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HEALTH BENEFITS, PHYSIOLOGICAL RESPONSES, AND INJURY RISKS ASSOCIATED WITH PADEL PRACTICE: A NARRATIVE REVIEW

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ABSTRACT

Background. Padel is a rapidly growing racket sport with intermittent activity, repeated strokes, frequent direction changes, and doubles-based tactical interaction. Its accessibility and social character make it a promising leisure-time activity, but increasing participation raises injury-prevention concerns.
Aim. This narrative review summarizes evidence on health benefits, physiological responses, and injury risks in padel.
Material and methods. Peer-reviewed padel articles were identified mainly through PubMed and screening of relevant reviews and studies. Evidence was synthesized thematically.
Results. Padel may support physical activity and improve selected fitness components, especially in youth and non-professional players, including strength, agility, lateral movement, cardiorespiratory capacity, and body composition. Physiological studies show moderate cardiovascular intensity, repeated high-intensity actions, and autonomic stress. Early evidence suggests acute inflammatory, myokine-related, and cognitive responses, but data are mainly from small acute studies. Injuries are common, especially tendinous and muscular injuries affecting the elbow, shoulder, knee, ankle, lower leg, and lower back. Risk appears multifactorial and may be influenced by exposure, player level, equipment, footwear, court surface, warm-up habits, wellness, and supervision.
Conclusions. Padel is an accessible activity with promising health and fitness benefits, but it also presents a relevant injury burden. Participation should be supported by warm-up, progressive load management, strength and conditioning, appropriate equipment, wellness monitoring, and early symptom management. Future research should prioritize standardized injury surveillance, prospective risk-factor studies, randomized interventions, biomechanical analyses, and padel-specific prevention and rehabilitation trials.

KEYWORDS

Padel; Racket Sports; Health Promotion; Injury Risk; Prevention; Rehabilitation

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1. Introduction

Padel is a rapidly expanding racket sport played in doubles on an enclosed 20 × 10 m court, divided by a central net and bounded by glass walls and metallic mesh fencing, which allow the ball to rebound and remain part of the rally [1,2]. Compared with tennis, padel is characterized by a smaller playing area, a short-handled solid racket, an underhand serve, and the tactical use of walls, creating an intermittent pattern of play based on frequent rallies, rapid changes of direction, repeated strokes, and continuous player interaction [1,2]. These characteristics require cardiovascular endurance, agility, strength, power, coordination, flexibility, and decision-making under time pressure [2,4,5,13,14].

The popularity of padel has increased markedly in recent years in both recreational and competitive settings across numerous countries [1–3]. This expansion has been attributed to its social doubles format, relatively accessible technical demands for beginners, moderate equipment requirements, and suitability for people of different ages and performance levels [1,2]. For this reason, padel has been proposed as a useful sport-based strategy for promoting leisure-time physical activity, particularly in populations in which long-term adherence to structured exercise remains a challenge [1]. This is clinically relevant because regular physical activity is associated with improved body composition, cardiometabolic health, cognitive function, mental health, and reduced risk of chronic diseases, whereas insufficient physical activity remains a major public health concern [1].

From a health-promotion perspective, padel may offer a favorable balance between enjoyment, social interaction, and physiological stimulation [1]. Evidence suggests that padel may support leisure-time physical activity and improve selected components of physical fitness, particularly in youth and non-professional

players [1,4,6,7]. Studies in youth players indicate associations with upper-limb strength, lower-limb power, agility, cardiorespiratory fitness, and lateral movement ability, although these outcomes may depend on age, sex, training experience, and competitive level [4–7]. Interventional and cohort data also suggest that structured padel training can improve selected fitness-related variables over periods ranging from several weeks to one season [6,7].

Padel produces measurable physiological responses during match play and competition [9–13]. It is described as an intermittent activity involving both aerobic and anaerobic metabolic contributions, with demands influenced by rally duration, work-to-rest ratio, playing level, tactical context, and court positioning [1,2,11,12]. Studies have reported moderate-to-high cardiovascular demands, autonomic modulation during and after match play, inflammatory and myokine-related responses, and mental-fatigue effects during consecutive professional matches [9–13]. These findings suggest that the physiological impact of padel includes cardiovascular, autonomic, immunological, neurobiological, and cognitive dimensions [9–13].

Despite these potential benefits, the rapid growth of padel has been accompanied by increasing concern regarding injury risk [2,3,15,16,21]. A systematic review reported an incidence of approximately 3 injuries per 1000 hours of padel training and 8 injuries per 1000 matches, with injury prevalence across studies ranging from 40% to 95% [3]. The elbow was identified as the most frequently affected anatomical region, followed by the knee, shoulder, and lower back, while tendinous and muscular injuries were the most commonly reported tissue types [3]. Other studies in amateur, professional, youth, and national cohorts have confirmed that injuries may affect both upper and lower limbs, with patterns influenced by sex, age, exposure, experience, equipment, court surface, playing level, and warm-up habits [8,15–20].

The injury profile of padel is likely related to sport-specific biomechanical and tactical demands [2,21]. Repeated overhead strokes, unilateral racket use, rapid accelerations and decelerations, lateral displacements, rotations, and abrupt changes of direction may increase mechanical load on the elbow, shoulder, wrist, knee, ankle, calf, and lumbar region [2,21]. Less frequent but clinically important maxillofacial and ocular injuries have also been reported in relation to the enclosed court, glass walls, racket rebounds, and high-speed ball or racket impacts [22,23]. Therefore, the health benefits of padel should be considered together with preventive strategies, including warm-up, load monitoring, equipment selection, technical education, and targeted conditioning [2,3,8,15,18,21].

Although scientific interest in padel has grown substantially, the literature remains heterogeneous in terms of study design, population characteristics, injury definitions, exposure measurement, and outcome reporting [1–3]. Current evidence includes narrative reviews, systematic reviews, cross-sectional surveys, cohort studies, physiological monitoring studies, and small experimental or observational investigations, while high-quality longitudinal and interventional research remains limited [1–3]. Therefore, a narrative synthesis may help integrate evidence from different research areas and provide a broader understanding of padel as both a health-promoting physical activity and a sport with specific physiological and injury-related demands [1–3].

2. Aim of the review

The aim of this narrative review is to summarize and critically discuss current evidence on the health benefits, physiological responses, and injury risks associated with padel practice. Specifically, the review focuses on: (1) padel as a health-promoting sport and a strategy to increase leisure-time physical activity; (2) physical fitness adaptations and performance-related characteristics in youth, recreational, amateur, and elite players; (3) acute physiological responses to padel training and competition, including cardiovascular, autonomic, inflammatory, myokine-related, and mental-fatigue responses; and (4) the incidence, prevalence, anatomical distribution, risk factors, and prevention-oriented implications of padel-related injuries.

By integrating evidence from health promotion, match demands, physical fitness, physiological monitoring, musculoskeletal injury epidemiology, sport-specific biomechanics, and rehabilitation-oriented literature, this review aims to provide a clinically and practically useful overview for researchers, sports medicine professionals, physiotherapists, coaches, physical trainers, and padel practitioners.

3. Material and methods

3.1. Review design

This article was designed as a narrative review. A narrative approach was chosen because the available literature on padel is heterogeneous in terms of study design, populations, outcomes, exposure definitions, and methodological quality. Previous reviews have also used narrative or overview-based approaches to synthesize evidence on health promotion, match-play demands, physical fitness, injury risk, and rehabilitation in padel [1,2]. Although systematic evidence on padel injuries is available, the broader relationship between health benefits, physiological responses, and injury risks requires integration of studies with diverse methods and outcomes [3].

3.2. Source material and literature base

The source material consisted of peer-reviewed scientific articles identified in biomedical and sport-science databases, primarily PubMed, and selected according to their relevance to padel, health, physiological responses, injury risk, prevention, and rehabilitation. The included literature covered narrative and systematic reviews, cross-sectional studies, cohort studies, retrospective epidemiological studies, experimental and observational studies, and physiological monitoring studies.

The thematic scope included health promotion, physical fitness, body composition, match demands, cardiovascular and autonomic responses, inflammatory and myokine responses, mental fatigue, musculoskeletal injury epidemiology, sport-specific risk factors, maxillofacial and ocular trauma, and rehabilitation-oriented considerations.

Previous padel reviews searched databases such as Web of Science, Scopus, Google Scholar, PubMed, Cochrane, PEDro, MEDLINE, SportsDiscus, and CINAHL, and emphasized the need for further synthesis because of the growing but still limited and heterogeneous evidence base [1–3]. Sánchez-Alcaraz and Courel-Ibáñez categorized padel studies into match-play demands, biomechanics, fitness, body composition, anthropometric characteristics, and injuries [1]. Demeco et al. focused on match analysis, anthropometric and physical training, injury risk, and rehabilitation [2]. Dahmen et al. systematically reviewed injury incidence, prevalence, and injury characteristics in padel up to December 2022 [3].

3.3. Eligibility criteria and synthesis

Studies were considered relevant if they addressed at least one of the following areas: padel as a health-promoting physical activity; physical fitness, body composition, strength, agility, cardiorespiratory fitness, or performance-related variables in padel players; physiological responses to padel practice or competition, including heart rate, heart rate variability, cytokines, myokines, or mental fatigue; incidence, prevalence, anatomical location, type, mechanism, or risk factors of padel-related injuries; or prevention, rehabilitation, biomechanics, or clinical implications related to padel practice.

