

Effects of strength training on ankle injuries in soccer players: a systematic review Efectos del entrenamiento de fuerza en lesiones de tobillo en futbolistas: una revisión sistemática

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Abstract. Purpose: The purpose of this systematic review was (I) to determine the quality of evidence from studies evaluating the effects of strength training on the incidence of ankle injuries in soccer and (II) to determine the effectiveness of strength training on the incidence of ankle injuries in soccer. Methods: Preferred Reporting Items for Systematic Reviews (PRISMA) statements were considered using keywords associated with ankle injuries, strength training, and soccer. The following four databases were used: PubMed, Web of Science, Scopus, and SPORTDiscus. The quality of evidence for the articles included in this review was assessed using the PEDro scale. Results: Of the 721 articles retrieved, two were included in this study. The total population included in the review was 132 male participants, including professional soccer players and youth players. Strength training in young soccer players could reduce the risk of injury and improve parameters related to sports performance; however, the two articles included in this review found no statistically significant differences in injury incidence between the proprioceptive training and control groups. Conclusions: The articles included in this review had a high risk of bias, indicating low quality of evidence. In addition, it was impossible to determine whether strength training effectively reduced ankle injuries in the soccer players.

Keywords: Sports, ankle sprains, athletic injuries, resistance training

Resumen. Propósito: El propósito de esta revisión sistemática fue (I) determinar la calidad de la evidencia de los estudios que evalúan los efectos del entrenamiento de fuerza sobre la incidencia de lesiones de tobillo en el fútbol y (II) determinar la efectividad del entrenamiento de fuerza sobre la incidencia de las lesiones de tobillo en el fútbol. Métodos: Se consideraron las declaraciones Preferred Reporting Items for Systematic Reviews (PRISMA) utilizando palabras clave asociadas con lesiones de tobillo, entrenamiento de fuerza y fútbol. Se utilizaron las siguientes cuatro bases de datos: PubMed, Web of Science, Scopus y SPORTDiscus. La calidad de la evidencia de los artículos incluidos en esta revisión se evaluó mediante la escala PEDro. Resultados: De los 721 artículos recuperados, dos fueron incluidos en este estudio. La población total incluida en la revisión fue de 132 participantes masculinos, incluidos jugadores de fútbol profesionales y jugadores juveniles. El entrenamiento de fuerza en jóvenes futbolistas podría reducir el riesgo de lesión y mejorar parámetros relacionados con el rendimiento deportivo; sin embargo, los dos artículos incluidos en esta revisión no encontraron diferencias estadísticamente significativas en la incidencia de lesiones entre los grupos de entrenamiento propioceptivo y control. Conclusiones: Los artículos incluidos en esta revisión tuvieron un alto riesgo de sesgo, lo que indica baja calidad de la evidencia. Además, fue imposible determinar si el entrenamiento de fuerza reducía efectivamente las lesiones de tobillo en los jugadores de fútbol.

Palabras clave: Deportes, esguinces de tobillo, lesiones deportivas, entrenamiento de fuerza.

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Introduction

Ankle injuries are one of the most common and frequent injuries in soccer (Kolokotsios et al., 2021; Larruskain et al., 2018; Valderrábano et al., 2014), reaching on many occasions, more than 50% of the injuries reported by soccer players (Sghir et al., 2021), for example, in Major League Soccer (MLS) 1210 (12.5%) ankle injuries were found between 2014 to 2019 (Forsythe et al., 2022). Gulbrandsen et al. (2019) in an analysis of the behavior of ankle injuries in soccer players of the National Collegiate Athletic Association (NCAA), reported that the four most common injuries of the ankle joint complex were: tears of the lateral ligament complex, sprains of the tibiofibular ligament, contusions and ruptures of the medial ligament, where sprains of the tibiofibular ligament generated a disability of more than 30 days (Gulbrandsen et al., 2019). On the other hand, lateral ankle injuries can reach up to 928 euros per player (Nouni-García et al., 2019), with an estimated 3–9 injuries per 1000 h of competition (Nery et al., 2016).

Soccer is an intermittent sport that alternates low and high-intensity efforts, in addition to the tactical role and

playing a position that determines kinematic variables such as total distance covered at different intensities, maximum speed, total impacts, accelerations and decelerations; generating efforts that require specific and individualized training (Akyildiz et al., 2022; Dellal et al., 2012; Morera-Barrantes et al., 2021; Raya-Gonzalez et al., 2022), where strength work can develop physiological adaptations that can contribute to the improvement of muscle function, neuromuscular qualities, increase in the strength-velocity ratio, increase in acceleration and maximum speed in sprinting (Silva et al., 2015).

It is essential to note that injuries have a negative influence on athletic performance; for example, players who suffer moderate to severe injuries considerably reduce playing time, achieve maximum speed, and increase the distance of high-intensity runs (Dellal et al., 2012). Lu et al. established that the higher the incidence of injuries, the higher the number of games lost and, therefore, the lower the score during the season (Lu et al., 2021). Additionally, a lower injury burden generates greater availability of players for matches, increasing the number of points obtained in national leagues. The teams present a higher club coefficient per season, increasing the chances of success in

the Champions League or the UEFA Europa League (Häglund et al., 2013).

On the other hand, the dynamic interaction of the different risk factors that cause injuries in the lower limbs has generated sports professionals to include preventive and injury risk control measures in the training processes, thereby promoting the sports health and performance of soccer players (Webster & Hewett, 2018). However, as stated by Crossley et al. (2020) in their systematic review, injury reduction rates have not been successful when the implemented programs include only a single component or present heterogeneity in preventive strategies.

