RISK FACTORS OF INJURY IN TENNIS SERVE AMONG JUNIOR PLAYERS: A SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

Studies of tennis injuries have identified the incidence rate, location and type of injury. Most studies have many perspectives on epidemiology, biomechanics and performance, but few studies have identified the risk factors for injury. Until now, there has been no systematic literature review identifying risk factors for tennis service injuries, especially in junior players.

Purpose: The aim of this study was to identify and critically assess the evidence relating to risk factors for tennis service injuries, particularly in junior players.

Materials and methods: The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) framework. Articles were searched using Google Scholar, PubMed and Scopus.

Results: The results of 9 selected articles revealed risk factors for tennis service injuries in junior players, namely, age and gender, weak muscles or muscle imbalances, racket use, grip on racket grips (hand grip), service technique, previous injury history, duration of training, overuse, and kinetic chains.

Conclusion: It can be concluded that the risk factors for tennis service injuries in junior players are age and gender, weak muscles or muscle imbalances, racket use, grip on racket grips (hand grip), service techniques, previous injury history, duration of training, overuse, and kinetic chains. The study was unable to identify most of the studies that met the criteria, and this was not due to restrictions, but because of poor study quality or no studies addressing the issue. Despite all the risk factors, tennis requires validated workload monitoring methods to examine workload behaviour during practice and matches and to identify potential injury associations. The need for more epidemiological studies of different age and performance groups of players and different skill levels is strongly encouraged and more research is needed to examine the mechanisms behind tennis injuries. Finally, identifying risk factors for service injuries in junior players can be beneficial to doctors, sports scientists and coaches to design exercise strategies and programmes for effective injury prevention, and it can improve performance.

Keywords: tennis, serve, biomechanics, injury, junior

INTRODUCTION

Tennis is a very popular sport in the world. About 25 million people play tennis in the United States, and nearly 10% of people play tennis more than 20 times a year. In Indonesia, tennis is known as an upper middle class sport, but it remains the choice of parents, adults, teenagers, and children. This is an option because it can be done to get a healthy body or achievements (Jatra & Firdaus, 2023)

Tennis continues to develop and improve. These developments and improvements can be seen through technological improvements in rackets, improved practice methods and improved playing styles. This is what causes increased emphasis, speed and strength in the game of tennis (Abrams et al., 2011). Tennis differs from other sports in terms of match duration (exposure), playing surface and equipment (Kibler & Safran, 2005). Tennis can be said to be a repetitive sprint sport, characterised by intermittent attacks and performed with high intensity interspersed with periods of rest (Fernandez et al., 2006). This can lead to injury (Kibler & Safran, 2005).

A tennis player needs a combination of fine and gross motor skills, agility, and strength to perform certain movements, such as serve, ground stroke, and volley (Munson et al., 2020). The success of a tennis player can be determined by several factors, such as physical condition, technical skills and tactical strategies (Delgado-García et al., 2019). One of them is service techniques.

The serve is an important stroke in tennis. A well-trained serve is a great advantage for a tennis player (Girard et al., 2005). Serving is complex and requires good technical and physical skills. The complexity of movement comes from the combination of leg and joint movements required to transmit force from bottom to top through kinetic chains and out into the sphere (Kovacs & Ellenbecker, 2011). Service strokes are improved and trained throughout the player's career process, from beginner to professional level (Whiteside et al., 2013). As a result, this can cause potential injuries to players, one of which is junior and youth players.

Biomechanics plays an important role in the understanding, prevention and management of injuries caused by sports training and competition. Therefore, it is important to analyse the service technique of tennis players in order to explain the risk factors and potential for injury to the junior tennis player's serve. The purpose of this literature review is to collect articles over the past eight years, evaluate service techniques and explain risk factors and potential injuries to serve based on junior tennis player biomechanics. As far as the researchers know, there is still no literature that explains injuries due to serve, specifically reviewed through player biomechanics in junior tennis.

MATERIALS AND METHODS

The design of this study uses the literature review method. A systematic literature review study is a research design using secondary data related to a particular topic. The literature review study aims to conclude the theory from some of the results of previous research. This article review data collection method uses access to Google Scholar, PubMed and Scopus. The literature review data collection stage uses the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow method. The search for research journals is determined on criteria (1) variables according to needs, (2) data collection methods are consistent, (3) research results are measured valid, and (4) data analysis is clearly and precisely defined.