Studies were excluded from the main synthesis if they were not focused on padel, did not provide information relevant to health benefits, physiological responses, injury risk, prevention, or rehabilitation, or were not available as full-text scientific articles. Because this was a narrative review, no formal meta-analysis, pooled effect estimation, or risk-of-bias scoring was performed.

Information was extracted narratively from each included article, including study design, sample characteristics, player level, age group, sex distribution when available, main outcomes, key findings, and relevance to the review topic. For injury-related studies, attention was given to incidence, prevalence, anatomical site, tissue type, severity, exposure context, and risk factors. For physiological studies, extracted information included match intensity, heart rate or heart rate variability, inflammatory markers, myokines, mental fatigue, and recovery-related outcomes.

The synthesis was organized thematically rather than statistically into: (1) padel as a health-promoting sport; (2) physical fitness and developmental adaptations; (3) physiological and psychophysiological responses; (4) injury incidence, prevalence, and anatomical distribution; (5) sport-specific risk factors and mechanisms; and (6) prevention, monitoring, and rehabilitation implications.

3.4. Citation style

References are cited according to the Vancouver style, using numerical citations in square brackets. Each factual statement, numerical result, comparison, mechanism, or conclusion derived from the literature is supported by an appropriate citation.

4. Health benefits and physiological responses of padel practice

4.1. Accessibility and health-promotion potential

Padel has been proposed as a promising sport-based strategy for health promotion because it combines physical activity with enjoyment, social interaction, and relatively low entry barriers [1]. Unlike some racket sports that require higher initial technical proficiency, padel can be practiced by beginners after a short familiarization period, and its doubles format may support social engagement and long-term adherence to exercise [1]. Sánchez-Alcaraz and Courel-Ibáñez emphasized that padel may encourage both youth and adults to participate in leisure-time physical activity because it is accessible, enjoyable, can be played outdoors, and does not require expensive equipment or advanced technical skills at the beginner level [1].

The potential public health value of padel should be interpreted within the broader context of physical inactivity and sedentary behavior [1]. The 2020 World Health Organization recommendations cited in the padel health-promotion literature indicate that adults should accumulate 150–300 minutes of moderate-intensity or 75–150 minutes of vigorous-intensity physical activity per week, together with regular muscle-strengthening activities [1]. Padel may contribute to these recommendations because match play involves repeated rallies, accelerations, decelerations, lateral movements, racket strokes, and intermittent cardiovascular stimulation [1,2]. However, direct experimental evidence on long-term clinical endpoints remains limited, so padel should be presented as a promising physical activity option rather than a universally sufficient health intervention [1].

4.2. Physical fitness and youth development

The available studies in young padel players suggest that padel practice is associated with several components of physical fitness, including body composition, agility, change-of-direction ability, upper-limb strength, lower-limb power, and cardiorespiratory capacity [4–7]. In a cross-sectional study of 34 amateur padel players aged 13–17 years, Courel-Ibáñez and Llorca-Miralles assessed body composition, padel-adapted agility and change-of-direction tests, and medicine-ball throwing performance with dominant and non-dominant hands [4]. Male and female players presented a generally healthy body composition profile, but the authors noted that regular padel practice does not necessarily produce superior adiposity-related benefits compared with other racket sports [4].

Regarding fitness performance, young male and female padel players showed similar results in most assessed tests, with the main exception of jumping ability [4]. Sex-related differences in jumping performance may reflect maturational and developmental differences during adolescence rather than padel-specific adaptations alone [4]. Moreover, previous synthesis indicates that young amateur padel players may present lower upper- and lower-limb strength values than youth athletes in some other racket sports, including poorer throwing and jumping performance [1,4]. Therefore, padel may contribute to healthy physical activity participation in youth, but current evidence does not support the conclusion that padel alone produces superior explosive-strength development compared with other racket sports [1,4].

Additional evidence indicates that physical fitness characteristics in youth padel players may vary by sex, age category, and competitive development [5]. In young players aged 13–16 years, Pradas et al. found that male players performed better in handgrip strength, vertical jump power, cardiorespiratory capacity, and lateral movement, whereas female players showed better reaction time and greater flexibility [5]. Under-16 players also performed better than under-14 players in flexibility, gestural speed, vertical jump power, cardiorespiratory capacity, and lateral movement, suggesting that training age, biological development, and sex-related factors should be considered when evaluating youth padel players [5].

Interventional and longitudinal studies provide early evidence that padel practice may improve selected fitness-related variables in children and adolescents [6,7]. In a randomized study of 25 healthy untrained children aged 11–15 years, Pereira et al. compared an 8-week padel training program with a control condition [6]. The padel group trained twice weekly, and the study found a significant interaction for the 5 m sprint test, increased handgrip strength in the padel group, and a decline in speed performance in the control group, suggesting that short-term padel training may support selected strength- and power-related variables in untrained children [6]. However, the sample size was small and no significant interactions were observed for handgrip strength, medicine-ball throw, or countermovement jump, so stronger randomized trials are needed before firm conclusions can be drawn [6].

Longer-term observational evidence also supports the potential of padel training to improve physical fitness in youth players [7]. In a prospective cohort study of Swedish high school padel players aged 15–18 years, Ryman Augustsson et al. assessed changes across 20 weeks of in-season training and reported improvements in all assessed tests, including isometric squat peak force, relative strength, rate of force

development, squat jump, countermovement jump, sit-up performance, and side-hop performance [7]. These findings suggest that structured padel training may support lower-limb strength, explosive power, core endurance, and lateral agility, although the results may not be directly generalizable to recreational youth players, beginners, or physically inactive children because the sample was small and likely exposed to specialized coaching [7].

Padel may be particularly relevant for youth physical activity promotion because it offers motor learning, social interaction, intermittent activity, and game-based enjoyment [1,4]. However, youth players may also develop sport-specific physical demands and asymmetries as training volume and competitive level increase [4,5]. Therefore, youth padel programs should combine technical instruction and match play with age-appropriate strength training, coordination exercises, mobility work, warm-up routines, and education about load management [4–8].

4.3. Match intensity and cardiorespiratory demands

Padel is generally described as a long-lasting intermittent racket sport in which aerobic metabolism predominates across the whole match, while repeated anaerobic contributions are required during short explosive actions, rapid changes of direction, accelerations, decelerations, net approaches, smashes, volleys, and defensive movements after wall rebounds [2,12]. This mixed physiological profile reflects the specific structure of padel, where rallies are interspersed with short recovery periods and where technical–tactical demands require repeated transitions between moderate activity, brief high-intensity actions, and pauses [2,12]. Therefore, internal load should not be interpreted only through average physiological values, because padel combines moderate average cardiovascular intensity with repeated high-velocity actions, accelerations, decelerations, changes of direction, and stroke actions [2,12].

Available evidence suggests that padel produces moderate-to-high cardiovascular stimulation, although the magnitude of this response depends on playing level, sex, match duration, rally characteristics, competitive context, and individual fitness status [9,11,12]. Mean oxygen uptake during official competition generally remains below 50% of VO_2max, whereas mean heart rate may reach approximately 74–77% of HRmax [12]. In the study by Pradas et al., simulated padel competition in trained players involved a real playing time of 27.8 ± 8.49 minutes and a relative intensity of 75.2 ± 7.9% HRmax, supporting the classification of padel as a physiologically meaningful, but not maximal, intermittent activity [12].

These values suggest that padel may stimulate cardiovascular and metabolic adaptations in recreationally active or moderately trained individuals while remaining more accessible than sports with higher continuous intensity demands [1,12]. Pradas et al. noted that cardiorespiratory responses and perceived exertion were similar to values previously reported in tennis but lower than those observed in squash and badminton [12]. However, padel should not be classified as a low-demand activity simply because average VO_2 values are moderate, because repeated technical actions, lateral displacements, braking, re-acceleration, and upper-limb strokes may impose substantial localized neuromuscular and mechanical loads [2,12,21]. Thus, padel combines moderate average metabolic demand with intermittent peaks of mechanical, autonomic, and cognitive stress [9–13,21].

Sex-related and playing-level differences may further modify cardiorespiratory responses [11]. In the study by Cádiz-Gallardo et al., laboratory VO_2max differed between female and male elite players, with values of 47.4 ± 4.8 and 57.5 ± 5.7 $mLkg^{-1}min^{-1}$, respectively [11]. During matches, HRmean reached 72.7 ± 9.8% HRmax in males and 77.2 ± 5.8% HRmax in females, suggesting that relative cardiovascular load may be comparable or slightly higher in female players despite lower absolute aerobic capacity [11]. The role of playing side remains uncertain: Cádiz-Gallardo et al. found no significant differences in laboratory HRmax or match HRmean according to playing side, and current evidence does not support a strong conclusion that playing side is a major determinant of cardiovascular response [11,14].

4.4. Heart rate variability and autonomic regulation

Heart rate variability has been introduced in padel research as a non-invasive method for assessing autonomic nervous system regulation during and after match play [9,10]. HRV reflects beat-to-beat fluctuations in R–R intervals and provides indirect information about sympathetic and parasympathetic modulation [9,10]. This is relevant because padel combines physical exertion, emotional stress, tactical decision-making, partner interaction, and repeated high-speed perceptual–motor responses [9,10,13]. Consequently, HRV may help characterize cardiovascular load, fatigue, stress tolerance, recovery kinetics, and readiness to perform [9,10].

