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Comparative analysis of movement patterns and lower – limb biomechanical demands in pickleball and other racket sports

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ABSTRACT

Pickleball has rapidly evolved into one of the fastest-growing racket sports worldwide; however, its movement and biomechanical characteristics remain less studied than those of traditional racket sports. The sport's unique features, including a smaller court and the non-volley zone, may produce distinct movement demands.

This review aimed to compare the movement patterns, change-of-direction (COD) requirements, and lower-limb biomechanical characteristics of Pickleball with those of Tennis, Badminton, and Table Tennis. A comprehensive literature review was conducted using PubMed, Web of Science, Scopus, and Google Scholar databases, including studies published up to February 2026. Relevant evidence related to movement trajectories, COD performance, acceleration–deceleration demands, sprint activities, and lower-limb biomechanics was synthesized through a comparative narrative approach.

The findings indicate that Pickleball is characterized by frequent lateral shuffling and short forward–backward movements performed within a limited playing area. Compared with Tennis, it involves fewer long-distance sprints but a greater frequency of directional changes. Relative to Badminton, Pickleball requires less vertical displacement while placing greater emphasis on knee and ankle joint stability during low and controlled positions near the non-volley zone. Compared with Table Tennis, it demands larger movement amplitudes and higher deceleration loads, particularly during net-approach actions.

Overall, Pickleball represents a hybrid movement model among racket sports, combining multidirectional footwork, rapid transitions, and moderate court coverage. These characteristics have important implications for sport-specific training, highlighting the need to develop agility, joint stability, and deceleration control while supporting injury-prevention strategies, particularly for recreational and older adult players.

Keywords: Pickleball; biomechanics; movement patterns; change of direction; racket sports; agility.

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1. INTRODUCTION:

Pickleball is a racket sport that combines elements of tennis, badminton, and table tennis. Since its introduction, the sport has experienced remarkable growth worldwide and has become one of the fastest-growing recreational sports, particularly in North America. The rapid increase in participation rates has attracted growing attention from researchers in sports science, sports medicine, and public health due to its potential health benefits and expanding player population (Vitale & Liu, 2020). Recent epidemiological evidence has further highlighted the increasing number of pickleball-related injuries presenting to healthcare systems, reflecting both the popularity and physical demands of the sport (McMillan et al., 2025; Owoeye et al., 2025).

Although pickleball is often perceived as less physically demanding than tennis because of its smaller court dimensions and lower ball velocity, competitive play requires players to perform frequent multidirectional movements, rapid accelerations, abrupt decelerations, and continuous positional adjustments. These movement demands place substantial mechanical stress on the musculoskeletal system, particularly the lower extremities. As participation continues to expand across different age groups, understanding the movement characteristics and biomechanical requirements of pickleball has become increasingly important for performance enhancement and injury prevention.

In racket sports, movement efficiency and the ability to rapidly change direction are considered fundamental determinants of performance. Change-of-direction (COD) ability involves the capacity to decelerate, reorient the body, and reaccelerate in a new direction while maintaining balance and movement control (Dos'Santos et al., 2018). Contemporary sports biomechanics research has demonstrated that deceleration tasks often impose greater mechanical loads on the lower limbs than acceleration tasks, thereby increasing the demands placed on neuromuscular control and joint stability (Harper et al., 2019, 2022).

Consequently, COD performance and deceleration capacity have become key areas of interest in sports involving frequent reactive movements.

Compared with other racket sports, pickleball possesses several unique structural and tactical characteristics. Tennis is characterized by extensive court coverage, repeated high-speed sprinting, and large-amplitude directional changes (Kovacs, 2007). Badminton requires frequent jumping, landing, and multidirectional locomotion performed at high intensities (Phomsoupha & Laffaye, 2015). In contrast, table tennis involves rapid reaction-based footwork within a highly restricted playing area (Malagoli Lanzoni et al., 2014). Pickleball appears to occupy an intermediate position among these sports, combining short-distance locomotion, lateral shuffling, and repeated net-approach actions within a confined court environment. Furthermore, the presence of the non-volley zone (NVZ) introduces tactical constraints that may influence movement behavior and biomechanical loading patterns in ways that differ from other racket sports.

