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Analyzing Basketball Techniques for Performance Enhancement: A Comprehensive Literature Review

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ABSTRACT

Background: Enhancing basketball player performance requires a clear understanding of effective movement techniques. This study aims to synthesize and analyze key biomechanical techniques that influence performance, based on a systematic review of recent research. Methods: Following PRISMA guidelines for systematic reviews and meta-analyses, a comprehensive literature search was conducted using the Scopus database. The search targeted studies published between January 2020 and December 2024 using the keywords "basketball" and "biomechanics." After three stages of screening based on predefined inclusion and eligibility criteria, 13 articles were selected from an initial pool of 231 for in-depth analysis. Results: The selected studies provided comprehensive insights into the biomechanical variables affecting basketball performance. Participants included both male and female athletes, with some studies emphasizing external conditions such as fatigue as injury risk factors. Key biomechanical factors identified include knee inversion and rotational moments, ground reaction forces, ankle stability, lower-limb characteristics, midsole hardness, joint loading during landing, core activation and stability, joint angles, knee flexion velocity, dynamic balance, directional changes, and shoulder positioning. Conclusion: Player performance in basketball is influenced by multiple biomechanical elements, including movement efficiency, joint stability, muscular strength, and technical execution. External factors such as fatigue and footwear characteristics also play a significant role in injury prevention and performance optimization. This review provides an integrated overview of key biomechanical determinants of basketball performance and highlights their practical implications for training design and injury prevention strategies. These findings support the need for targeted, biomechanically informed training interventions in basketball.

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1. INTRODUCTION

Over the past few decades, basketball has developed into one of the most globally recognized and rapidly growing sports. Its appeal lies not only in its fast-paced, exciting gameplay but also in its accessibility, relatively low cost, and wide popularity across age groups and skill levels (Karatrantou et al., 2024) These characteristics make basketball a sport with significant social and economic value. As participation rates continue to rise, the demand for optimized training strategies and injury prevention methods becomes more pressing—for both elite and recreational players.

To achieve peak performance on the court, athletes must possess specific physical attributes. Prior research has highlighted the importance of lower-limb explosiveness, acceleration, and the ability to change direction quickly—attributes that often vary according to playing position, such as guard, forward, or center (Ivanović et al., 2022). However, beyond physical conditioning alone, movement efficiency plays a pivotal role. Interestingly, elite-level players have been found to move more efficiently during games, covering shorter distances at lower average speeds and heart rates compared to their sub-elite counterparts (Petway et al., 2020).

Despite these findings, existing research on basketball performance still tends to cluster around a few familiar themes: competitive metrics, gender-based differences, and sports injury analysis. While these topics are undoubtedly valuable, they often leave other critical aspects—such as off-ball movements, joint-specific techniques, and biomechanical coordination—underexplored. Moreover, the recent rise of wearable technology and big data analytics presents new opportunities to study basketball performance with greater precision and contextual relevance (Zhong, 2022).

Female athletes, for instance, continue to receive comparatively less biomechanical attention, despite facing unique physiological and external load demands (Reina et al., 2020) At the same time, technical statistics such as assists, turnovers, and field goals have proven to be key to team success—as seen in Indonesia's national team performance at the 2022 Southeast Asian Games—but such outcomes are often emphasized more than the underlying biomechanical mechanics that make them possible. Several gaps persist across the literature. Studies often rely on narrow sample populations (Chen, 2024), avoid in-depth joint analysis or report no significant kinematic variations due to inconsistent methodological approaches (Stojanović et al., 2019). Furthermore, off-ball contributions remain difficult to measure objectively (Wu et al., 2023) limiting our understanding of player efficiency beyond possession-based metrics. This literature review aims to synthesize and critically assess current biomechanical research and technical analyses in basketball. By exploring how specific movements and techniques contribute to performance enhancement, this paper seeks to bridge the gap between data-driven analysis and real-world application. Ultimately, the findings are expected to support coaches, trainers, and researchers in developing more effective, science-based interventions to improve player outcomes and advance the sport's future development.

