



# The incidence of injuries across various tennis surfaces: A systematic review

Sneha Alexander, Nabeela Naaz & Shifra Fernandes

Manipal Academy of Higher Education, India.

## ABSTRACT

Tennis players' joints are subjected to enormous loads, with supraphysiological stresses generated at the shoulder and elbow hundreds of times per match. Chronic injuries typically concern the upper extremity while acute injuries typically affect the lower extremities. The type and frequency of injuries have also changed as a result of advancements in equipment and playing surfaces. Top athletes and coaches need some understanding of how the playing surface affects tennis performance. Thus, the purpose of this review is to provide an overview of the most recent research on injuries and playing surface effects in tennis. The main aim of this study was to ascertain whether there is a difference in the incidence of tennis injuries between the four most popular court surfaces, including clay, hard, grass and concrete. Tennis court surfaces have been identified as a factor that influences the occurrence of injuries. The evidence strongly suggests that the surface is a significant component in injury causation and varying surfaces have been found to have considerably different injury rates. A systematic search of published reports was conducted in four electronic databases from 2010 to discover relevant articles relating to tennis injuries and surfaces.

**Key words:** tennis injury, surfaces, incidence, elite athletes.

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**Corresponding author:**

Sneha Alexander. Email:

[snehaalexander235@gmail.com](mailto:snehaalexander235@gmail.com)

## INTRODUCTION

Tennis is a well admired and frequently practiced racquet sport (Girard et al., 2007). While playing tennis, the joints of the body undergo larger physiological forces (Dines et al., 2015). The muscle segment and force associated by the kinetic chain starting from the feet moves to knee and from there it moves to shoulder and elbow, terminating at the wrist to the racquet. Serving is the most intensive shot of the play (Dines et al., 2015). During serving the greatest muscle activation occurs in shoulder and forearm. The tennis serving is divided into 8-stage model involves three distinct phases. Preparation, acceleration, and follow-through. The phase reflects the distinct dynamic functions of the serve: Start, Release, Loading, Cocking, Acceleration. Contact, Deceleration and Finish (Kovacs and Ellenbecker, 2011). The physical demands of the sport place unique demands on the musculoskeletal system. Acute injuries, like ankle sprains, are more frequent in the lower extremity, whereas chronic overuse injuries, like lateral epicondylitis, are more prevalent in the upper extremity in recreational players and shoulder pain is more prevalent in high-level players (Abrams et al., 2012).

According to research, the injuries that occur while playing tennis have been linked to many internal and external factors. The nature and rate of tennis injuries can differ depending on the various surfaces where the sport is played upon and the equipment used in the sport. The three classic surfaces are hard, clay and grass courts. The four Grand Slams are

played on different court surfaces: the Australian Open on Plexicushion Prestige hard courts, Roland Garros on clay courts, Wimbledon on grass courts, and the US Open on DecoTurf hard courts (Anna et al., 2019).

The physical demands of the sports combined with the volume of play can result in musculoskeletal injuries. Numerous studies have reported on the frequency and prevalence of injuries in tennis (Abrams et al., 2012). Tennis involves high aerobic as well as anaerobic energy system requirements throughout the game play (Dines et al., 2015). Tennis matches frequently last longer than one hour, occasionally even longer than five hours (Michael et al., 2010). The rally can last between 6 to 10 seconds, while grass courts and fast courts both have shorter rally times than clay courts do. The length of the rally is substantially longer in the women's game than the men's when professional tennis players are playing on clay (Torres et al., 2011). Different ball speeds and bounces have an impact on the ball-surface interaction, which in turn affects the style of play. Clay is called a sluggish surface because when the ball touches the ground it undergoes a greater friction with the surface, so the speed of the ball gets reduced. On hard courts, the faster the ball travels, the more force is applied to the upper extremity. (Martin and Prioux, 2016). The loading conditions of tennis players are impacted by complex dynamic movements (side jumping, cutting, and braking) (Orendurff et al., 2008). Friction between the shoe and surface is influenced by the intensity of these forces as well as other factors, such as surface roughness (Clarke et al. 2012).