From a biomechanical perspective, repeated multidirectional movements performed in a limited space may increase the demands placed on knee and ankle joint stability. Previous research has demonstrated that neuromuscular control and dynamic joint stabilization are critical factors associated with movement efficiency and lower-limb injury risk (Hewett et al., 2005). Similarly, agility has been recognized as a multifactorial performance component involving perceptual, cognitive, and neuromuscular processes that enable athletes to react effectively to rapidly changing game situations (Sheppard & Young, 2006). These factors are likely to play a substantial role in pickleball performance due to the sport's emphasis on reactive movement and continuous positional adjustments.

Despite the growing body of literature on pickleball, current research has primarily focused on participation trends, health benefits, and injury epidemiology (Vitale & Liu, 2020; McMillan et al., 2025; Owoeye et al., 2025). A recent scoping review of pickleball research highlighted the limited availability of studies investigating movement characteristics, biomechanical demands, and sport-specific performance requirements compared with established racket sports (Casals et al., 2023). Consequently, there remains a lack of comprehensive evidence synthesizing how pickleball movement patterns and lower-limb biomechanical demands compare with those of tennis, badminton, and table tennis.

Therefore, the purpose of this narrative review was to synthesize and compare the movement characteristics, change-of-direction demands, and lower-limb biomechanical features of pickleball with those reported in tennis, badminton, and table tennis. By integrating evidence across these racket sports, this review aims to clarify the unique movement profile of pickleball and provide a scientific foundation for sport-specific training, performance optimization, and injury-prevention strategies.

2. Methods

2.1. Study Design

This study was conducted as a comparative narrative review aimed at synthesizing and comparing the available evidence regarding movement patterns, change-of-direction (COD) demands, and lower-limb biomechanical characteristics in Pickleball and three widely practiced racket sports: tennis, badminton, and table tennis. Narrative reviews provide a flexible framework for integrating findings from diverse research domains and are particularly valuable for emerging research areas where the available evidence is heterogeneous and relatively limited (Grant & Booth, 2009; Snyder, 2019). Given the relatively recent development of Pickleball research and the limited number of sport-specific biomechanical investigations currently available (Casals et al., 2023), a narrative review approach was considered appropriate for identifying common themes, comparing findings across sports, and highlighting future research directions.

2.2. Literature Search Strategy

A literature search was conducted between January and February 2026 using four major scientific databases, including PubMed, Scopus, Web of Science, and Google Scholar. These databases were selected because of their extensive coverage of literature related to sport science, biomechanics, sports medicine, and human performance research (Gusenbauer & Haddaway, 2020). The search strategy combined keywords and Boolean operators (AND, OR), including “Pickleball”, “racket sports”, “tennis”, “badminton”, “table tennis”, “movement patterns”, “change of direction”, “COD”, “agility”, “acceleration”, “deceleration”, “biomechanics”, “lower-limb biomechanics”, “joint stability”, and “injury risk”. A representative search expression was (“Pickleball” OR “Racket Sports”) AND (“Change of Direction” OR “Agility”) AND (“Biomechanics” OR “Movement Patterns”). The search procedure was

developed according to recommended practices for comprehensive literature searching in evidence synthesis studies (Bramer et al., 2018).

2.3. Eligibility Criteria

Studies were eligible for inclusion if they were published in peer-reviewed journals, written in English, focused on Pickleball, tennis, badminton, or table tennis, and reported findings related to movement characteristics, change-of-direction performance, acceleration–deceleration demands, lower-limb biomechanics, neuromuscular control, joint stability, external movement loads, or injury risk factors. Studies were excluded if they were conference abstracts without full-text availability, editorials, commentaries, opinion papers, letters to the editor, publications unrelated to movement or biomechanical characteristics, or studies lacking sufficient methodological information.