2. METHODS

This systematic literature review was conducted to explore current trends and advancements in biomechanical research related to basketball performance. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Stewart, et al., 2016) to ensure methodological transparency and replicability. A comprehensive search was carried out in the Scopus database, employing the keywords “biomechanics” AND “basketball”. The search was limited to peer-reviewed journal articles published between January 2020 and December 2024. To ensure broader accessibility of the findings and to support open science principles, only open access articles were included in the final review. This decision was based on the authors' intention to avoid excluding readers who might not have institutional access to paid content.

Articles were included in this review if they explicitly focused on the biomechanical aspects of basketball, such as movement analysis, injury biomechanics, or sport-specific technique evaluation. Additional inclusion criteria required that the studies be published in English, report original empirical research involving human participants, and be freely accessible in full text as open access publications.

Conversely, studies were excluded if they primarily addressed other sports without a clear focus on basketball, were review articles, editorials, opinion pieces, or conference abstracts, lacked methodological rigor or relevance to biomechanics, or were not available under an open access license. These criteria ensured that only high-quality, relevant, and accessible studies were included in the final analysis. A summary of the inclusion and exclusion criteria is presented in Table 1.

Table 1. Inclusion and Exclusion Criteria

Inclusion criteria	Exclusion Criteria
Articles on basketball biomechanics	Studies on other sports
Published 2020-2024	Review articles/editorials
Peer-reviewed journal articles	Conference abstracts
English language	No biomechanical relevance
Open access full text	Non-open access

The review process emphasized article titles, abstracts, and keywords as these were found to be sufficient in capturing the thematic focus of each publication and producing a reliable set of core articles for further analysis. The initial search yielded 231 articles. After removal of duplicates, two reviewers independently screened the titles and abstracts. Articles that met the inclusion criteria proceeded to full-text assessment. Discrepancies were resolved through discussion. During the full-text screening stage, the methodological relevance and clarity of biomechanical measurements were also considered as part of a qualitative appraisal of study quality. A total of 13 articles were included in the final analysis. The selection process is detailed in the PRISMA flow diagram (Figure 1).

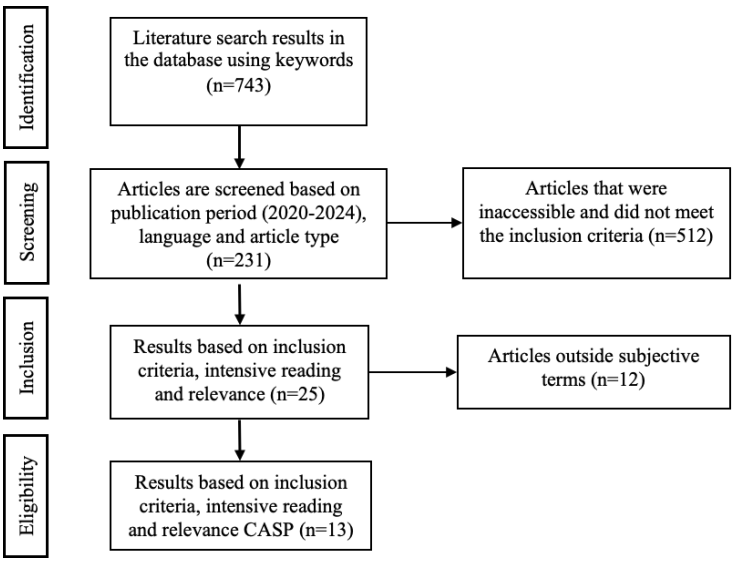


Figure 1. Flow Diagram PRISMA

Information extracted from each article included the following variables: (a) Annual publication trends; (b) Institutional affiliation of the first author; (c) Number of authors per article; (d) Subject area classification (training, health, management, education, other, or mixed); (e) Study design/type (experimental, descriptive, correlational, or other); and (f) Average number of citations per article.

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3. RESULTS

The table 2 below provides a comprehensive overview of the total number of publications within the selected time period. It includes detailed information on the year of publication, allowing for an analysis of trends and patterns in research output over time. Various publications based on distribution can be seen in table 1. The number varies every year: 121 (2020), 128 (2021), 109 (2022), 100 (2023), 89 (2024). The decrease in the number of publications reflects fluctuations in the intensity of the research.