Professional and competitive tennis players nowadays train and compete in different sporting surfaces. Because of the calendar year (Martin & Prioux, 2016). They compete and practice in different surfaces as well (Martin et al., 2011) 210 diverse court surfaces were approved in 2011 by the International Tennis Federation (ITF) (Martin & Prioux, 2016). On each of these surfaces the bounce of the tennis ball is different which may cause a change in game style from the players, and therefore the results (Martin & Prioux, 2016). The ITF classifies field surface into classes by structure and by court speed rating (CPR). Two key boundaries are utilized to decide the properties of CPR: their frictional coefficient and restitution coefficient (Martin & Prioux, 2016). Due to the frictional and stress absorption qualities of these courts, the hard court has a higher injury rate than the clay court (Pluim et al., 2018). The available data which can be used for validation is however opposing the above fact. The proper conditioning for tennis will strengthen the kinetic core and will ensure healthy play while minimizing injuries (Dines et al., 2015). High frictional surfaces cause longer braking and relevant conditioning to reduce the heavy loads on the joints has been proposed. With the greater pace in serves and the other shots of tennis, the loading in the joints of the upper limb increased drastically. Furthermore, the stress in the joints of the lower extremities increased because of the strong flexion and extension of the lower extremity, resulting in both upper and lower limb injuries (Dines et al., 2015).

Therefore, tennis players are vulnerable to several injuries (Dines et al., 2015). Acute injuries appear to harm the lower extremity; the upper extremity is typically implicated with chronic conditions (McCurdie et al., 2017). Several researchers found that lower limb injuries are the most common in tennis, with upper extremity and trunk injuries following in prevalence (Dines et al., 2015). Ankle and thigh are the frequently injured lower extremity joints, whereas the shoulder and elbow are the most damaged upper extremity joints and the lower back is the most injured trunk area. The most frequent forms of injuries, followed by inflammation and sprains, were muscle strains (Dines et al., 2015). The various tactics adopted by Players are likely to impact the occurrence of injuries because of changes in the playing field. Because lower limb injuries account for more than half of all tennis injuries, it is vital to think about what causes them (Pluim et al., 2018). Epidemiological studies have backed up and suggested that surfaces that allow for smooth sliding and slipping have a lesser risk of causing injury. Allowing sliding on the court reduces the strain on the lower extremities.

## OBJECTIVES

Primary objective is to study the incidence and type of injuries across different tennis surfaces. In order to ascertain whether there are any differences in the occurrence of tennis injuries across the four most popular court surfaces among professional athletes. Condition or domain being studied: Any injury that occurred while playing or practicing on the various sporting surfaces of tennis. Participants included all professional and elite adult tennis players. Exposure to the various sporting surfaces (clay, hard, grass and concrete). Injury rates will be calculated for match play, training, and total play, and reported as the number of injuries per 1000 playing hours.

There will be no comparator and the outcome is Upper limb, trunk, as well as lower limb injuries developed during competition and practice across the various tennis surfaces.

## METHODS

### Information sources and literature search strategy

We conducted a literature search to find potentially pertinent articles published after 2010. This systematic review was conducted according to the framework provided in the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-analysis). Using research questions developed in the Patient Problem, (or Population) Intervention, Comparison or Control, and Outcome (PICO) methodology. A computerized English language literature search of the grey literature: The research was done using Google Scholar and electronic databases such as PubMed (MEDLINE), Scopus, Cinahl, and Web of Science. Combinations of Mesh terms were applied, with the aim of identifying hidden studies. Articles are organized using the reference management software package, Rayyan, a web and mobile application for systematic review. The following search syntax, which uses Boolean operators in titles, abstracts, and keywords of indexed articles, was used to find relevant information relating to tennis injuries, epidemiology, and incidence: ("epidemiology\*" OR "incidence" OR "injury incidence" OR "prevalence" OR "injury rate\*" OR "risk factor\*" OR "injury surveillance" AND ("Hip Injuries" OR "Back Injuries" OR "Foot Injuries" OR "Ankle Injuries" OR "Wrist Injuries" OR "Tendon Injuries" OR "Leg Injuries" OR "Knee Injuries" OR "Hand Injuries" OR "Forearm Injuries" OR "Athletic Injuries" OR "Abdominal Injuries" OR "Rotator Cuff Injuries" OR "Shoulder Injuries" OR "Cumulative Trauma Disorders" OR "Anterior Cruciate Ligament Injuries" OR "Reinjuries" was conducted.