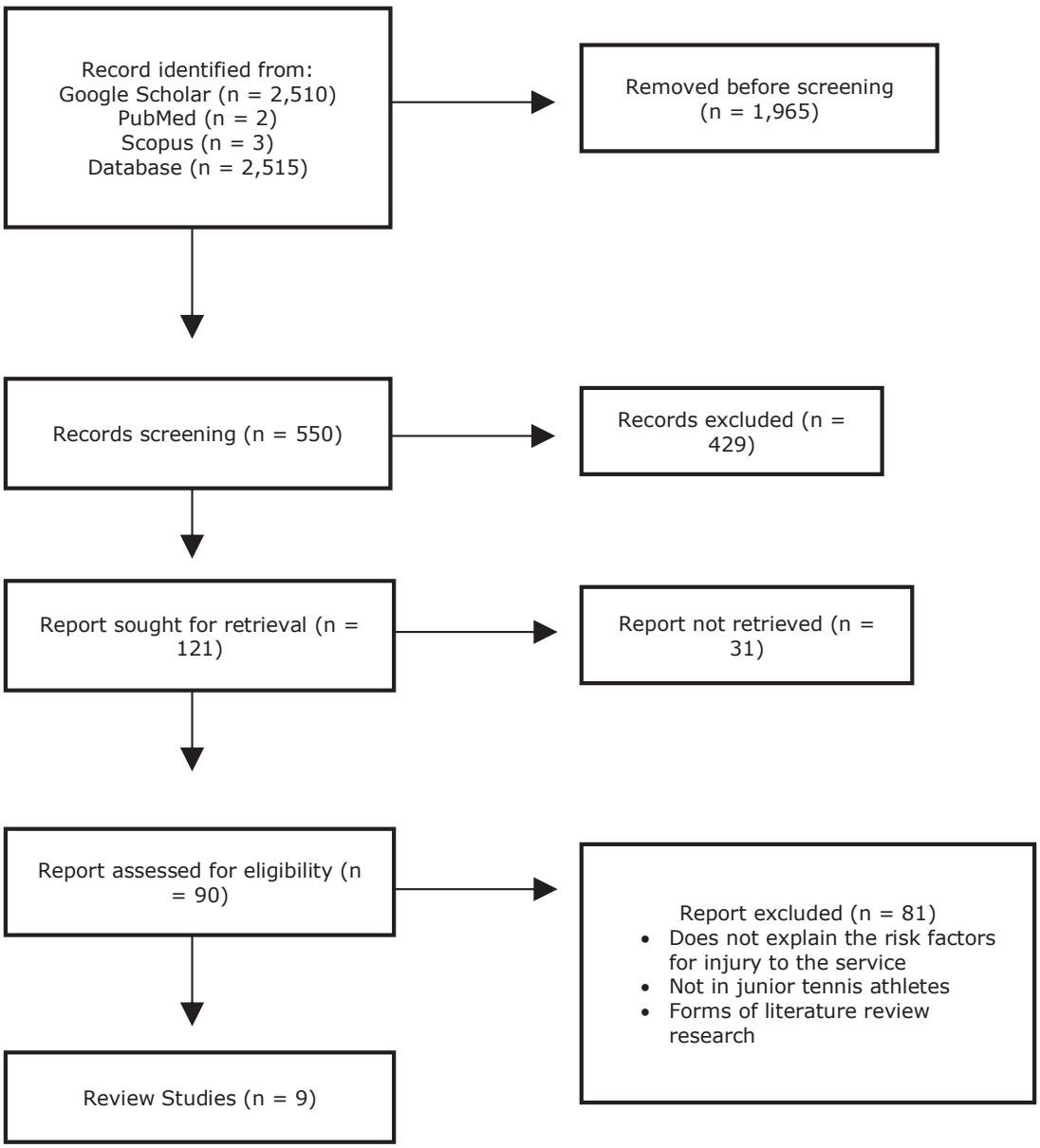
Researchers searched for articles on the topic of biomechanics analysis of injury in tennis serve using databases, Google Scholar, PubMed, and Scopus. Google Scholar, PubMed, and Scopus were chosen because of their ease of access and eligibility to get complete and in-depth articles. In addition, researchers are looking for open access articles so that they can access them for free. Keywords used include tennis, serve, biomechanics, and injury.