During exercise, increasing intensity is generally accompanied by sympathetic activation and parasympathetic withdrawal, resulting in increased heart rate and reduced vagal-related HRV indices [9,10].

Parraca et al. monitored 27 amateur players before, during, and after a 90-minute padel game and found that autonomic modulation was significantly affected by match play [9]. RMSSD decreased from 39.87 ± 19.64 ms at baseline to approximately 6 ms during the match and partially recovered to 15.06 ± 10.15 ms after the match [9]. SD1 and SD2 showed similar reductions during play and partial post-match recovery, indicating strong HRV suppression during play and incomplete but evident recovery after the match [9].

The frequency-domain results in the same study also showed significant changes in LF, VLF, HF, and LF/HF ratio, although these measures require careful interpretation during exercise because they are influenced by respiration, movement, and methodological factors [9]. Overall, the findings support the conclusion that padel induces marked autonomic perturbation and that recovery after match play is not immediate [9]. This led Parraca et al. to suggest that cool-down protocols may deserve more attention, especially because recreational players may finish matches without structured recovery, hydration strategies, or progressive reduction of intensity [9].

Recent research has extended HRV analysis to the internal dynamics of padel competition [10]. Picabea et al. analyzed 44 individual HRV recordings from 11 official matches involving 12 high-level amateur players, with measurements taken before the match, during each set, and during rest periods [10]. Winners displayed higher Mean RR, SDNN, RMSSD, LnRMSSD, SD1, and SD2 during the first set, as well as higher Mean RR, RMSSD, LnRMSSD, and SD1 during the first rest period [10]. These findings suggest that greater early parasympathetic modulation or autonomic flexibility may be associated with match outcome, although differences disappeared later in competition [10].

Taken together, HRV studies indicate that padel produces substantial autonomic stress and dynamic recovery responses [9,10]. HRV monitoring may therefore be useful for training-load management, recovery planning, and performance analysis, but current evidence remains limited by small samples, different playing levels, methodological heterogeneity, and the influence of breathing, hydration, emotional state, sleep, and previous training load [9,10]. HRV should therefore be considered a promising monitoring tool rather than a validated stand-alone marker of padel performance, injury risk, or cardiovascular safety [9,10].

4.5. Inflammatory, myokine-related and cognitive responses

The inflammatory response to padel is an emerging research area with implications for health promotion and athlete monitoring [11]. Exercise-induced cytokine responses depend on intensity, duration, muscle damage, recovery time, training status, sex, nutrition, sleep, and environmental conditions [11]. Low- to moderate-intensity exercise is generally associated with anti-inflammatory and immunoregulatory effects, while very intense or insufficiently recovered exercise may increase pro-inflammatory signaling and oxidative stress [11]. Therefore, cytokine responses may help clarify whether padel acutely resembles moderate health-promoting exercise or a more inflammatory competitive stressor [11].

Cádiz-Gallardo et al. analyzed acute cytokine dynamics in 21 elite padel players before and after a competitive match and found a significant decrease in IL-7, a significant increase in IL-8, and a significant increase in IL-10 [11]. The authors interpreted this pattern as an acute anti-inflammatory response, particularly because IL-10 increased and selected pro-inflammatory activity decreased after competition [11]. At the same time, the increase in IL-8 complicates interpretation because IL-8 is involved in inflammatory signaling but also in neutrophil chemotaxis, angiogenic processes, and exercise-related tissue adaptation [11]. The intermittent structure of padel, including short high-intensity bursts, rallies lasting approximately 13.5–16.2 seconds, 20-second rest periods, and longer 90-second breaks, may partly explain this cytokine profile [11]. However, current evidence remains preliminary because the study was cross-sectional, included a small sample, and did not allow conclusions about chronic adaptations [11].

Padel has also been studied in relation to exercise-induced myokines and brain health-related biomarkers [12]. Pradas et al. evaluated BDNF, LIF, and irisin responses to simulated padel competition in 24 trained players, with real playing time of 27.8 ± 8.49 minutes and relative intensity of 75.2 ± 7.9% HRmax [12]. The most notable finding was an increase in BDNF in female players, from 1531.12 ± 269.09 to 1768.56 ± 410.75 ng/mL after competition, whereas LIF and irisin did not show significant post-competition changes [12]. This selective BDNF response may indicate that padel competition can stimulate neurotrophic signaling in some contexts, but it does not demonstrate that all players or all forms of padel practice produce consistent BDNF increases [12]. Therefore, current evidence does not justify a strong claim that padel improves brain health through BDNF or myokines; rather, it suggests that padel competition may acutely influence selected biomarkers related to muscle–brain communication, particularly BDNF in female trained players, whereas LIF and irisin did not show significant post-competition changes [12].

The physiological demands of padel should also be interpreted together with its cognitive and emotional demands [13]. Padel requires players to anticipate ball trajectories, adjust to wall rebounds, coordinate with a partner, select tactical responses, react to opponents' positioning, and execute precise strokes under time pressure [13]. Díaz-García et al. studied mental fatigue during consecutive World Padel Tour qualifying matches in 14 professional players and found that mental fatigue increased from pre- to post-match and accumulated between matches played on the same day, with the highest perceived mental fatigue observed during the second match [13]. Padel matches also impaired motivation and reaction time, supporting the hypothesis that mental fatigue may negatively affect performance [13].

These findings broaden the concept of physiological response in padel because match load is not purely cardiovascular, metabolic, or musculoskeletal [13]. Cognitive fatigue may interact with autonomic regulation, perceived exertion, tactical accuracy, reaction speed, emotional control, and possibly injury risk [13]. However, this injury-related interpretation remains hypothetical because the available mental-fatigue study did not directly measure injury outcomes [13]. Overall, inflammatory, myokine-related, and cognitive evidence remains promising but preliminary, and future research should use larger samples, repeated measures, different playing levels, and longer follow-up to determine whether acute responses translate into meaningful health, performance, or recovery outcomes [11–13].

5. Injury burden, mechanisms and risk factors in padel

5.1. Injury incidence, prevalence and anatomical distribution

The rapid expansion of padel has been accompanied by increasing clinical interest in sport-related injuries among recreational, amateur, youth, and professional players [3,8,15,16,20]. Although padel is often promoted as an accessible and health-enhancing sport, its intermittent movement profile, repeated racket actions, enclosed court environment, and frequent changes of direction create specific injury risks [2,3,21]. Current evidence indicates that padel injuries are common, although reported incidence and prevalence vary substantially because of differences in injury definitions, study design, recall periods, player level, exposure measurement, and data collection methods [3,15–17,20].

The systematic review by Dahmen et al., which included eight studies and 2022 participants, reported an injury incidence of approximately 3 injuries per 1000 hours of padel training and 8 injuries per 1000 matches, with prevalence ranging from 40% to 95% [3]. The elbow was the most frequently reported anatomical site, followed by the knee, shoulder, and lower back, while tendinous and muscular injuries were the most common tissue types [3]. Epidemiological studies in different national and competitive contexts confirm a substantial injury burden [15–17,20]. In Portuguese practitioners, 69.2% reported at least one lifetime padel injury, with an estimated incidence of 3.4 ± 4.7 injuries per 1000 hours of exposure in the total sample [15]. In Chilean amateur players, 53.8% sustained a padel-related injury during the previous six months, with the ankle–foot region, elbow–forearm, and shoulder–upper arm most frequently affected [16]. In a Saudi cohort, injury prevalence differed significantly between women and men, with women showing a higher prevalence in that sample; stress and poor warm-up practices were also identified as associated lifestyle factors [17].

Across the literature, the elbow, shoulder, knee, ankle, calf, Achilles tendon, and lower back appear as recurrently affected regions, although their ranking differs between studies and populations [3,15,16,19–21]. The elbow is one of the most consistently reported injury sites in padel [3,15,19,21]. Dahmen et al. identified it as the most common anatomical region of injury, and Ferreira et al. similarly reported the elbow as the most affected site in Portuguese players, followed by the ankle, knee, and shoulder [3,15]. Lower-limb injuries also represent a substantial part of the injury burden [15,16,20,21]. In professional World Padel Tour players, lower-leg muscle injuries were particularly common, representing 28.13% of injuries [20]. Knee injuries are also frequently reported in adult and youth populations, probably reflecting repeated deceleration, lateral cutting, rotation, and changes of direction [3,8,15,21].

Overall, these findings indicate that padel-related injuries are frequent and clinically relevant, particularly in amateur and recreational contexts where players may have variable physical preparation, inconsistent warm-up routines, limited technical instruction, and heterogeneous training exposure [3,15–17]. However, the wide range of prevalence values shows that injury burden must be interpreted in light of methodological differences, especially recall period, injury definition, player level, and exposure calculation [3]. Therefore, standardized prospective injury surveillance is needed in padel, using consistent definitions of time-loss, medical-attention, acute, and overuse injuries [3,15,16].

5.2. Injury tissue type and clinical presentation

Injury type in padel is most frequently reported as tendinous or muscular, while ligamentous injuries are also relevant in selected cohorts [3,15,16,19]. Dahmen et al. concluded that tendinous and muscular injuries were the most common types in the literature [3]. Ferreira et al. reported tendinous injuries in 35.6% and muscular injuries in 26.1% of injuries among Portuguese practitioners [15], while Belmar-Arriagada et al. also found tendons and muscles to be the most commonly injured tissues in Chilean amateur players [16].