Table 2. Evolution of the number of publication per year

Year of publication	Number of articles	Percentage
2020	121	22%
2021	128	23%
2022	109	19%
2023	100	18%
2024	89	16%
Total	547	100%

Table 3 presents the findings from 13 articles, including the authors' names and publication years, titles, and the results obtained. This summary provides a clear overview of the key contributions and outcomes of each study.

Table 3. Summary table

Author, year	Topic/Source	Result
(Zhu et al., 2024)	Effects of Fatigue and Unanticipated Factors on Knee Joint Biomechanics in Female Basketball Players during Cutting	knee inversion and rotation moments
(Alonzo et al., 2020)	Effects of midsole thickness on ground reaction force, ankle stability, and sports performances in four basketball movements	reaction force, ankle stability
(Cheng & Cheng, 2024)	Optimization research on biomechanical characteristics and motion detection technology of lower limbs in basketball sports	lower limbs
(Alonzo et al., 2020)	Effects of basketball shoe midsole hardness on lower extremity biomechanics and perception during drop jumping from different heights	midsole hardness, reaction forces and joint loadings during landing
(Arora et al., 2021a)	Biomechanics of core musculature on upper extremity performance in basketball players/	core activation and stability
(Bai & Yang, 2024)	Prediction and treatment of joint injuries in basketball training based on improved regression algorithm from the perspective of sports biomechanics	joint angle

(Kraszewski et al., 2024)	Association Between Longitudinal Changes in Patellar Tendon Abnormality and Land-Jump Biomechanics in Male Collegiate Basketball Players	knee flexion velocity
(Jamkrajang et al., 2022)	The Effect of Arm Dominance on Knee Joint Biomechanics during Basketball Block Shot Single-Leg Landing	the effect of arm dominance on knee joint biomechanics during basketball block shot single-leg landing
(Nishino et al., 2023)	Single-leg medial drop landing with trunk lean includes improper body mechanics related to anterior cruciate ligament injury risk: A comparison of body mechanics between successful trials and failed trials in the drop landing test among female basketball athletes	biomechanical factors related to acl injury risk, as compared to landing with anticipation
(Feng et al., 2024)	The effect of 12-week core strength training on dynamic balance, agility, and dribbling skill in adolescent basketball players	dynamic balance, direction
(Tai et al., 2020)	Biomechanical characteristics of single leg jump in collegiate basketball players based on approach technique	higher activation of ta and ga during rsj may have the benefit of decreasing risk of injury and jump training
(Vencúrik et al., 2021)	Kinematic analysis of 2-point and 3-point jump shot of elite young male and female basketball players	kinematic differences between 2-pt and 3-pt shooting and to optimize the shooting technique.
(Irawan & Prastiwi, 2022)	Biomechanical analysis of the three-point shoot in basketball: shooting performance	knee and shoulder angle

This review identified several recurring themes and emerging insights within the biomechanical literature on basketball performance. A total of 13 studies were analyzed, revealing both consensus and inconsistencies in how biomechanical demands and risks are assessed in basketball. One of the clearest findings from this review was the inconsistency in how physical demands are measured across studies. Petway et al., (2020) emphasized the need for standardized guidelines in defining measurement durations, validating tools, and classifying competition levels. Without such standardization, comparing results across studies remains challenging. While elite players consistently exhibit more efficient on-court movement—covering less distance at lower velocities and with reduced heart rate—there is a lack of comparable data for sub-elite and youth levels, limiting generalizability.

In addition, training variables such as team size, playing area, and drill structure influence workload. Full-court, continuous, games-based drills produce greater internal and external workloads than half-court or intermittent activities (O'Grady et al., 2020), highlighting the importance of training context in biomechanical load analysis.