2.4. Study Selection and Data Extraction

Following the database search, studies were screened based on title, abstract, and full-text content. Relevant studies were reviewed in detail, and information was extracted using a standardized approach. Extracted variables included authorship, publication year, participant characteristics, sport investigated, study design, movement-related variables, COD measures, acceleration–deceleration characteristics, lower-limb biomechanical parameters, injury-related outcomes, and principal findings. The extracted data were subsequently organized to facilitate comparisons across the four racket sports.

2.5. Data Synthesis

Due to substantial heterogeneity among studies in terms of participant characteristics, research design, measurement techniques, and outcome variables, a formal meta-analysis was not performed. Instead, findings were synthesized using a narrative synthesis approach, which enables the integration and interpretation of evidence derived from diverse research methodologies (Popay et al., 2006). The evidence was organized into five thematic categories: playing environment and movement characteristics, change-of-direction and acceleration–deceleration demands, lower-limb biomechanical characteristics, injury risk profiles, and training and injury-prevention implications. This approach is consistent with recommendations for integrative reviews aimed at developing conceptual frameworks and identifying research trends in areas where direct empirical evidence remains limited (Whittemore & Knafl, 2005).

Furthermore, epidemiological evidence on Pickleball (Vitale & Liu, 2020; McMillan et al., 2025; Owoeye et al., 2025) and biomechanical evidence from tennis, badminton, and table tennis (Kovacs, 2007; Phomsoupha & Laffaye, 2015; Malagoli Lanzoni et al., 2014) were incorporated to establish a comprehensive comparative framework for interpreting the unique movement and biomechanical characteristics of Pickleball.

3. Results

3.1. Comparison of Playing Environment and Movement Characteristics

The synthesized evidence indicates that Pickleball exhibits distinctive movement characteristics compared with other racket sports (Table 1). Although the dimensions of a Pickleball court are similar to those of a badminton court, the presence of the non-volley zone (NVZ) substantially influences player movement patterns.

Table 1. Comparison of Playing Environment and Movement Characteristics

Variable	Pickleball	Tennis	Badminton	Table Tennis
Court dimensions (m)	13.41 × 6.10	23.77 × 8.23 (singles)	13.40 × 6.10	Playing area not standardized
Court area (m^2)	81.8	195.7	81.7	Very limited movement space
Primary movement pattern	Lateral shuffling and short forward–backward movements	Sprinting and multidirectional court coverage	Lunging, multidirectional movement, and jumping	Short footwork and rapid positioning
Movement range	Short	Long	Moderate	Very short
Movement intensity	Moderate to high	High	High	Moderate
Dominant movement characteristic	Frequent movement transitions near the NVZ	Repeated acceleration and court coverage	Explosive multidirectional actions	Rapid reaction and movement precision

Abbreviations: NVZ = Non-Volley Zone.

Sources: Adapted and synthesized from Vitale and Liu (2020), Casals et al. (2023), Kovacs (2007), Phomsoupha and Laffaye (2015), and Malagoli Lanzoni et al. (2014).

In Pickleball, movement is primarily characterized by short lateral shuffles, short-distance forward–backward transitions, and repeated net-

approach actions. In contrast, tennis requires frequent accelerations and longer movement distances across a larger playing area. Badminton is characterized by multidirectional movements combined with frequent jumping actions, whereas table tennis primarily involves short footwork movements and rapid reactions within a highly restricted space.

Overall, the available evidence suggests that Pickleball incorporates movement characteristics commonly observed in tennis, badminton, and table tennis, but these actions are performed within a more confined playing environment, resulting in a distinctive movement profile characterized by a high density of activity.

3.2. Change-of-Direction and Acceleration–Deceleration Demands

Findings from studies investigating racket sport movement demands indicate that change-of-direction (COD) ability represents a fundamental performance component across all sports examined (Table 2).