The selection of study types is carried out through a screening process and determination of eligibility to be made in the meta-analysis. The selection of studies in this research used several criteria: 1) articles related to tennis, serve, biomechanics, and injury, and 2) published in the last 8 years. Next, the researcher selected all titles and abstracts to check for duplication using the Mendeley application. The search results and the process of selecting articles will be outlined using a flow chart. The 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flowchart was used to summarise the study selection process.

RESULTS

From the search that has been carried out, researchers found 9 journals related to risk factors for tennis service injuries in junior players through biomechanical analysis. In the last 8 years, these journals have been reviewed and obtained a variety of research methods and different results. The following are the authors' names, year, study design, research sample, number of samples, and risk factors for injury.

Figure 1. Literature Search Methods



Author	Years	Design Study	Journal	Risk Factor Injury
Danielle T. Gescheit, Stuart J. Cormack, Rob Duffield, Stephanie Kovalchik, Tim O. Wood, Melanie Omizzolo, and Machar Reid [10]	2019	Prospective Cohort	Journal of Science and Medicine in Sport	Age and Gender
Jaime Fernandez-Fernandez, David Sanz-Rivas, and Alberto Mendez-Villanueva (Fernandez-Fernandez et al., 2019)	2019	Experiment	Plos One	Muscle strength
Pierre Touzard, Chloé Lecomte, Benoit Bideau, Richard Kulpa, Loïc Fourel, Maxime Fadier, Nicolas Cantin, and Caroline Martin(Touzard et al., 2023)	2023	Experiment	Frontiers in Psychology	Using a scaled racket has the advantage of reducing shoulder and elbow loads without compromising service performance.
Kristin Kalo, Lutz Vogt, Johanna Sieland, Winfried Banzer, and Daniel Niederer (Kalo et al., 2020)	2020	A cross-sectional study	BMC Musculoskeletal Disorders	Previous injury history and length of training
Tomáš Vodička, Martin Zvonař, Jiři Pačes, Damir Knjaz, Pavel Ružbarský, and Jiří Zháněl (Vodička et al., 2018)	2018	Comparative	Kinesiology	Muscle imbalance
Pierre Touzard, Richard Kulpa, Benoit Bideau, Bernard Montalvan, and Caroline Martin (Touzard et al., 2019)	2019	Experiment	European Journal of Sport Science	Technique and Hand grip
Christos Mourtzios, Ioannis Athanailidis, Vasilia Arvanitidou, and Eleftherios Kellis ABSTRACT (Mourtzios et al., 2022)	2022	Comparative	European Journal of Sport Science	Kinetic Chain
Nathanial Maraga, Rob Duffield, Danielle Gescheit, Thomas Perri, and Machar Reid (Maraga et al., 2018)	2018	Experiment	International Journal of Performance Analysis in Sport	Overuse during competitions of up to 3 matches in a day
Benoît Gillet, Mickaël Begon, Marine Diger, Christian Berger-Vachon, and Isabelle Rogowski (Gillet et al., 2018)	2018	A cross-sectional study	Physical Therapy in Sport	Previous injury resulted in a lower external/internal glenohumeral muscle strength ratio

An overview of the study identification process is described in Figure 1. In the initial search, we found 2,515 articles consisting of 2,515 articles from Google Scholar, 2 articles from PubMed and 3 articles from Scopus. After going through the selection process, 1,965 articles were automatically deleted and 550 potentially relevant articles were obtained to go through the next selection process. Out of the 550 articles, a total of 429 articles were removed that did not meet the inclusion criteria and a total of 121 articles was found. Out of the 121 articles reviewed through research titles and abstracts, 31 articles were deleted and the remaining 90 articles were worthy of analysis. Out of the 90 articles analysed by researchers, 9 articles were found to be reviewed. The deletion of 81 articles was caused by (1) the article did not explain the risk factors for service injury specifically (2) the sample used was not in accordance with inclusion, namely junior tennis players, and (3) the existing types of research use a more systematic literature review.

DISCUSSION

This study is a systematic review that evaluates the risk factors for tennis service injury in junior tennis players based on biomechanical analysis. A total of 9 risk factors have been investigated, namely, age and sex, weak muscles or muscle imbalance, racket use, grip on the racket grip (hand grip), service technique, previous injury history, duration of exercise, overuse, and kinetic chain.