Tendinous injuries are particularly relevant because padel combines high stroke frequency, repeated racket impacts, prolonged participation, and substantial upper-limb loading [3,19,21]. Lateral elbow tendinopathy is frequently emphasized as a common upper-limb condition, consistent with repeated gripping, wrist extension, forearm rotation, and racket-impact forces during padel strokes [19,21]. Shoulder tendinopathy or subacromial-subdeltoid bursitis may also occur in association with repetitive overhead actions, especially when players lack adequate shoulder strength, scapular control, thoracic mobility, or technical efficiency [19,21].

Muscular injuries are also frequent, particularly in the lower limb and shoulder region [15,20,21]. Professional players may be especially exposed to lower-leg muscle injuries because of repeated plantarflexion, split-step actions, braking, short sprints, and directional changes [20,21]. Ligament injuries are particularly relevant in the ankle and knee, and sudden-onset injuries appear more often ligamentous, whereas gradual-onset injuries are more often tendinous [16]. Injury severity also varies: Portuguese data reported frequent moderate-to-severe injuries, Chilean data showed more serious injuries in advanced players, and professional data indicated that lower-ranked players had more severe injuries lasting more than 28 days [15,16,20].

5.3. Upper- and lower-limb injury mechanisms

The injury profile of padel reflects the combined demands of racket use, repetitive upper-limb actions, rapid lower-limb movements, trunk rotation, and sudden changes of direction [3,19–21]. Upper-limb injuries are a major component of padel-related injury burden because the sport requires repetitive racket handling, ball striking, grip force, wrist stabilization, elbow flexion–extension, forearm pronation–supination, shoulder rotation, and overhead actions [19,21]. In amateur players, Muñoz et al. found that the shoulder and elbow were the most affected upper-body regions and that tendon injuries were the most common type of injury [19]. This is consistent with systematic and biomechanical evidence identifying the elbow and shoulder as frequent anatomical sites in padel injury epidemiology [3,21].

Elbow injuries may be promoted by repeated racket impact, excessive grip force, vibration transmission, technical errors, and high training volume [19,21]. Cocco et al. linked lateral elbow tendinopathy to repeated contractions of the forearm extensor muscles, eccentric stress on the common extensor tendon, mechanical overload of the ECRB origin at the lateral epicondyle, and rubbing of the ECRB tendon against the lateral edge of the capitellum [21]. Shoulder injuries may arise from repeated overhead strokes and high-frequency acceleration–deceleration cycles involving the rotator cuff, subacromial space, biceps tendon, scapular stabilizers, and posterior shoulder structures [19,21]. Wrist and hand injuries appear less frequently but may occur in players with high exposure, inappropriate grip configuration, or excessive wrist-dominant technique [19].

Lower-limb injuries are linked to repeated accelerations, decelerations, lateral movements, pivots, lunges, jumps, and rapid transitions between defensive and offensive positions [15,16,20,21]. The small court size and the use of walls require players to react quickly to rebounds, adjust body position in confined spaces, and perform frequent braking and re-acceleration actions [21]. These movement patterns load the ankle, knee, calf, Achilles tendon, and hip–pelvis complex [15,16,20,21]. Ankle–foot injuries in amateur players are often sudden in onset and may reflect acute inversion sprains, unstable landing or cutting mechanics, and footwear–surface interactions [16,18,21]. Knee injuries may be associated with rapid deceleration, rotation, lateral cutting, repeated flexion–extension, and poor neuromuscular control, and they are relevant in both youth and adult populations [8,15,21].

5.4. Exposure, competitive level and player-related risk factors

Padel-related injuries should be interpreted as multifactorial events resulting from the interaction between player characteristics, training exposure, technical level, equipment, court surface, psychological status, fatigue, and sport-specific biomechanics [8,13,15,18,19,21]. Epidemiological studies indicate that injury occurrence is associated with both intrinsic factors, such as sex, BMI, age, strength, flexibility, previous injuries, well-being, and psychological status, and extrinsic factors, such as racket characteristics, footwear, playing surface, training volume, match exposure, coaching supervision, and warm-up behavior [8,15–19].

Training exposure is one of the most consistent factors associated with injury occurrence in padel [15,18,19]. Rocamora-López and Mateo-Orcajada reported higher injury incidence in players with more experience, more hours of play, and amateur or professional competitive levels [18]. Muñoz et al. also found that upper-body injuries in amateur players were associated with weekly practice volume, years of padel experience, racket weight of at least 350 g, and playing more than six hours per week [19]. The relationship between experience and injury risk is complex: more years of participation may increase cumulative exposure to repetitive loads, whereas greater technical experience may reduce injury risk through more efficient movement, better stroke mechanics, and improved load self-regulation [15,18,19].

Competitive level may also influence injury patterns [18,20]. Lower-level players may compensate for limited technique with greater physical effort and less efficient movement, whereas higher-level players may perform more overhead, high-velocity, and tactically demanding actions [18]. In professional players, top-ranked athletes had a higher prevalence of muscle injuries, whereas lower-ranked players had more tendon injuries and more severe injuries lasting more than 28 days [20]. Therefore, exposure should not be reduced to training hours alone; risk depends on technical proficiency, conditioning, recovery, match density, fatigue, coaching supervision, and progression of training load [8,15,18–20].

Sex-related differences in injury patterns have been reported in several padel studies, although findings are not fully consistent across populations [16,17,19,20]. Muñoz et al. found that injury occurrence and anatomical location differed according to sex in amateur players, and that differences in racket characteristics and playing volume may partly explain these patterns [19]. In professional players, injury prevalence per 1000 matches was higher in female than male players, while the Saudi study reported substantially higher injury prevalence among women; in contrast, the Chilean amateur cohort found similar injury prevalence between women and men [16,17,20]. Therefore, sex should not be treated as an isolated causal factor but should be interpreted together with exposure, strength, flexibility, racket selection, technique, competitive level, and access to coaching or medical support [16,17,19,20].

Player-related characteristics such as BMI, physical condition, stress, and perceived wellness may also influence injury risk, although the available evidence remains observational [8,15,18]. Ferreira et al. reported that BMI was directly associated with overall injury incidence and that higher BMI was linked to greater likelihood of neck injuries [15]. In youth players, injured athletes had worse total wellness scores than non-injured players, and female players reported slightly higher stress levels than male players [8]. Psychological factors may influence injury risk through attention, decision-making, technique, movement quality, stress regulation, and recovery behavior [8,13,17,18]. Rocamora-López and Mateo-Orcajada reported that tendon injuries were associated with lower mental ability scores, while professional match play has been shown to increase mental fatigue and impair motivation and reaction time [13,18]. Although direct evidence linking mental fatigue to injury is lacking, slower reaction time and impaired cognitive control could theoretically affect positioning, stroke preparation, and movement mechanics [13].

5.5. Equipment, footwear and court-surface factors

Equipment and surface-related factors are important because they may modify mechanical load, traction, braking capacity, and tissue stress during padel practice [15,18,19,21]. Racket characteristics may influence upper-limb load by modifying impact forces, vibration transmission, swing mechanics, grip force, muscle activation, and joint loading [15,18,19]. Muñoz et al. reported that injuries were more frequent when the racket weighed at least 350 g, while Rocamora-López and Mateo-Orcajada found that muscle, tendon, and ligament injuries occurred more frequently with rackets weighing 350–370 g [18,19]. The Portuguese study also identified racket and overgrip characteristics as part of the multifactorial injury profile, with higher BMI associated with heavier rackets and more overgrips [15]. Therefore, racket selection should consider strength, experience, sex, anthropometry, injury history, grip comfort, swing control, and playing style rather than only power or professional-player preferences [18,19].

Court surface may modify lower-limb injury mechanisms by changing traction, braking capacity, sliding behavior, and eccentric loading [18]. Rocamora-López and Mateo-Orcajada reported that muscle and ligament injuries occurred more frequently on sand courts, whereas tendon and bone injuries appeared on both sand and non-sand courts [18]. These findings suggest that changing between surface types may expose players to different mechanical constraints and require adaptation in movement strategy [18].

Footwear appears to be an important and potentially modifiable risk factor in padel [18]. Rocamora-López and Mateo-Orcajada reported that mild and moderate injuries were mainly observed among players using mixed or herringbone soles, whereas severe injuries were more frequently reported among players using herringbone soles [18]. In a separate analysis of injured tissue type, most muscle, tendon, and ligament injuries occurred in players wearing mixed or herringbone sole shoes [18]. These findings should not be interpreted as

proof that a specific sole type directly causes injury, but rather as evidence that shoe–surface interaction may influence injury characteristics in padel [18]. Footwear recommendations should therefore be individualized according to court surface, player level, movement style, injury history, and physical conditioning [18].

5.6. Youth, amateur and professional players

Youth padel players represent an important population because adolescents may be exposed to increasing training volume, competition, growth-related changes, and sport-specific asymmetries [8]. Ryman Augustsson and Durdel investigated 104 youth players aged 15–20 years and recorded 6 acute and 49 overuse injuries during a one-week recall period, corresponding to 0.53 injuries per player [8]. Most injuries affected the knee, while the foot and lower leg had the highest severity scores [8]. Injured players also had worse wellness scores than non-injured players, suggesting that perceived well-being, stress, and overuse symptoms may be useful monitoring targets in youth padel [8]. Youth injury patterns should therefore be interpreted together with growth, maturation, sex differences, training exposure, fitness development, and upper-limb asymmetry [4–8].