Table 2. Comparison of Change-of-Direction and Acceleration–Deceleration Demands

Variable	Pickleball	Tennis	Badminton	Table Tennis
Change-of-direction (COD) frequency	High	Moderate to high	High	Moderate
Movement distance per action	Short	Long	Moderate	Very short
Acceleration demand	Moderate to high	High	High	Moderate
Deceleration demand	High	High	Moderate to high	Moderate
Reactive agility requirement	High	High	High	Very high
Dominant movement characteristic	Frequent COD in confined space	Repeated sprinting and COD	Explosive multidirectional movement	Rapid reaction and footwork

Abbreviations: COD = Change of Direction; NVZ = Non-Volley Zone.
Sources: Adapted and synthesized from Sheppard and Young (2006), Kovacs (2007), Malagoli Lanzoni et al. (2014), Phomsoupha and Laffaye (2015), Dos'Santos et al. (2018), Harper et al. (2019, 2022), and Vitale and Liu (2020).

Pickleball was identified as a sport characterized by a high frequency of directional changes performed within a relatively small playing area. COD actions frequently occur between the baseline and the NVZ, involving relatively

short movement distances but a high occurrence density. In contrast, tennis involves larger-amplitude COD actions due to greater movement distances across the court. Badminton demonstrates high COD frequency combined with repeated jumping and landing actions, whereas table tennis involves the smallest movement amplitudes but requires extremely rapid reactive responses.

Furthermore, the reviewed studies indicate that Pickleball places considerable demands on both acceleration and, particularly, deceleration capabilities. Sudden stopping actions during net approaches or transitions between defensive and offensive situations occur frequently during match play. Consequently, movement-control-related physical demands appear to represent a prominent characteristic of Pickleball performance.

3.3. Lower-Limb Biomechanical Characteristics

Analysis of the biomechanical literature revealed substantial differences in lower-limb demands among the four racket sports (Table 3).

Table 3. Comparison of Lower-Limb Biomechanical Characteristics

Variable	Pickleball	Tennis	Badminton	Table Tennis
Primary movement pattern	Repeated lateral and short forward–backward movements	Sprinting and multidirectional court coverage	Lunging, jumping, and multidirectional movements	Short-distance footwork and rapid positioning
Jumping demand	Low	Moderate	High	Low
Deceleration demand	High	High	Moderate to high	Moderate
Joint stability requirement	High	Moderate to high	High	Moderate
Neuromuscular control demand	High	High	High	Very high
Main lower-limb loading sites	Knee and ankle	Knee, ankle, and hip	Knee, ankle, and Achilles tendon	Knee and ankle
Dominant biomechanical characteristic	Repetitive COD and postural control in confined space	High-speed movement and force production	Jump–landing mechanics	Rapid reaction and movement precision

Sources: Adapted and synthesized from Hewett et al. (2005); Kovacs (2007); Malagoli Lanzoni et al. (2014); Phomsoupha and Laffaye (2015); Dos'Santos et al. (2018); Harper et al. (2019); Harper et al. (2022).

Compared with badminton and tennis, Pickleball requires considerably fewer jumping actions. Nevertheless, players frequently adopt a low center-of-mass position and perform repeated lateral movements throughout match play. These characteristics increase the demands placed on knee and ankle joint stability.

In tennis, mechanical loading primarily occurs during high-speed acceleration and directional-change actions. In contrast, badminton generates substantial mechanical stress through repetitive jumping and landing activities. Table tennis generally imposes lower mechanical loads due to its restricted movement range, although it still requires a high degree of neuromuscular control.

Overall, Pickleball appears to be characterized by the combination of repetitive lower-limb loading and continuous postural-control requirements within a confined playing environment.

3.4. Injury Risk Profiles

The synthesized evidence suggests that each racket sport exhibits a distinct injury-risk profile (Table 4).

Table 4. Comparison of Injury Risk Profiles among Pickleball, Tennis, Badminton, and Table Tennis

Variable	Pickleball	Tennis	Badminton	Table Tennis
Most affected body regions	Knee, ankle	Knee, ankle, shoulder	Knee, ankle, Achilles tendon	Shoulder, elbow, wrist
Main injury mechanism	Repeated COD, sudden stopping, loss of balance	High-intensity acceleration–deceleration and repetitive strokes	Jumping, landing, and lunging actions	Repetitive upper-limb loading
Acute injury risk	Moderate	Moderate to high	High	Low
Overuse injury risk	Moderate to high	High	Moderate to high	High
Dominant injury characteristic	Lower-limb and balance-related injuries	Lower-limb and overuse injuries	Landing-related and ligament injuries	Upper-extremity overuse injuries

Population at greatest risk	Recreational and older adults	Competitive and recreational players	Competitive athletes	Frequent players and competitive athletes

Sources: Synthesized from Hewett et al. (2005), Phomsoupha and Laffaye (2015), Vitale and Liu (2020), McMillan et al. (2025), and Owoeye et al. (2025).