### Study selection

Research studies were included if they accessed the incidence rate or prevalence or epidemiology of injuries with relation to different tennis surfaces. If the title and abstract did not provide enough information to determine whether the article was relevant to the review, the entire article was obtained and read. This allowed us to see if the paper met the primary criteria for inclusion. Letters to the editor, conference abstracts, and literature reviews were all excluded from the study.

### Eligibility for inclusion and exclusion

The studies will be selected based on the population, exposure, comparison, and outcomes criteria. All three authors agreed on the inclusion and exclusion criteria. Following the initial study selection process, three authors independently completed a blinded standardized eligibility assessment by screening the titles and abstracts. The literature had to meet the following inclusion criteria to be considered.

### Inclusion and exclusion criteria

To be considered for inclusion in this review, studies had to meet the following inclusion criteria. Articles that met the following criteria were included: (1) Articles addressing incident rate tennis injuries, in relation to various sporting surfaces and activity level in athletes- Recreational/Elite, (2) Study design: Should be primary observational studies and Primary observational studies, Cohort or Descriptive Epidemiological studies usually report incidence rates of injuries. To enable comparison and analysis, these two study designs are selected. Excluding reviews and RCTs (Randomized control trials). (3) Study participants included all

professional and elite adult tennis players, (4) They had to be published in English. As a greater amount of studies has been published in English both the authors understand only that language, articles which are published only in English will be included and (5) Years Considered: January 2010- November 2020- Last 10 years. Only studies published in the last decade were considered because the game of tennis has changed. (6) Published articles, (7) any tennis surface (e.g.: clay, grass, hard and concrete courts) and excluded Injuries reported not in relation to tennis surfaces, (8) Comparison between different tennis surfaces, (9) Must report incidence of injuries (upper or lower extremity or both).

RESULTS

PRISMA chart

After searching five databases, on the search Based strategy, a total of 7196 articles were discovered through Rayyan software (<https://rayyan.ai>) which is formerly (<https://rayyan.qcri.org>). Figure 1 depicts the process of selecting and screening articles in more detail.