Amateur and recreational players are especially relevant because they form the largest participation base and may have variable physical preparation, inconsistent warm-up routines, limited technical instruction, and heterogeneous training exposure [3,15–17]. These players may be particularly vulnerable to overuse complaints, inappropriate equipment selection, rapid increases in weekly volume, and delayed management of early symptoms [15,18,19]. For this group, injury prevention should focus on education, progressive exposure, warm-up habits, equipment selection, and early recognition of pain or overload [15,17–19].

Professional players may show different injury patterns because they are exposed to greater match density, higher speed of play, greater training volume, and more specialized technical–tactical demands [20]. Pérez et al. reported 44 injuries in 36 World Padel Tour players during the 2021 season, with higher injury prevalence per 1000 matches in female than male players [20]. Ranking also influenced injury characteristics: top-ranked players had higher injury incidence and more muscle injuries, whereas lower-ranked players had more tendon injuries and more severe injuries lasting more than 28 days [20]. These findings suggest that professional injury prevention should be individualized and should consider sex, ranking, exposure, tissue type, match density, and access to medical support [20].

5.7. Eye and maxillofacial injuries

Although musculoskeletal injuries dominate padel epidemiology, the enclosed court environment introduces additional trauma mechanisms involving the ball, racket, glass walls, and metal structures [22,23]. Catalfamo et al. reported 16 cases of maxillofacial injuries caused by racket rebound against the glass wall, with injuries including skin wounds, soft-tissue damage, and fractures mainly at the dentoalveolar junction [22]. This mechanism is specific to padel because the glass wall may redirect the racket toward the player's face after impact [22].

Ocular injuries have also been reported as an emerging concern in countries where padel participation has rapidly increased [23]. Kasiga and Bro showed that padel became an increasing cause of sport-related eye injuries in Sweden between 2017 and 2021 and emphasized that many sports-related ocular injuries may be prevented with protective eyewear [23]. These findings support consideration of eye and facial protection in prevention strategies, particularly in settings with frequent wall-related rebounds or less experienced players [22,23].

5.8. Integrative interpretation

Current evidence indicates that padel is associated with a substantial but potentially modifiable injury burden despite its accessibility and health-promotion potential [1–3,15,16,20]. Injuries are most frequently tendinous or muscular, with recurrent involvement of the elbow, shoulder, knee, ankle, lower leg, and lower back [3,15,16,19–21]. The mechanisms of injury can be summarized as the interaction between repetitive upper-limb loading, multidirectional lower-limb demands, asymmetric trunk rotation, equipment-related mechanical load, surface-dependent traction, cumulative exposure, fatigue, and psychological factors [8,13,15,18–21].

The injury burden in padel should not be interpreted as a reason to discourage participation, but rather as an argument for structured prevention [1–3]. Because padel may promote physical activity, social participation, and fitness development, the key clinical challenge is to maximize its benefits while reducing preventable injuries through warm-up routines, progressive load management, technique, strength and conditioning, footwear, racket selection, court-surface awareness, recovery, and early management of pain or overuse symptoms [1–3,8,15,17–21]. Therefore, padel injury risk should be viewed as a modifiable risk profile shaped by technique, conditioning, equipment, surface, load, recovery, and supervision rather than as an unavoidable consequence of participation [1–3,8,15,18,19,21].

6. Prevention, monitoring and rehabilitation implications

6.1. General prevention framework

Injury prevention in padel should be based on a multifactorial model that integrates player characteristics, training exposure, physical preparation, technical skills, equipment, court surface, recovery, and early symptom management [3,8,15,18,19,21]. This approach is justified by evidence showing that padel injuries are not limited to one anatomical region or mechanism, but include tendinous, muscular, ligamentous, joint-related, ocular, and maxillofacial conditions across different populations and levels of play [3,15,16,19,20,22,23]. Because padel is also a potentially health-promoting sport, prevention should aim to improve safety, sustainability, and long-term adherence rather than discourage participation [1,3,15].

A practical prevention model should distinguish between acute traumatic injuries and overuse injuries [3,8,15,16,21]. Acute injuries may occur during sudden changes of direction, pivots, slips, falls, ball impacts, racket impacts, or wall-related events, whereas overuse injuries may develop gradually through repeated upper-limb strokes, high weekly exposure, insufficient recovery, poor technique, inappropriate equipment, and inadequate strength or mobility [15,16,18,19,21–23]. Therefore, prevention should combine structured warm-up, neuromuscular preparation, progressive load management, technical correction, equipment optimization, and education about early warning symptoms [8,15,17–19,21].

6.2. Warm-up, strength and neuromuscular preparation

Structured warm-up should be considered a core element of padel injury prevention [15,17]. Epidemiological evidence from Madinah identified poor warm-up practices as one lifestyle factor associated with increased injury risk, while the Portuguese study found that players supervised by a padel instructor were more likely to perform warm-up routines [15,17]. These findings suggest that education and supervision may improve preparation habits among recreational and amateur players [15,17].

A padel-specific warm-up should prepare both the cardiovascular system and the musculoskeletal structures most exposed during play [15,17,21]. It may include general activation, dynamic mobility of the ankle, hip, thoracic spine, shoulder, elbow, and wrist, lower-limb neuromuscular drills, lateral movements, deceleration tasks, balance exercises, and progressive sport-specific strokes [15,16,18,21]. Upper-limb preparation should include scapular activation, rotator cuff exercises, forearm and wrist activation, grip preparation, and gradual progression toward full-intensity rallies [19,21]. Although padel-specific randomized trials on warm-up effectiveness are still lacking, observational evidence and known injury mechanisms support its routine implementation [15,17,19,21].

Strength and conditioning programs should address the specific physical demands of padel, including upper-limb endurance, rotator cuff capacity, scapular control, trunk rotation, lower-limb strength, eccentric braking capacity, balance, and lateral agility [2,8,19,21]. For upper-limb prevention, exercises should target the rotator cuff, scapular stabilizers, forearm flexors and extensors, wrist stabilizers, and grip endurance, because elbow and shoulder injuries are common and tendinous injuries represent a major component of the padel injury profile [3,15,19,21]. For lower-limb prevention, programs should emphasize eccentric quadriceps and hamstring strength, calf strength, hip control, ankle stability, balance, landing mechanics, and deceleration capacity [8,15,16,20,21].

Conditioning should be adapted to player level [15,18,20]. Beginners may need general strength, coordination, and movement-quality training before increasing weekly match volume [15,18,19]. Competitive and professional players may require more specific eccentric, plyometric, repeated-effort, and recovery-oriented training to tolerate match intensity, tournament density, lower-leg muscle load, and tissue-specific injury risk [20].

6.3. Load management and wellness monitoring

Load management is essential because injury risk in padel is associated with weekly exposure, years of practice, competitive level, and accumulated fatigue [8,15,18–20]. Rocamora-López and Mateo-Orcajada reported higher injury incidence in players with more experience, more hours of play, and amateur or professional levels [18], while Muñoz et al. found that upper-body injuries were associated with weekly practice volume and experience in amateur players [19]. In youth players, worse wellness scores were observed in injured compared with non-injured athletes, suggesting that perceived well-being may help identify reduced load tolerance [8].

Monitoring should include both external and internal load indicators [8–10]. External load may include number of sessions, match duration, number of matches, tournament density, playing surface, and changes in training volume [8,15,18–20]. Internal load may include perceived exertion, fatigue, soreness, stress, sleep quality, and wellness scores [8,9]. In higher-level players, HRV may provide additional information about

autonomic recovery and match-related stress, although it should complement rather than replace subjective and clinical monitoring [9,10].

Practical load management should focus on gradual progression, especially for beginners, youth players, and athletes returning from injury [8,15,18–20]. Sudden increases in weekly play may expose tendons, muscles, and joints to repetitive loading before adequate adaptation occurs [18,19,21]. Return after injury should avoid abrupt exposure to full match intensity, overhead volume, or competition, particularly after elbow tendinopathy, shoulder pain, ankle sprain, knee injury, or calf muscle injury [16,19–21].

6.4. Equipment and court-surface prevention

Equipment selection is a modifiable prevention target in padel, particularly regarding racket weight, grip configuration, footwear, and shoe–surface compatibility [15,18,19]. Racket characteristics may influence upper-limb load by modifying swing inertia, vibration, grip force, and impact transmission [18,19]. Injuries were reported more frequently among amateur players using rackets weighing at least 350 g, and muscle, tendon, and ligament injuries were more frequent with rackets weighing 350–370 g [18,19]. Therefore, racket choice should be individualized according to player strength, experience, sex, playing style, previous injury, and technical capacity rather than guided only by power or professional-player preference [18,19].

Footwear should be selected according to court surface, movement style, and injury history [18]. Rocamora-López and Mateo-Orcajada reported that injury severity differed according to sole type: mild and moderate injuries were mainly observed among players using mixed or herringbone soles, whereas severe injuries were more frequently reported among players using herringbone soles [18]. Most muscle, tendon, and ligament injuries occurred in players using mixed or herringbone sole shoes [18]. These observations should be interpreted as associations rather than causal proof, but they suggest that shoe–surface interaction may influence injury characteristics [18]. The goal of footwear selection should be to balance grip, sliding capacity, support, torsional control, and rotational release [18].