In Pickleball, the knee and ankle joints were identified as the most frequently reported injury sites. These injuries are commonly associated with rapid directional changes, balance disturbances, and repetitive loading over prolonged periods. Tennis demonstrates a relatively high prevalence of lower-extremity and hip-related injuries due to repeated high-intensity acceleration and deceleration actions. In badminton, ligament injuries and injuries involving structures surrounding the knee joint are frequently reported as a consequence of repetitive jumping and landing activities. Conversely, table tennis is more commonly associated with overuse conditions affecting the shoulder and wrist.

Although the level of physical contact in Pickleball is generally lower than in many other sports, the repetitive nature of directional changes and postural-control activities may contribute significantly to injury risk.

3.5. Training Implications

The available evidence suggests that the physical demands of Pickleball are primarily associated with change-of-direction ability, deceleration control, joint stability, and neuromuscular control (Table 5).

Table 5. Training Implications for Pickleball Compared with Other Racket Sports

Training Component	Pickleball	Tennis	Badminton	Table Tennis
Primary physical demand	COD ability, deceleration control, dynamic stability	Speed, acceleration, court coverage	Explosive agility, jumping and landing	Reaction speed and movement precision
Strength-training focus	Lower-limb strength and joint stabilization	Whole-body strength and power	Explosive lower-limb power	Neuromuscular and postural strength
Agility-training emphasis	Reactive agility and multidirectional movement	Multidirectional agility and sprint recovery	Explosive agility and directional transitions	Rapid reaction and footwork
Balance and stability training	High priority	Moderate priority	Moderate priority	High priority

Plyometric training	Moderate priority	High priority	Very high priority	Low priority
Injury-prevention focus	Knee and ankle stability, balance control, fall prevention	Lower-limb load management	Landing mechanics and ligament protection	Upper-limb overuse prevention
Recommended training characteristic	High-density multidirectional movement in confined spaces	Repeated sprint and court-coverage training	Jumping, landing, and explosive movement training	Reaction-based movement training

Sources: Synthesized from Sheppard and Young (2006), Dos'Santos et al. (2018), Kovacs (2007), Phomsoupha and Laffaye (2015), Harper et al. (2019, 2022), and Vitale and Liu (2020).

Compared with tennis and badminton, the requirements for explosive power development and jumping ability appear to be lower in Pickleball. However, training programs designed for Pickleball players should emphasize reactive movement capability, dynamic balance, and movement control within confined spaces.

In addition, net-oriented movement drills and reactive agility exercises appear to be particularly relevant for addressing the specific movement demands of the sport.

3.6. Research Gaps and Future Directions

The literature synthesis revealed that research on Pickleball remains relatively limited compared with tennis, badminton, and table tennis (Table 6).

Table 6. Key Research Gaps and Future Directions in Pickleball Research

Research Area	Current Gap	Future Direction
Movement patterns	Limited quantitative match-analysis data	Investigate movement frequency, distance, and activity profiles during competition
Change-of-direction (COD)	Lack of sport-specific COD measurements	Quantify COD frequency, angles, and movement density
Biomechanics	Insufficient lower-limb biomechanical evidence	Conduct 3D motion-capture and kinetic analyses
Mechanical loading	Limited data on ground reaction forces and joint loading	Examine external and internal loads during sport-specific actions

Injury mechanisms	Poor understanding of injury causes and risk factors	Identify biomechanical predictors of injury through prospective studies
Population differences	Limited comparisons by age, sex, and skill level	Investigate demographic and performance-level differences
Training interventions	Lack of evidence-based conditioning programs	Evaluate the effectiveness of Pickleball-specific training strategies
Injury prevention	No validated injury-prevention models	Develop and test sport-specific prevention programs

Sources: Synthesized from Vitale and Liu (2020), Casals et al. (2023), McMillan et al. (2025), and Owoeye et al. (2025). The proposed future directions were developed based on gaps identified across the reviewed literature.