OVERUSE

Overuse and fatigue are the most common risk factors that can lead to injury. A study reports that the most common injuries are in the knees and shoulders (Acquaye et al., 2020). Playing many matches with limited recovery time can result in accumulated fatigue (Fernandez-Fernandez et al., 2009). Poorly programmed exercise can also lead to excessive use and fatigue (Acquaye et al., 2020). A study explains the physical, physiological and perceptual responses to three tennis matches played for 90 minutes in one day in junior players. This is felt to increase pain and fatigue evidenced by a decrease in internal and external rotation of the shoulder along with a decrease in slowing directional speed (Maraga et al., 2018). It is confirmed that playing tennis for a long time can cause risk factors for upper extremity injuries in tennis players (Moore-Reed et al., 2016). A study reports that playing tennis more than 6 h per week were identified as risk factors for back pain (Hjelm et al., 2012).

In addition, it is explained that the game of tennis can put a high load on the knee, with short movements that are done repeatedly, and this can cause injury to the lower extremities (Abrams et al., 2012). In addition, the shoulder is another part of the body that is often injured. This can be associated with repetitive service movements. The serve is the most difficult and powerful blow, as a result of which repeated use can cause injury (Abrams et al., 2012). Often, the outcome of a competitive tennis match depends on the effectiveness of the serve (Maquirriain et al., 2016). However, the serve will not be effective when the body feels fatigue; a decrease in the external rotation of the shoulder may indicate a change in service kinematics to maintain service speed after several matches on the same day (Martin, Bideau, et al., 2016).

RACKET

The racket is a tool used in the game of tennis. Previous studies reported that racket size, racket grip size, string tension, and proposed use of vibration dampers would have an effect on lateral epicondylitis (De Smedt et al., 2007). The use of racket sizes that are too heavy can overload upper extremities and potentially cause injury to young tennis players (Miller, 2006). In addition, other studies report that racket grips of different sizes can cause changes in the quality of strokes and kinematics of the wrist joint. This can result in poor technique and can increase risk factors for injury (Hatch et al., 2006).

The use of a racket size that is too heavy will burden the upper extremities (Hennig, 2007). The increased racket swing load for junior tennis players will have an impact on decreasing the maximum shoulder internal rotation speed and wrist flexion speed (Whiteside et al., 2014). A study reported that 13% of U-10 players and 61% of U-12 players in an academy suffered injuries during 2 years of tennis practice. The data showed the highest frequency of injuries to the upper extremities, namely the shoulders and elbows (O'Connor et al., 2020). Advice from a study reported that using rackets with a scale of 23 inches has more advantages to reduce shoulder and elbow loads without reducing service performance (ball speed and maximum racket head speed) in junior tennis players with an average age of 9.9 years. This can help junior players avoid the risk of injury that will occur in the long run (Touzard et al., 2023)

TECHNIQUES

Service technique is an important thing to train for junior tennis players. The skill and technique level in tennis has been identified as a risk factor for upper extremity injuries and shoulder strain, especially during serves and smashes that are directly related to a player's skill level. Professional tennis players can place a lower burden on the kinetics of the shoulder joint, thereby reducing the percentage of shoulder, elbow or wrist injuries (Martin et al., 2013).

The impact of tennis on shoulder flexibility, specifically the internal rotation of the shoulder has been

investigated. Both studies revealed that tennis players showed significant changes in the dominant nature of shoulder rotation (Cools et al., 2010; Kibler & Chandler, 2003). Another study identified waiter's serve in the upper body loading phase as a pathomechanical one that occurs in junior tennis athletes. Higher loads on upper extremity body parts on the waiter's serve will result in overuse injury (Touzard et al., 2019).

The injury directly related to the waiter's serve is an elbow injury. This can be seen through the grasp of the player's racket (Touzard et al., 2019). Lateral epicondylitis injury or "tennis elbow" injury is identified as one of the injuries caused by excessive use, especially in young tennis players (De Smedt et al., 2007). So, a coach needs to be careful and pay attention to good and correct service techniques to avoid mistakes and injuries to junior tennis players.