4. DISCUSSION

Lower limb mechanics, particularly at the knee joint, are central to basketball-specific movements such as jumping, cutting, and changing direction. Several studies identified biomechanical risk factors for injuries, especially to the anterior cruciate ligament (ACL). Movements involving knee valgus collapse, internal tibial rotation, and landing with near-full extension have been strongly associated with non-contact ACL injuries (Fujii et al., 2012). Female players, in particular, tend to demonstrate greater knee valgus angles during cutting tasks, which may explain their higher risk of knee injuries (Leppänen et al., 2021). Supportive measures such as ankle taping have shown biomechanical effects by reducing range of motion (ROM) at both the ankle and knee. However, taping may also alter joint loading, such as increasing knee internal rotation moment, which could have unintended consequences (Klem et al., 2017; Williams et al., 2018). Players recovering from ACL reconstruction demonstrate altered movement patterns in the sagittal plane, especially at the hip and knee, suggesting a need for targeted neuromuscular retraining (Warathanagasame et al., 2023).

Court surface interaction and reaction forces also significantly influence movement quality and injury risk. Effective management of ground reaction forces during high-impact activities such as jumping and pivoting enhances performance and reduces injury likelihood (Arboix-Alió et al., 2024). Intervention studies such as that by Huang et al., (2024) have shown that axial stability training can improve force management, jump performance, and take-off mechanics in elite male players. Footwear characteristics—particularly midsole hardness—play a role in both comfort and shock absorption. Softer midsoles tend to offer better rearfoot cushioning but may compromise forefoot stability, affecting landing quality (Lam, Liu, et al., 2019). In contrast, stiffer shoes improve forefoot support but may increase impact loading elsewhere. Shoe modifications, such as increased traction, forefoot bending stiffness, and high collars, have been proposed to reduce injury risk while maintaining performance (Lam, Kan, et al., 2019).

Ankle and core stability are critical for maintaining balance and posture during dynamic movements. Ankle instability, if left unaddressed, can lead to frequent sprains and disrupt movement mechanics. Core stability training has been found to significantly improve dynamic balance and agility in basketball players (Gong et al., 2024). while foot orthotics can reduce sway motion and improve shooting stability by optimizing base of support (Lam, Liu, et al., 2019). Core muscle activation is also associated with enhanced upper-body control, especially during explosive movements and performance tests.

Shooting technique, particularly the biomechanics of the shoulder and upper limbs, is another focal area of basketball performance research. Shoulder positioning, especially shoulder flexion at ball release, is a key kinematic determinant of shot accuracy and power (Cabarkapa et al., 2021). Efficient shooters often demonstrate locked shoulder alignment and coordinated upper-body rotation during release and landing phases (Štirn et al., 2019). Shooting over taller defenders improves efficiency but requires higher jump height and ball release angle, increasing the physical demand of each shot (Kambič et al., 2022).

Although significant insights have been gained, several gaps remain. Measurement approaches vary widely in terms of tools used, durations defined, and population segments targeted. The emphasis in current literature remains heavily skewed toward elite male athletes, with limited representation of sub-elite, youth, or female players. Furthermore, off-ball movements and compensatory mechanics are rarely addressed, despite their importance to game performance and injury prevention. Future research should aim to establish standardized biomechanical assessment protocols, incorporate more diverse athlete populations, and examine underexplored areas such as fatigue-related adaptations, neuromuscular asymmetries, and task-specific biomechanics. The integration of wearable sensors, big data analytics, and real-time monitoring could offer more personalized and precise insights into basketball performance.

5. CONCLUSIONS

This review highlights the important role of biomechanics in enhancing basketball performance while also reducing the risk of injury. Although research in this area has increased in recent years, several inconsistencies remain, particularly in the measurement of physical demands, validation of biomechanical tools, and classification of competition levels. In addition, most studies focus primarily on elite male athletes, which limits the generalizability of findings to youth players, female athletes, and other competitive levels.

The reviewed studies indicate that basketball performance is influenced by a combination of physical and technical biomechanical factors, including knee and ankle joint mechanics, ground reaction forces, footwear characteristics such as midsole hardness, landing mechanics, core stability, balance, directional changes, and shoulder positioning during shooting. These elements interact to influence both movement efficiency and injury risk.

Overall, this review provides an integrated overview of key biomechanical determinants that influence basketball performance. Future research should focus on developing more standardized biomechanical assessment methods and including more diverse athlete populations. Such efforts will help coaches, sport scientists, and practitioners design more evidence-based training programs that enhance performance while promoting athlete safety and long-term development.

6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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