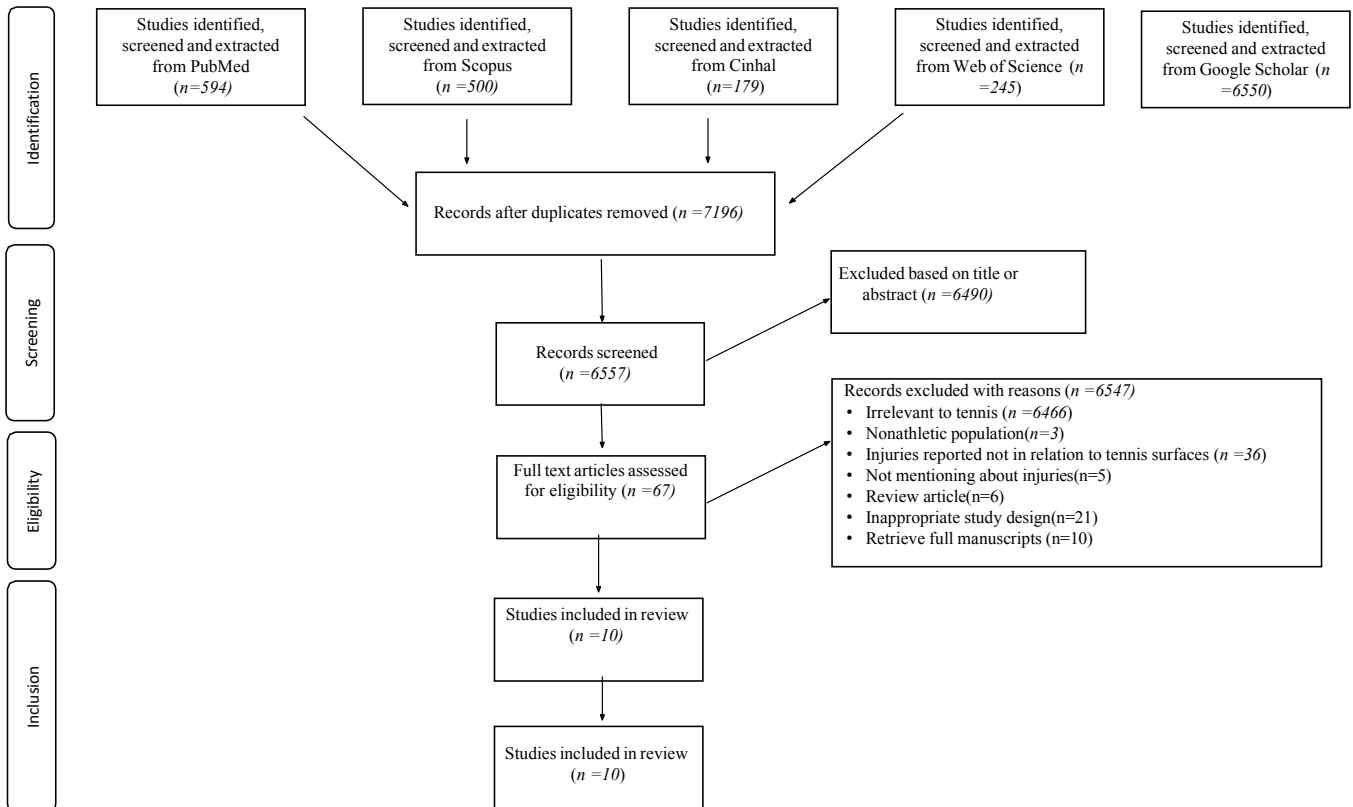


Figure 1. PRISMA flow chart for the article inclusion process.

Data extraction

Data was extracted from the 10 studies. The following data was extracted from the included studies for data extraction: Authors and year of publication (Study ID), DOI, Publication Type (e.g., Journal article, letter, abstract), Country in which study was conducted, Funding Source, Ethical Approval, Reference citation, Type of Study, No. of participants (total number and number of male and female players), Duration of the study, Type of game session, (competitive / practice) name if competitive, Type of surface, Type of Intervention (I), Type of Outcome (O), Description of the Population (From which study participants are drawn), Criteria for inclusion, exclusion, method, and allocation units (individuals/clusters/groups), Age (Mean/Median/ Range), Participant Characteristics (Height, weight and Body mass and other details if mentioned), Aim of the study, Objectives of the study, Sampling Technique, Study Start Date, Study

End Date (if any cohort), In results section mentioned the types of injuries, Incidence of injuries reported, Statistical analysis used and the appropriateness of these methods, analysis method used to measure within group difference and statistical analysis value.

Data collection process

The form for data extraction for each included study that consisted of all the required contents about the context of the study, information on the study design, study methods, Characteristics and size of the sample, source of the study participants, attributes of the exposure, outcome definitions and analyses used. Since this study emphasized on the incidence rate of injuries related to different tennis surfaces was extracted from the individual studies in order to understand the determinants better.

The following is a summary of the study's features. Characteristics and results of included study.

**Table 1**

Summarises the percentage of the incidence of injuries in surfaces.

Study	Incidence Rate	Surface the injury been reported
1	Total of 700 injuries occurred at a rate of 20.7%	Grass Courts (throughout the competition season, switching between surfaces)
2	50% to 65% for men. 60% and 70% for women	Hard, Clay and Grass court
3	Less than 50%	Clay and grass court
4	Men and women are respectively- 80%	Clay and hard courts
5	57% of the injured players	Clay and hard courts

The results of the study indicate that there were few differences in the rate of injury among the four different court surfaces examined: More injuries to lower extremities on hard courts compared to clay, being 56 % and 38 %, respectively. Male athletes, on the other hand, had a higher likelihood to sustain an injury when playing on hard courts than when on the clay ones (Hartwell et al., 2017). The most reported location for males was found to be lower back injuries. The most pervasive injury location for women was the thigh, which included both quadriceps and hamstring injuries.

However, players who played on multiple surfaces had a higher injury prevalence, particularly of overuse injuries, than those who primarily played on one court surface.

Compared with the other court surfaces, there was a higher prevalence of lower limb overuse injuries when playing on hard court (Pluim et al., 2017). This might be because they played more tennis each week, putting more physical strain on their bodies, or because players do not have enough time to become used to new surfaces, which puts more stress on their bodies (different ball bounce and ball speed, different sliding characteristics). Which allow for fast changes in direction and high acceleration and deceleration, are likely to put more pressure on muscles and tendons.