Several important research gaps were identified, including: (1) a lack of quantitative data regarding the frequency and angles of directional changes during match play; (2) limited use of three-dimensional motion-capture systems; (3) insufficient information on ground reaction forces and mechanical loading during sport-specific movements; (4) a lack of longitudinal investigations examining injury mechanisms; and (5) limited evidence comparing movement and biomechanical characteristics across different sexes and age groups.

These limitations highlight the need for future experimental studies employing advanced motion-analysis technologies to provide a more comprehensive understanding of the movement and biomechanical characteristics of Pickleball.

4. Discussion

4.1. Pickleball as an Emerging and Distinctive Racket Sport

The primary purpose of this review was to synthesize and compare the movement characteristics, change-of-direction (COD) demands, and lower-limb biomechanical requirements of Pickleball with those reported in tennis, badminton, and table tennis. The findings suggest that Pickleball occupies a unique position within the spectrum of racket sports, combining elements of all three sports while exhibiting movement characteristics that appear to be specific to its court dimensions and tactical structure.

The rapid growth of Pickleball participation worldwide has generated increasing scientific interest in understanding the physical and biomechanical demands of the sport (Vitale & Liu, 2020). However, compared with traditional

racket sports, the available body of research remains relatively limited (Casals et al., 2023). Consequently, much of the current understanding of Pickleball movement demands must be interpreted within the broader context of racket sport biomechanics.

The present review indicates that Pickleball shares several movement characteristics with tennis, badminton, and table tennis while simultaneously demonstrating unique tactical and spatial constraints. The presence of the non-volley zone (NVZ) fundamentally influences player positioning and movement behavior, creating a competitive environment characterized by repeated short-distance movements, frequent positional adjustments, and rapid transitions between offensive and defensive actions. These characteristics distinguish Pickleball from the larger court coverage requirements of tennis, the vertical movement demands of badminton, and the highly localized footwork patterns observed in table tennis.

4.2. Change-of-Direction and Deceleration Demands

One of the most notable observations emerging from this review is the apparent importance of change-of-direction ability in Pickleball performance. Although direct biomechanical studies remain scarce, the movement structure of the sport suggests that COD actions occur frequently during match play, particularly during transitions between the baseline and the NVZ.

Previous research has demonstrated that COD performance is a complex motor skill requiring effective force production, force absorption, and movement control across multiple planes of motion (Dos'Santos et al., 2018). Within racket sports, successful performance depends not only on movement speed but also on the ability to repeatedly decelerate and rapidly reposition the body in response to changing game situations.

Recent sports biomechanics literature has increasingly emphasized the role of deceleration as a distinct physical quality. Harper et al. (2019) reported that high-intensity deceleration actions may impose greater mechanical loads on the musculoskeletal system than acceleration tasks. Similarly, Harper et al. (2022) proposed that effective deceleration requires coordinated neuromuscular control, lower-limb strength, and dynamic stability. These concepts may be particularly relevant to Pickleball because players frequently perform short

accelerations followed by abrupt stopping actions when approaching the NVZ or responding to opponents' shots.

Compared with tennis, Pickleball likely involves shorter movement distances but a greater frequency of directional transitions within a confined playing area. This suggests that movement density rather than total running distance may represent a defining characteristic of Pickleball. Consequently, physical preparation for Pickleball may benefit from a greater emphasis on reactive movement control and repeated COD performance rather than maximal sprint capacity alone.

4.3. Lower-Limb Biomechanical Considerations

The current review also highlights the potential importance of lower-limb biomechanics in Pickleball performance and injury prevention. Although badminton is characterized by repeated jumping and landing actions (Phomsoupha & Laffaye, 2015) and tennis involves substantial acceleration and court-coverage demands (Kovacs, 2007), Pickleball appears to place relatively greater emphasis on maintaining stability during repeated lateral and multidirectional movements performed within a limited space.