PREVIOUS INJURY HISTORY

A history of previous injuries is associated as one of the most common and frequent intrinsic factors in sports (Bahr & Krosshaug, 2005). A study reports range of motion (ROM) deficits often occur in athletes who were previously injured (Johnson et al., 2018). A systematic review revealed that tennis players who had shoulder injuries showed altered shoulder kinematics and higher shoulder kinetics, compared to players with no injury history (Martin, Kulpa, et al., 2016). Loss of glenohumeral internal rotation in young tennis players is due to increased training and a history of injuries (Kalo et al., 2020). A finding in the study explained that players with a history of shoulder injuries have a higher ratio of external and internal glenohumeral rotation as well as rotator muscle imbalances (Gillet et al., 2018).

Changes resulting from injury to the lower extremities have the potential to result in future injury (Fulton et al., 2014). Previous ACL reconstruction is a risk factor for ACL injury in several prospective studies (Waldén et al., 2006). Players with a history of ACL reconstruction had a higher incidence of new knee injuries of any type, compared with players without a history of ACL injury (Waldén et al., 2006). A finding in the study explained that a previous injury regardless of body location was found to be an injury risk factor (Hjelm et al., 2012) and can cause excessive injury (Giroto et al., 2017).

AGE AND GENDER

Increasing age and changes in upper body performance have been studied extensively in the past. A study explained that male U-15 years had better strength when compared to male U-13 and female U-13 and U-15, but the results showed that the decrease in the range of motion (ROM) in male U-15 coincided with a higher and specific internal rotational bilateral deficit, compared to male U-13 and female U-13 and U-15 (Fernandez-Fernandez et al., 2019). However, the decrease in the range of motion (ROM) has nothing to do with age; it is more related to the length of exercise (Kalo et al., 2020).

A study that conducted a comprehensive and longitudinal examination of the incidence and severity of injuries in junior tennis players reported that, with age, the number of injuries suffered by players also increased (Gescheit et al., 2019). Injuries suffered by male junior players have a higher severity than those of female junior players (Gescheit et al., 2017). The increased incidence of injuries in junior players is generally experienced at the age of 13-15 years (Van Der Sluis et al., 2015), where at this age, there is physical growth, an increase in the volume and intensity of training and an increase in the intensity of matches. This increased load is associated with injury risk factors (Myers et al., 2016).

KINETIC CHAIN

Service movements are very complex multi-joint movements that require good muscle coordination and special skill development. Good service can be determined by complex interactions with several factors, including the maximum force that can be generated by the muscles involved and their joints. Most of the force exerted at the time of service comes from the muscles of the lower extremities (Komi & Nicol, 2010). One study explains that junior tennis players need to strengthen their ankle and knee joints during the loading phase of serve, when trying to serve slice and top spin (Mourtzios et al., 2022). In addition, a study explains and evaluates service biomechanics and provides a kinetic chain review of the three types of services, namely, flat serve, slice serve and top spine serve. It is explained that the top spine service has a greater potential for injury to the back and shoulders (Abrams et al., 2011).

After going through the kinetic chain process in the lower extremity muscles, the energy is transferred through the abdominal muscles to the shoulder. The scapula plays a very important role; it converts the potential energy developed in the legs and body into kinetic energy in the upper extremities when the ball is hit. Scapula dyskinesis involving pathological movements and position of the scapula is a common breaking point in the kinetic chain and has been implicated in successive injuries (Saini et al., 2020).

MUSCLE STRENGTH

Muscular strength is one of the most important components of physical performance in sport, in terms of both high-level performance and injury occurrence (Lehance et al., 2009). Muscle weakness can have an impact on tennis service injuries. Tomáš Vodička (2018) explains that the incident aspect of injury can arise as a result of shoulder instability (Vodička et al., 2018). Ellenbecker and Roetert (2003) tried to define the ratio between external and internal rotational force levels, and recommended a ratio of external and internal rotator strength of 66-75% for competitive elite tennis players (Ellenbecker & Roetert, 2003). If the number is close to 50%, it may be said to be a high risk of injury related to shoulder joint instability (Vodička et al., 2018). A study reported that preseason weakness of external rotation and supraspinatus strength is associated with in-season throwing-related injury resulting in surgical intervention in professional baseball pitchers (Byram et al., 2010).