Athletes who played on surfaces that allowed for controlled sliding, such as clay, experienced much lower "pain and injury" compared to athletes who played on surfaces that do not allow for controlled sliding, including concrete. Clay courts have been found to have lower injury rates than hardcourts, which is thought to be due to lesser friction (Starbuck et al., 2015). Women have reported a higher injury rate on courts of clay, when compared to hard courts (Hartwell et al., 2017). In comparison to clay and hard-court sports, trunk injuries are more common on grass courts. Compared to hard courts, clay courts have been reported to have lower injury rates. This is likely because these surfaces have less frictional resistance. The risk of lower back injuries was influenced by the playing surface (Kryger 2014). As opposed to clay courts, hard court surfaces substantially more frequently caused injuries to women. For both women and men, trunk injuries were much more common on grass than on hard courts (Kryger 2014).

**DISCUSSION**

The major goal of the current research was to identify the occurrence and types of injuries that occur across various tennis surfaces. Tennis is a sport in which players perform rapid, intense, and repetitive start-stop motions, direction changes, sprinting, and sliding side-to-side type of movements. Injury rates are impacted by the nature of the sport as well as the impact of different surfaces. The second objective of review

**Table 2**

Summarises the characteristics of the 10 papers included in this study.

Study	The game session type (competitive / practice)	No. of participants/duration of the study	Population	Surface
1	Competitive - Wimbledon	From 2003 through 2012, 10-year span	Elite tennis players	Clay courts
2	Competitive	10 tennis players	Elite tennis players	Clay courts
3	Competitive - The Australian Open, French Open, Wimbledon, US Open	For males, 2001-2012. For women, 2003-2012	Elite tennis players	Hard, grass, and clay courts
4	Competitive	10 (7males, 3 females) Experienced male tennis players	Elite tennis players	Hard, clay, and grass courts
5	Competitive	Records of men's and women's tournament from USTA Pro Circuit of the year 2013	Professional tennis players	Clay, hard
6	Competitive	65 players [40 boys,25 girls]	Elite junior players	Clay and hard court
7	Competitive level	8 tennis players University level (5 males, 3 females)		Hard, clay court
8	Competitive	10 tennis players (9 men, 1 women)	Elite junior players	Clay court
9	Competitive tennis players	7 players (5 males, 2 females)	Elite junior players	Hard court, artificial clay

is to point out which types of injuries are common on various surfaces. The finding of this research indicates the variations in the occurrence of the injuries between the courts. In today's professional tennis season, players must adjust to each court surface within a relatively short period of time, which tests their ability to compete without injury. The lower limb was observed to be the most impacted body component in both sexes, followed by upper limb and trunk (Starbuck et al., 2016). When compared to women, men had an injury rate that was more than twice as high overall and more than triple that of women (Alexis et al., 2016). The existing literature suggests that when compared to clay courts, hard courts were found to be significantly more foreseeable, having higher grasp, higher hardness, and difficulty to slide on (Starbuck et al., 2016). High loading has been linked to hardcourts, especially on the lateral parts of the foot (Damm et al., 2014). This means that the foot is upside-down. Ankle inversion injuries have previously been linked to high degrees of inversion (Kristianslund, Bahr, & Krosshaug, 2011). The researchers discovered that while there were more incomplete matches for women on Australian hardcourts and more for males on US hardcourts, grass had the fewest of them (Abrams et al., 2012). Lower knee flexion angles are claimed to be produced by cutting tasks on high friction surfaces, which increases the risk of anterior cruciate ligament (ACL) injuries (Dowling et al., 2010). Hard court surfaces, which permit rapid changes in movement direction and high rates of acceleration and deceleration, are likely to put more strain on muscles and tendons. Because of the stress placed on the bone, medial tibial stress syndrome (also known as "shin splints") is frequently mentioned and is more prevalent on hard courts (Damm, 2014).

According to studies, injuries to the back, knee, and ankle joints were the most common, and athletes who played on surfaces that allowed for sliding, like clay courts, experienced considerably less pain and injury than those who played on non-sliding surfaces (Damm. et al., 2013).