Court surface should also be considered part of the injury-prevention environment [15,18]. Differences in sand content, friction, maintenance, compaction, and humidity may influence traction, sliding, braking, ball speed, movement strategy, and lower-limb loading [15,18]. Surface-related prevention should include regular court maintenance, adequate sand distribution, inspection of uneven areas, and player education about adapting movement strategy across surfaces [18]. Coaches should incorporate deceleration, lateral movement, and surface-adaptation drills into training, especially for beginners and players who regularly change court types [18,21].

6.5. Eye and maxillofacial injury prevention

Although eye and maxillofacial injuries are less frequent than musculoskeletal injuries, their potential severity justifies preventive attention [22,23]. The enclosed court environment may contribute to traumatic events involving the ball, racket, glass walls, and metal structures [22,23]. Catalfamo et al. reported 16 cases of maxillofacial injuries caused by racket rebound against the glass wall, including skin wounds, soft-tissue damage, and fractures mainly at the dentoalveolar junction [22]. Kasiga and Bro reported that padel became an increasing cause of sport-related eye injuries in Sweden and emphasized that many ocular injuries may be prevented with protective eyewear [23].

Prevention should include safe racket handling, avoidance of emotional racket throwing, awareness of ball and racket trajectories, safe play near glass walls, and consideration of protective eyewear in players who may be at higher risk, such as less experienced players or those with previous ocular vulnerability [22,23]. Facilities should also ensure proper maintenance of glass panels, metal structures, doors, and court boundaries [22,23].

6.6. Rehabilitation and return-to-play considerations

Because padel-specific rehabilitation trials are scarce, return-to-play recommendations should be interpreted as clinically informed implications based on reported injury patterns, biomechanical demands, and general sports rehabilitation principles [2,3,15,21]. Rehabilitation in padel should be guided by the injured tissue, anatomical site, mechanism, player level, and functional demands of the sport [2,3,15,21]. Because tendinous and muscular injuries are common, rehabilitation often requires progressive loading rather than prolonged rest alone [3,15,21]. Elbow tendinopathy may require gradual forearm strengthening, grip-load modification, racket adjustment, technique correction, and progressive reintroduction of strokes [19,21]. Shoulder symptoms may require rotator cuff and scapular strengthening, thoracic mobility, kinetic-chain training, and gradual return to overhead shots [19,21].

Lower-limb rehabilitation should address strength, balance, proprioception, deceleration control, lateral movement, and change-of-direction mechanics [8,15,16,20,21]. After ankle sprain, players should regain range

of motion, peroneal strength, balance, hopping ability, lateral stability, and confidence before returning to full match play [16,21]. After calf or lower-leg muscle injury, rehabilitation should include progressive calf loading, plyometric exposure, acceleration–deceleration drills, and monitoring of match density [20]. Knee-related rehabilitation should address hip and trunk control, quadriceps and hamstring strength, landing mechanics, lateral movement, and sport-specific cutting manoeuvres [8,21].

Return-to-play decisions should include symptom resolution, sport-specific functional testing, and progressive exposure to padel-specific demands [15,20,21]. Players should tolerate progressive hitting, lateral movement, deceleration, overhead strokes, match-like rallies, and fatigue exposure before unrestricted competition [20,21]. Because padel also requires rapid perception, decision-making, and confidence under game-like pressure, return-to-play should consider psychological readiness and cognitive–technical tolerance, especially in competitive players [13,20,21].

6.7. Practical recommendations

Based on current evidence, several practical recommendations can be proposed for safer padel participation, although most are supported by observational data and expert interpretation rather than padel-specific randomized trials [3,8,15,17–19,21]. Players should perform structured warm-up before training and matches, increase weekly exposure gradually, and include strength and conditioning focused on the shoulder, elbow, wrist, trunk, hip, knee, ankle, and calf complex [8,15,17–21]. Equipment should be selected according to physical characteristics and injury history, with attention to racket weight, grip size, overgrips, footwear, and court-surface compatibility [15,18,19].

Players and coaches should monitor pain, fatigue, stress, sleep, soreness, and wellness, especially in youth and high-volume players [8,15,18,19]. HRV monitoring may be useful in high-level contexts to understand autonomic stress and recovery, but it should complement subjective and clinical monitoring [9,10]. Eye and facial injury prevention should include safe racket behavior, awareness near glass walls, and consideration of protective eyewear in high-risk players [22,23]. Early referral to physiotherapy or sports medicine professionals should be encouraged when pain persists, function declines, or recurrent injuries occur [15,21].

7. Discussion

7.1. Integrated interpretation of current evidence

The current literature indicates that padel occupies a clinically relevant position between recreational physical activity, competitive racket sport, and emerging public health tool [1,2]. Its doubles format, social character, relatively low technical entry threshold, moderate average physiological intensity, and suitability for different ages and performance levels may support adherence to physical activity [1]. At the same time, padel imposes repeated technical, neuromuscular, autonomic, cognitive, and mechanical demands that may expose players to clinically relevant injury risks, particularly when training exposure, equipment, technique, physical preparation, and recovery are not adequately managed [2,3,8,15,18,19,21].

This dual profile is central to understanding padel from a health perspective [1–3]. Padel should not be described only as a low-risk recreational sport, because injury data show a substantial musculoskeletal burden involving the elbow, shoulder, knee, ankle, lower leg, and lower back [3,15,16,19–21]. Conversely, it should not be framed primarily as a hazardous sport, because its accessibility, enjoyment, intermittent cardiovascular load, and potential effects on physical fitness may make it a valuable strategy for increasing leisure-time physical activity [1,4–7,9,12]. A balanced interpretation is that padel may provide meaningful health and fitness benefits when participation is supported by adequate preparation, progressive load management, equipment selection, and injury-prevention strategies [1–3,8,15,18,19,21].

The health-promoting potential of padel is supported mainly by narrative and observational evidence, with limited interventional or longitudinal data in youth players [1,4,6,7]. Available studies suggest improvements in selected fitness components, including handgrip strength, sprint performance, lower-limb strength, jump performance, core endurance, and lateral agility [6,7]. However, current evidence does not establish padel as an independently superior modality for cardiometabolic, body composition, or long-term clinical outcomes [1,4,6,7]. Therefore, padel should be presented as a promising and practical physical activity option rather than a proven clinical intervention for disease prevention or treatment [1].

7.2. Physiological and biological interpretation

From a physiological standpoint, padel combines moderate average metabolic demand with intermittent peaks of mechanical, autonomic, and cognitive stress [9–13,21]. Match-play studies indicate that mean cardiovascular intensity may contribute to cardiovascular stimulation in recreational or moderately trained players, while remaining lower than the intensity reported in some other racket sports [9,12]. However, average heart rate or oxygen uptake values may underestimate localized tissue load and cognitive demand, because padel involves repeated accelerations, decelerations, overhead strokes, rapid tactical decisions, and intermittent recovery periods [9,11–13,21].

HRV studies show that padel match play produces measurable autonomic perturbation, with reduced vagal-related indices during play and partial recovery during rest or post-match periods [9,10]. These findings suggest that padel is not simply a light recreational activity, but a sport capable of generating relevant autonomic stress and recovery demands [9,10]. HRV may therefore be useful for monitoring training load and recovery in selected contexts, although current evidence is still too limited to treat it as a stand-alone marker of performance, injury risk, or cardiovascular safety [9,10].

The cytokine and myokine literature adds a biological dimension to the interpretation of padel, but should be considered preliminary [11,12]. Acute cytokine data suggest an immunoregulatory response after elite padel competition, including increased IL-10 and changes in IL-7 and IL-8 [11]. Myokine data suggest that simulated padel competition may increase BDNF in female trained players, whereas LIF and irisin did not show consistent changes [12]. These findings connect padel to inflammation, recovery, and muscle–brain communication, but they should not be overinterpreted as evidence of chronic anti-inflammatory or neuroprotective effects [11,12].

Mental fatigue should also be included in the physiological profile of padel [13]. Professional matches may increase mental fatigue and impair motivation and reaction time, particularly during consecutive matches with limited recovery [13]. This is relevant because padel performance depends heavily on anticipation, tactical decision-making, partner coordination, and rapid technical execution [13]. Although the relationship between mental fatigue and injury risk has not been directly tested, slower reactions and impaired cognitive control could plausibly affect positioning, stroke preparation, and movement quality [13].

7.3. Injury risk and prevention opportunity

The injury evidence is stronger and more developed than the evidence for long-term health outcomes [3,15,16,19–21]. Systematic and epidemiological studies consistently show that padel-related injuries are common, with tendinous and muscular injuries dominating the clinical picture [3,15,16]. The elbow is frequently reported as one of the most affected regions, while lower-limb injuries such as ankle, knee, and lower-leg injuries are also highly relevant [3,15,16,20,21]. These patterns reflect the combined effect of repeated racket impacts, overhead strokes, grip force, unilateral loading, rapid lateral displacements, decelerations, and surface-dependent traction [15,18–21].

An important conclusion is that injury risk in padel cannot be reduced to a single cause [8,15,17–19]. Exposure, competitive level, training history, racket characteristics, footwear, court surface, BMI, sex, wellness, stress, warm-up habits, and supervision all appear as relevant variables in different studies [8,15,17–19]. However, most evidence is observational and frequently based on self-reported injury data, so these associations should be interpreted as plausible prevention targets rather than definitive causal relationships [3,15,18,19].