The suggestion of a study explains the need to focus on strengthening the external rotator (concentric and eccentric modes) and internal rotator (eccentric mode) to provide stability to the head of the humerus during upper extremity movement in athletes who do overhead. The importance of giving training weights must be emphasised optimally, considering the frequency of matches and the intensity of training is getting higher and can predict injuries (Tooth et al., 2020). A finding of a study explains that a short-term training programme for young tennis players, using minimum equipment and effort, can result in improved tennis performance (i.e., serve velocity) and a reduction in the risk of a possible overuse injury, reflected by an improvement in shoulder external/internal range of motion (Fernandez-Fernandez et al., 2013).

CONCLUSIONS

From all the explanations above, it can be concluded that the risk factors for tennis service injuries in junior players are age and gender, weak muscles or muscle imbalances, racket use, grip on racket grips (hand grip), service techniques, previous injury history, duration of training, overuse, and kinetic chains. The study was unable to identify most of the studies that met the criteria, and this was not due to restrictions, but because of poor study quality or no studies addressing the issue.

Despite all the risk factors, tennis requires validated workload monitoring methods to examine workload behaviour during practice and matches and to identify potential injury associations. The need for more epidemiological studies of different age and performance groups of players and different skill levels is strongly encouraged and more research is needed to examine the mechanisms behind tennis injuries. Finally, identifying risk factors for service injuries in junior players can be beneficial to doctors, sports scientists and coaches to design exercise strategies and programmes for effective injury prevention, and it can improve performance.

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FAKTORI RIZIKA OD POVREDA PRILIKOM IZVOĐENJA TENISKOG SERVISA KOD JUNIORA: SISTEMATSKI PREGLED I META-ANALIZA

SAŽETAK

Istraživanja teniskih povreda su identifikovala stopu incidencije, lokaciju i vrstu povrede. Većina studija iskazuje stanovišta o eipdemiologiji, biomehanici i efikasnosti, ali malo njih identifikuje faktore rizika od povreda. Do sada se nije proveo sistematski pregled literature koji identifikuje faktore rizika od povreda prilikom izvođenja teniskog servisa. a posebno kod juniora.

Svrha: Cilj ove studije je identifikovati i kritički procijeniti dokaze koji se odnose na faktore rizika od povreda prilikom izvođenja teniskog servisa, a posebno kod juniora.

Materijali i metode: Sistematski pregled je proveden u skladu sa PRISMA okvirom - Preferirane stavke izvještavanja za sistematske preglede i meta-analize. Pretraga radova je izvršena korištenjem Google Scholar, PubMed i Scopus baza.

Rezultati: Rezultati odabranih 9 radova su otkrili faktore rizika od povreda prilikom izvođenja teniskog servisa kod juniora, i to: dob i spol, slaba muskulatura ili mišićna neravnoteža, korištenje reketa, stisak drške reketa (stisak ruke), tehnika serviranja, historija povreda, trajanje treninga, prekomjerna upotreba i kinetički lanci.

Zaključak: Možemo zaključiti da su faktori rizika od povreda prilikom izvođenja teniskog servisa kod juniora dob i spol, slaba muskulatura ili mišićna neravnoteža, korištenje reketa, stisak drške reketa (stisak ruke), tehnika serviranja, historija povreda, trajanje treninga, prekomjerna upotreba i kinetički lanci. Istraživanje nije moglo identifikovati mnogo studija koje ispunjavaju kriterije, a razlog tome nije bio zbog ograničenja, nego zbog loše kvalitete studija ili nedostatka studija koje se bave ovim pitanjem. Uprkos svim faktorima rizika, tenis zahtijeva potvrđene metode monitoringa opterećenja kako bi se isto ispitalo tokom treninga i mečeva te identifikovale potencijalne povezanosti sa povredom. Potreba za više epidemioloških studija različitih dobnih grupa igrača i različitih nivoa vještina se ohrabruje te je potrebno više istraživanja koja ispituju mehanizme teniskih povreda. Na kraju, identifikovanje faktora rizika od povreda prilikom izvođenja servisa kod juniora može biti korisno za doktore, sportske naučnike i trenere kako bi dizajnirali trenažne strategije i programe za efektivnu prevenciju povreda uz poboljšanje efikasnosti.

Ključne riječi: tenis, servis, biomehanika, povreda, junior

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