The coefficient of translational friction on clay courts is lower than on hard courts. As a result, it has been hypothesized that playing on clay could result in lower frictional resistance and a reduction in joint loadings, which lowers the likelihood of lower extremity injuries (Damm. et al., 2013). The clay court has a longer ground contact time (Starbuck et al., 2016). Results from this study show that playing on clay court surfaces increased the risk of injury for women. In a study of tennis injuries, senior tennis players who had spent their career on clay courts as opposed to hard courts reported fewer knee problems (Abrams et al., 2012). Slow courts, on the other hand, are likely to have a greater incidence of muscular strains/spasms due to the lower frictional coefficient, which results in further sliding motions. Several ligament injuries have been observed on the clay and one could say that the high level of inversion during a sole lateral side-shuffle action might cause a sprain on the ankle. Studies reveal that clay-specific adaptations improve player steadiness. On the clay court, higher hallux pressures and lower midfoot pressures were seen, allowing for sliding while maintaining forefoot grip. However, those with more experience on clay courts may lower their risk of injury due to reduced loading from later peak knee flexion (Starbuck et al., 2015). Significant frictional differences between clay and hard court surfaces. As a result of greater horizontal pressures resisting motion, fixing the foot more firmly to the ground has been linked to an increased risk of both ankle and knee injuries. The main element that could cause sliding is the higher peak horizontal loading rate that was measured on clay and was only seen

during the side jump movement (Damm. et al., 2013). Another difference between clay and hard courts is a greater ankle inversion angle during stance (Damm. et al., 2013). Results showed that hard courts required injury care substantially more frequently than clay courts did during matches (Damm. et al., 2013).

On grass, Injuries to the trunks are more prevalent than on clay or hard-court surfaces. Playing on the quicker surface of grass, with a smaller ball bounce and shorter point length, may significantly affect patterns of injury because there is a potential risk of injury when moving from clay to grass. The increased stress felt in the foot on Grass courts can be a possible cause for people playing tennis due to hyper pronation. Moreover, the slipperiness of the court, landing motions or braking actions resulting from side- shuffle movements can result in significant constraint on the musculoskeletal system.

According to research, playing on grass or a hard court increases your risk of needing medical attention compared to playing on clay (Abrams et al., 2012), the risk of injury is the least. Because of the longer braking phase and resulting lower peak force on clay, it may be related to the ability to slide, which has been proposed to be more significant than the cushioning effect of grass for reducing load on the locomotor system of tennis players (Encyclopedia of sports medicine;16).

On the contrary, hard courts have reported higher injury incidences as compared to clay surfaces. Women have reported a higher injury rate on courts of clay, when compared to hard courts (Hartwell et al., 2017). Male athletes, on the other hand, had a higher likelihood to sustain an injury when playing on hard courts than when on the clay ones (Hartwell et al., 2017). The clay courts seemed to have significantly less impact than grass courts or even hard courts. Tennis court surfaces have been identified as a factor which influences the occurrence of injuries. The true impact surface on which tennis is played on injuries is yet unclear. The evidence strongly suggests that the surface is a significant component in injury causation and varying surfaces have been found to have considerably different injury rates.

## CONCLUSION

Overuse injuries are highly prevalent in tennis players at competitions of all levels, according to most of the research. Lower limb difficulties have been found to be approximately equal to or exceeding upper limb symptoms among these injuries. The most affected joints were the back, knee, and ankle. It is possible to successfully treat these frequent injuries by understanding how tennis courts affect the pathophysiology of these conditions. Moreover, tennis-specific prevention programs that aim to lower the risk of injuries. The key finding of this research is that there is no discernible difference between the total injury rate on clay, hard, and grass courts. These findings could then be used to encourage further study into tennis injury rates and prevention, as well as to help create training programs. Hard-court players had a greater rate of lower limb overuse injuries, while players who played on numerous court surfaces had the highest injury rates overall. The use of injury prevention techniques should be directed towards these groups. This study may raise awareness of the suitable footwear required for various court surfaces and emphasizes the significance of effective load control to prevent tennis overuse injuries.

The nature of injuries is something that both coaches and top tennis players should be aware of. The specificity principle of training states that workout plans must be tailored to the physical and mechanical demands of tennis. In this way, when coaches decide on specific training plans for high level tennis players, the court surface should be considered as a vital aspect. Additionally, these data should make it possible to provide players with better continuity of care throughout the competitive season. Opportunities to advance the expertise of clinicians working with tennis players and to create efficient, empirically supported injury prevention strategies may then materialize.

### CONFLICT OF INTEREST AND FUNDING

The author declares that she does not have any conflict of interest and that she did not receive any funding to conduct the research.

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