The prevention opportunity is substantial because many identified factors are modifiable [8,15,17–19,21]. Warm-up habits, progressive training exposure, strength and conditioning, racket choice, grip configuration, footwear, court adaptation, recovery routines, and early symptom management can all be addressed in coaching and clinical practice [8,15,17–19,21]. Equipment is particularly relevant for recreational players, because heavier rackets, inappropriate grip size, unsuitable footwear, and poor shoe–surface compatibility may increase mechanical stress in players with limited technique or insufficient conditioning [15,18,19]. These recommendations should nevertheless be framed as risk-reduction strategies rather than guaranteed injury-prevention measures, because direct biomechanical and prospective intervention studies in padel remain limited [18,19].

7.4. Practical implications for different player groups

Youth players require specific attention because padel participation is increasing in adolescents and because young athletes may be exposed to growth-related vulnerability, overuse symptoms, perceived stress, and increasing training demands [4–8]. Evidence from youth players shows fitness improvements across training periods, but also reports overuse injuries, knee involvement, stress differences, and worse wellness among injured players [7,8]. Youth padel should therefore combine technical training with strength development, neuromuscular control, wellness monitoring, and progressive load management [4–8].

Female players may present different injury patterns or physiological responses in some studies, although evidence is inconsistent [11,12,16,17,19,20]. Some studies have examined sex-related differences in physiological and injury-related outcomes, including BDNF responses, injury prevalence, equipment use, and injury patterns, although findings remain inconsistent [11,12,16,17,19,20]. Therefore, sex-specific recommendations should avoid oversimplification and should consider exposure, training level, strength, flexibility, racket choice, footwear, and competitive context [16,17,19,20].

Amateur and recreational players are particularly important because they form the largest participation base and may have variable physical preparation [15,16,18,19]. These players may increase weekly volume rapidly, play without structured warm-up, select inappropriate rackets or shoes, and delay seeking care for early symptoms [15,17–19]. Professional players, by contrast, may experience greater match density, higher speed of play, and more intense neuromuscular demands, but may also have better conditioning and medical support [20]. Prevention strategies should therefore differ by player profile rather than applying a single model to all padel participants [8,15,19,20].

For clinicians, coaches, and physical trainers, the current evidence supports a multidimensional approach. Clinical assessment should include not only the symptomatic region but also kinetic-chain factors such as grip, racket characteristics, shoulder mobility, scapular control, trunk rotation, hip strength, ankle stability, and deceleration mechanics [19,21]. Coaches should prioritize structured warm-up, progressive load planning, neuromuscular training, strength and conditioning, and education about equipment and recovery [8,15,17–19,21]. Players should not ignore persistent elbow or shoulder pain, recurrent ankle instability, knee symptoms, calf tightness, or eye/facial trauma risk [15,16,19–23]. Protective eyewear and safe racket handling near glass walls should be considered because ocular and maxillofacial injuries, although less frequent, may have serious consequences [22,23].

8. Limitations and future research directions

8.1. Methodological heterogeneity and injury surveillance

The current body of evidence on padel is growing rapidly, but it remains methodologically heterogeneous [1–3]. Available studies include narrative and systematic reviews, cross-sectional and retrospective epidemiological studies, cohort studies, small experimental studies, physiological monitoring studies, and biomechanical or imaging-oriented reviews [1–3,8,9,11,12,15–21]. This diversity helps build a broad understanding of padel, but it also limits the strength and comparability of conclusions across health, physiological, and injury-related outcomes [1–3].

A major limitation is the heterogeneity of studied populations [1–3,8,15,16,20]. Existing studies include youth players, recreational and amateur adults, elite players, professional World Padel Tour athletes, and national cohorts from different countries [4–8,11,12,15–17,20]. These groups differ in age, sex distribution, training history, competitive level, weekly exposure, physical conditioning, coaching support, and access to medical care [8,15–17,20]. Therefore, findings from one population cannot be automatically generalized to another [8,15–17,20]. This is especially relevant for injury data, because injury patterns reported in Chilean amateur players, Portuguese practitioners, Saudi players, Swedish youth players, and professional athletes differ in prevalence, anatomical distribution, sex-related patterns, and severity [3,8,15–17,20].

One of the most important limitations in padel injury research is the lack of standardized injury definitions [3]. Dahmen et al. emphasized that there is no consensus injury definition provided by the International Padel Federation, which may contribute to misclassification, under-reporting, and difficulty comparing injury rates across studies [3]. Some studies assess lifetime injuries, whereas others report injuries from the previous season, previous year, previous six months, or one-week recall periods [8,15,16,19,20]. These different time windows strongly influence prevalence estimates and make direct comparison difficult [3,8,15,16,19,20].

Future padel research should therefore prioritize standardized injury surveillance systems [3,8,15,16,20]. A standardized framework should distinguish between medical-attention injuries, time-loss injuries, self-

reported pain, acute injuries, and overuse injuries, while recording anatomical site, tissue type, injury mechanism, onset pattern, severity, exposure context, and return-to-play time [3,8,15,16,20]. Data harmonization should also include standardized reporting of player level, age, sex, exposure, court type, equipment, warm-up habits, and training load, which would allow stronger comparisons and future meta-analyses [3,8,15,18–20].

8.2. Predominance of retrospective data and need for prospective risk-factor studies

Much of the current padel injury literature is based on cross-sectional or retrospective self-report designs [3,15–20]. These designs are useful for identifying common injury patterns, but they are limited by recall bias, selection bias, inaccurate exposure estimation, and inability to establish causality [3,15–20]. Players may forget minor injuries, misclassify tissue type, overestimate or underestimate weekly exposure, or report only the most severe or memorable injuries [15,16,19].

Cross-sectional studies also cannot determine whether a factor preceded the injury or resulted from it [15,18,19]. For example, associations between injury and racket characteristics, footwear, BMI, mental ability, or warm-up habits do not prove that these factors caused the injury [15,18,19]. Injured players may have changed equipment, modified training habits, or become more aware of pain and risk factors after the injury [15,18,19]. Therefore, current risk-factor findings should be considered hypothesis-generating rather than definitive [15,18,19].

Prospective registries would be especially valuable because they could reduce recall bias, improve exposure accuracy, and allow stronger assessment of risk factors [3,15,16]. Future studies should collect weekly data on training hours, match exposure, number of matches, court surface, footwear, racket characteristics, warm-up habits, wellness, pain, and medical diagnoses [8,15,17–20]. Such surveillance would help determine whether variables such as weekly exposure, experience, competitive level, BMI, sex, racket weight, footwear, court surface, stress, warm-up habits, and wellness status predict new injuries over time [8,15,17–20].

Particular attention should be given to modifiable risk factors, including racket weight, grip size, number of overgrips, footwear type, shoe–surface interaction, warm-up routines, strength deficits, flexibility limitations, training-load spikes, poor recovery, and insufficient technical instruction [8,15,17–19]. Future studies should also examine interactions between variables, because injury risk is likely multifactorial rather than dependent on one factor alone [15,18].

8.3. Limited evidence on long-term health benefits

The evidence supporting padel as a health-promoting sport is promising but still incomplete [1,4,6,7]. Current studies suggest potential benefits for physical fitness, especially in youth players, but there are few randomized controlled trials and limited long-term longitudinal data [6,7]. The available interventional study in children suggests improvements in selected strength- and power-related variables, but the sample was small and not all outcomes showed significant between-group changes [6]. Cohort data in youth players show improvements across a season, but these findings may be influenced by maturation, school-based training structure, coaching quality, and concurrent physical development [7].

There is also limited padel-specific evidence on long-term clinical health outcomes [1]. Although broader exercise and racket-sport literature supports benefits for cardiovascular health, body composition, mental health, cognition, and chronic disease prevention, these outcomes have not yet been thoroughly tested in padel-specific trials [1]. Therefore, claims that padel improves cardiometabolic health, mental health, bone density, or chronic disease risk should be presented cautiously unless directly supported by padel-specific data [1].

Future studies should test padel-based interventions in inactive adults, older adults, children, adolescents, women, and clinical populations [1,6,7]. Outcomes should include aerobic fitness, muscular strength, agility, balance, body composition, blood pressure, glucose metabolism, lipid profile, inflammatory markers, sleep, mental health, enjoyment, adherence, quality of life, and injury occurrence [1,6,7]. Long-term follow-up is needed to determine whether padel's social and enjoyable nature translates into sustained participation and meaningful health benefits [1].

8.4. Physiological, biological and cognitive research needs

Physiological studies in padel provide valuable mechanistic insight, but many are based on small samples [9–13]. HRV studies have included limited numbers of players or recordings, and findings may be influenced by playing level, match context, emotional state, breathing patterns, hydration, sleep, and previous training load [9,10]. Cytokine, myokine, and mental-fatigue studies are also limited by small samples, acute designs, and a focus on trained, elite, or professional players [11–13].

The cytokine study by Cádiz-Gallardo et al. suggested an acute anti-inflammatory response after elite padel competition, including increased IL-10 and changes in IL-7 and IL-8, but these findings cannot be generalized to all padel players or interpreted as evidence of chronic anti-inflammatory adaptation [11]. Similarly, Pradas et al. reported an increase in BDNF in female trained players, while LIF and irisin did not change significantly [12]. These findings should be considered preliminary and hypothesis-generating [11,12].