Neuromuscular control has long been recognized as a critical factor influencing movement efficiency and injury risk. Hewett et al. (2005) demonstrated that deficits in dynamic knee control are associated with increased injury risk in athletic populations. In addition, agility has been described as an integrated process involving perceptual, cognitive, and neuromuscular components that collectively determine an athlete's ability to respond to rapidly changing environments (Sheppard & Young, 2006).

Applying these concepts to Pickleball suggests that lower-limb stability may be particularly important because players frequently perform rapid directional changes while maintaining a relatively low center of mass during net play. Repeated exposure to these movement patterns may increase the mechanical demands placed on the knee and ankle joints, especially among recreational and older participants who constitute a large proportion of the Pickleball population (Vitale & Liu, 2020).

4.4. Injury Implications and Practical Applications

The growing popularity of Pickleball has been accompanied by increasing reports of sport-related injuries. Recent epidemiological studies have documented a rising number of Pickleball injuries presenting to emergency departments and healthcare systems (McMillan et al., 2025). Furthermore, Owoeye et al. (2025) emphasized the need to better understand injury mechanisms and risk factors associated with the sport.

Although direct causal relationships cannot be established from the currently available evidence, the movement characteristics identified in this review provide several plausible explanations for injury occurrence. Frequent directional changes, repeated deceleration actions, and sustained demands on lower-limb stability may contribute to cumulative mechanical loading of the knee and ankle joints. These factors may be particularly relevant for older players, whose neuromuscular function and balance capacity may be reduced compared with younger athletes.

From a practical perspective, training programs for Pickleball players should prioritize multidirectional movement skills, dynamic balance, reactive agility, and lower-limb strength development. Particular attention should be given to deceleration control, neuromuscular training, and joint stabilization exercises, as these components are likely to contribute both to performance enhancement and injury-risk reduction.

4.5. Limitations and Future Research Directions

Several limitations should be acknowledged. First, the current body of Pickleball-specific biomechanical research remains relatively small compared with the literature available for tennis, badminton, and table tennis. Second, many conclusions presented in this review are derived from indirect comparisons across sports rather than direct experimental investigations. Third, considerable methodological heterogeneity exists among studies regarding participant characteristics, measurement techniques, and performance variables.

Future research should focus on direct biomechanical investigations of Pickleball using advanced motion-analysis technologies, wearable sensors, and force-platform assessments. Particular attention should be given to quantifying movement patterns, COD frequency, acceleration–deceleration profiles, and lower-limb loading during competitive play. In addition, future studies should

examine potential differences according to age, sex, skill level, and playing format. Such investigations would contribute substantially to the development of evidence-based training programs and injury-prevention strategies for this rapidly expanding sport.

5. Conclusions

This review synthesized and compared the movement characteristics, change-of-direction (COD) demands, and lower-limb biomechanical requirements of Pickleball with those of tennis, badminton, and table tennis. The findings indicate that Pickleball possesses a distinctive movement profile characterized by frequent multidirectional movements, a high density of COD actions, and continuous movement control within a confined playing space.

Compared with tennis, Pickleball involves shorter movement distances but more frequent directional changes. Compared with badminton, it requires fewer jumping and landing actions but greater emphasis on maintaining postural stability and joint control. Compared with table tennis, Pickleball imposes higher acceleration–deceleration demands and greater lower-limb involvement.

A key finding of this review is the important role of deceleration control, joint stability, and neuromuscular coordination in Pickleball performance and injury prevention. The repetitive transitions between the baseline and the non-volley zone (NVZ) place considerable mechanical demands on the knee and ankle joints, highlighting the need for sport-specific conditioning programs that emphasize multidirectional agility, dynamic balance, lower-limb strength, and reactive movement control.

Despite the rapid growth of Pickleball, biomechanical and movement-related evidence remains limited. Future research should focus on objective movement analysis, three-dimensional biomechanics, ground reaction force assessment, and injury-mechanism investigations to further enhance the scientific understanding of this emerging sport.

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