механіку спринту.

Ключові слова: легкоатлетичний спринт, біомеханіка, техніка.

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