Future physiological research should use larger samples and more standardized protocols [9–12]. Match duration, real playing time, competitive setting, environmental conditions, blood sampling timing, nutritional control, menstrual cycle phase, recovery status, and prior training load can all affect physiological markers [9,11,12]. HRV studies should standardize measurement windows, breathing control, match context, environmental conditions, and recovery assessment, and should determine whether HRV can predict readiness, recovery, match outcome, or injury risk [9,10].

The cytokine and myokine literature also requires expansion [11,12]. Future studies should include repeated sampling, different playing levels, inactive individuals, older adults, and sex-specific analyses [11,12]. It would also be useful to evaluate whether regular padel training produces chronic changes in inflammatory status, muscle–brain biomarkers, neurocognitive function, or metabolic health [11,12]. Mental fatigue should also be integrated into future research, particularly because padel requires continuous tactical decision-making, partner coordination, emotional control, and rapid reaction [13]. Future studies should examine whether mental fatigue affects technical errors, decision quality, reaction time, injury risk, and recovery in recreational, youth, and professional players [13].

8.5. Biomechanics, equipment and court-surface research

Although several studies discuss plausible injury mechanisms in padel, direct biomechanical evidence remains limited [18,21]. Many proposed mechanisms are inferred from match characteristics, injury distributions, movement demands, or evidence from related racket sports such as tennis [18,21]. For example, associations between footwear, court surface, traction, and injury risk are plausible, but direct padel-specific studies measuring shoe–surface interaction, joint loading, deceleration forces, and injury outcomes remain scarce [18].

Future studies should quantify joint kinematics, kinetics, muscle activation, and load distribution during common padel strokes and movements [18,21]. Particular attention should be given to the smash, bandeja, vibora, volley, lob, defensive wall shots, rapid lateral shuffles, split-step actions, pivots, jumps, landings, and decelerations [18,21]. Such analyses would help explain why tissues such as elbow tendons, the rotator cuff, calf muscles, Achilles tendon, ankle ligaments, and knee structures are frequently affected [3,8,15,16,19–21].

Wearable technologies, inertial measurement units, local positioning systems, force platforms, electromyography, and video analysis may help quantify padel-specific load in real or simulated match conditions [18,21]. Combining biomechanical measures with prospective injury surveillance would allow researchers to identify movement patterns that predict future injury and inform coaching cues, technical corrections, strength programs, and return-to-play criteria [18,19,21].

Equipment and surface-related research should also be developed because racket characteristics, grip configuration, footwear, sole type, and court surface appear as plausible modifiable factors [15,18,19]. Future studies should directly measure how racket weight, balance, stiffness, core material, shape, grip size, and overgrips affect vibration, grip force, swing mechanics, shoulder load, elbow load, and perceived comfort [15,18,19]. Footwear and court-surface research should examine traction, rotational resistance, sliding capacity, braking forces, joint loading, and injury incidence across courts with different sand content and surface characteristics [18].

8.6. Prevention, rehabilitation and special populations

Although prevention and rehabilitation recommendations can be derived from injury mechanisms and clinical reasoning, direct padel-specific intervention studies are limited [2,15,18,21]. Current recommendations regarding warm-up, strength training, load management, footwear, racket selection, and recovery are largely based on observational associations, biomechanical plausibility, clinical expertise, and evidence from related sports [15,17–19,21]. Randomized or prospective intervention studies are needed to test whether padel-specific warm-up programs, neuromuscular training, equipment modifications, or load-monitoring systems reduce injury incidence [8,15,17,18].

Padel-specific prevention programs should be developed and tested in controlled studies [2,15,17,18,21]. These programs may include dynamic warm-up, lower-limb neuromuscular training, balance exercises, shoulder and scapular strengthening, forearm tendon conditioning, trunk control, deceleration mechanics, progressive racket exposure, and education about load management [8,15,17,19,21]. Injury outcomes should

be tracked prospectively to determine whether such programs reduce elbow tendinopathy, shoulder pain, ankle sprains, knee complaints, calf injuries, and overuse symptoms [3,8,15,16,19–21].

Similarly, rehabilitation evidence is mostly extrapolated from general sports medicine principles and from knowledge of common tissues affected in padel [2,3,21]. Elbow tendinopathy, shoulder pain, ankle sprain, knee complaints, calf injuries, and lower-back symptoms have established rehabilitation frameworks in sports medicine, but padel-specific return-to-play criteria remain underdeveloped [19–21]. Future studies should identify functional tests reflecting padel demands, such as repeated lateral movement, deceleration, overhead-stroke tolerance, grip endurance, forearm loading capacity, calf endurance, and match-like fatigue exposure [20,21]. Return-to-play decisions should combine clinical symptoms, tissue capacity, movement quality, technical tolerance, psychological readiness, and exposure progression [20,21].

Future padel research should also include more diverse populations [1,8,15–17,20]. Less is known about older adults, inactive beginners, clinical populations, and underrepresented groups [1]. Sex-specific research should consider not only biological sex but also exposure, training level, strength, flexibility, racket selection, footwear, coaching access, and cultural participation patterns; menstrual cycle phase or hormonal measures may be relevant when physiological outcomes are assessed [11,12,16,17,19,20]. Youth research should integrate growth, maturation, perceived stress, wellness, training load, and injury monitoring [4–8].

8.7. International collaboration and data harmonization

Many padel studies come from countries where the sport is highly popular or rapidly expanding, including Spain, Portugal, Sweden, Chile, and Saudi Arabia [1,8,15–17,22,23]. These data are valuable, but geographic and cultural differences may affect participation patterns, court conditions, coaching access, equipment use, competitive structure, medical care, and reporting behavior [8,15–17]. Therefore, injury prevalence or risk factors identified in one country may not fully apply to another context [15–18].

For example, the Saudi study reported much higher injury prevalence in women than men, whereas the Chilean amateur study found similar injury prevalence between sexes [16,17]. These differences may reflect true sex-related variation, but they may also result from differences in exposure, sampling, experience, cultural participation patterns, or injury reporting [16,17]. International multicenter studies using standardized methods are needed to distinguish universal padel-related patterns from population-specific findings [3,15–18].

International collaboration would strengthen padel research because the sport is expanding rapidly across countries with different participation patterns, facilities, coaching systems, and healthcare contexts [1,15–17,22,23]. Multicenter studies could compare injury rates, health benefits, and physiological responses across countries using standardized methods, helping distinguish universal padel-related patterns from local or cultural factors [3,15–17]. Because padel research is still emerging, establishing common methodological standards now would improve the quality and comparability of future studies [3].

9. Conclusions

Padel is a rapidly growing racket sport with promising potential to promote physical activity because it combines social interaction, enjoyment, and relatively low technical barriers for beginners [1,2]. Its intermittent structure produces moderate average cardiovascular intensity with repeated high-intensity actions, making it physiologically meaningful for recreational and trained players [9,12]. Current evidence suggests that padel may contribute to selected components of physical fitness, including upper-limb strength, lower-limb strength and power, agility, lateral movement ability, and cardiorespiratory fitness, particularly in youth and non-professional players [4–7]. However, the literature does not yet allow strong conclusions about long-term clinical outcomes such as cardiometabolic health, obesity prevention, mental health, or chronic disease risk [1,6,7].

The physiological profile of padel is characterized by moderate average cardiovascular intensity combined with repeated short high-intensity actions, rapid changes of direction, overhead strokes, tactical decision-making, and intermittent recovery periods [2,9,12,13,21]. HRV studies indicate measurable autonomic stress and partial recovery during rest or post-match periods, while early biological evidence suggests possible inflammatory and myokine-related responses, including changes in IL-10, IL-7, IL-8, and BDNF [9–12]. These findings are promising but should be interpreted cautiously because much of the evidence comes from small acute studies [9–12].

Injury risk is a clinically important aspect of padel participation [3,15,16,20,21]. Available evidence indicates that padel-related injuries are common, with tendinous and muscular injuries being the most frequently reported tissue types and the elbow, shoulder, knee, ankle, lower leg, and lower back among the most relevant anatomical regions [3,15,16,19–21]. Injury mechanisms are multifactorial and involve repetitive

upper-limb loading, unilateral racket use, overhead actions, rapid changes of direction, abrupt decelerations, surface-dependent traction, equipment-related load, fatigue, stress, and insufficient preparation [8,13,15,18–21].

Padel should therefore be viewed neither as a risk-free recreational activity nor as a sport that should be discouraged because of injury concerns [1–3]. A balanced interpretation is that padel can be a valuable health-promoting sport when participation is supported by appropriate education, preparation, monitoring, and prevention strategies [1,3,8,15,18,19,21]. Prevention should be individualized and should combine structured warm-up, progressive load management, strength and conditioning, neuromuscular training, equipment optimization, surface adaptation, wellness monitoring, and early clinical management of symptoms [8,15,17–19,21].

Future research should prioritize standardized injury surveillance, prospective risk-factor studies, randomized padel-based health interventions, biomechanical analyses, physiological monitoring, and padel-specific prevention and rehabilitation trials [1,3,8–13,15,18–21]. Overall, the main challenge for clinicians, coaches, researchers, and sport organizations is to maximize the benefits of padel participation while reducing preventable injuries through evidence-informed training, monitoring, equipment selection, and multidisciplinary care [8,15,17–21].

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