However, among the practices implemented to reduce injury risk, strength training programs have been considered, which have shown that an appropriate combination of training methods (strength training, eccentric training, plyometric training) can reduce the incidence of lower limb injuries (Beato et al., 2021) and can also improve ankle strength (Hall et al., 2015), balance, and functional performance in people with chronic instability (Hall et al., 2018).

In soccer, it has been demonstrated that the implementation of strength training favors the integral development of the player's capacity; however, for the effects to be produced, adequate management of workloads is indispensable because these play a key role in the biomechanical and neuromuscular adaptations in the performance and prevention of sports injuries (Beato et al., 2015; Beato et al., 2021; Menezes et al., 2018). Although the importance of strength in prevention and intervention programs is known, there is no analysis in the literature to establish the effectiveness of strength training programs on the incidence of ankle injuries in soccer. Therefore, the objectives of this review are to (I) determine the quality of evidence of studies evaluating the effects of strength training on the

incidence of ankle injuries in soccer and (II) determine the effectiveness of strength training on the incidence of ankle injuries in soccer.

Materials and methods

Experimental Approach to the Problem

The Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines were used (Page et al. 2021). The protocol of this review was registered in the International Platform of Registered Systematic Review and Meta-analysis Protocols (INPLASY) (INPLASY202260093).

Search strategy

Two authors (AV-H and DJ-M) performed this search. The PubMed, Web of Science, Scopus, and SPORTDiscus databases were used. The initial search was conducted from April 06, 2022, to April 17, 2022. The following keywords were included: "futsal," "soccer," "indoor soccer," "five-a-side soccer," "street soccer," "street football," "resistance training," "strength training," "resistance exercise," "strength exercises," "muscle strength," "ankle," "ankle sprain," "ankle fracture," "ankle Injuries" and "ankle injury." These search terms were combined using two Boolean operators (AND/OR). In addition, the bibliographies of previous related reviews and the selected studies were examined to search for new studies. In addition, a manual search of the reference lists included in the selected studies was performed.

Eligibility criteria

The specific criteria for inclusion and exclusion are listed in Table 1.

Table 1.
Inclusion criteria and exclusion criteria

Criteria	Type	Definition
Inclusion Criteria	Study	Randomized Controlled Trial (RCT)
	Participants/Population	professional soccer players, amateur soccer players, and young soccer players.
	Intervention	strength training, without combining it with other types of exercise.
	Comparison/Control	Another training program in soccer players or in a control group.
Exclusion Criteria	Outcome	Incidence of an ankle injury
		Studies that used ergogenic drugs or aids
		Conference presentations, theses, books, editorials, review articles, and expert opinions
		Missing full text or incomplete data on outcome indicators.

Screening process

The articles retrieved from the initial search were entered into the Rayyan QCRI application, an app that assists in the article selection process, optimizes evaluation time, and allows collaborative work (freely available at <http://rayyan.qcri.org> (accessed April 06, 2022) (Ouzzani et al., 2016) (Ouzzani et al., 2016). Duplicate references have been eliminated. Next, two independent investigators (AV-H and DJ-M) reviewed the titles and abstracts to identify relevant articles for the systematic re-

view. Next, full-text reading of these articles was performed to assess eligibility criteria, and finally, the reference list was checked for suitable articles to include.

Data collection process

Data extraction was performed by two independent researchers (AV-H and DJ-M), which were related to article identification (authors, country, and year of publication), participant characteristics (age, sex, professional soccer players, amateur soccer players, young soccer play-

ers), and strength training protocols (protocol exercise, duration, training frequency, intensity, volume, and rest between sets). In addition to the variables under study, the main results were missing data.

Studies risk of bias assessment

The quality of evidence for the articles included in this review was assessed using the PEDro scale. This scale is based on criteria that allow us to identify whether the RCTs have sufficient internal validity and statistical information to interpret the results (external validity (item 1), internal validity (items 2-9), and statistical reporting (items 10-11)). Each item was classified as yes or no (1 or 0, respectively) according to whether the criterion was met in the study. The total score considers items two to 11; hence, the maximum score was 10 (Cashin & McAuley, 2020). Two independent researchers (AV-H and DJ-M) evaluated the articles using this scale. In cases of discrepancy, a third evaluator (LJC-R) was consulted. After this evaluation, the available articles in the PEDro database (<https://search.pedro.org.au/search>) were assessed. Concerning the quality of evidence, scores < 4 are considered poor quality, 4–5 are considered moderate quality, 6–8 are good, and 9–10 are excellent (Cashin & McAuley, 2020).

Results

Article Selection

The initial search yielded 721 articles, of which 224 were excluded as duplicates. All articles that presented

ankle strength training included control groups. Therefore, the number of articles that included achieving the objectives (I and II) was the same. After evaluating the titles and abstracts, 492 articles were excluded because they did not meet the inclusion criteria, leaving five studies (Farshid, 2007; Zouita et al., 2016; Wang et al., 2021; Lauersen et al., 2018; Vriend et al., 2016) for full-text analysis (Figure 1).

Of the five selected articles, when the full text was read and analyzed, three of these manuscripts were not considered because they presented incorrect outcomes, which did not allow the objectives of this review to be achieved.

Characteristics of the included studies

Table 2 shows the characteristics of the studies included in this review. One study (Zouita et al., 2016) performed progressive strength training for 12 weeks, dividing the program into three phases: familiarization phase, progression phase 1, and progression phase 2. The periodization of the training started with a 2-week familiarization phase, with three training sessions per week. The strength training and control groups were evaluated at the beginning of the study, in the middle of the intervention period, and at the end of the study. In terms of injury incidence, this study evaluated the injury rate during the season (Zouita et al., 2016). Each team's medical staff recorded the type, location, and severity of the injuries. This study also determined anthropometric and physical characteristics, and training and match exposure.

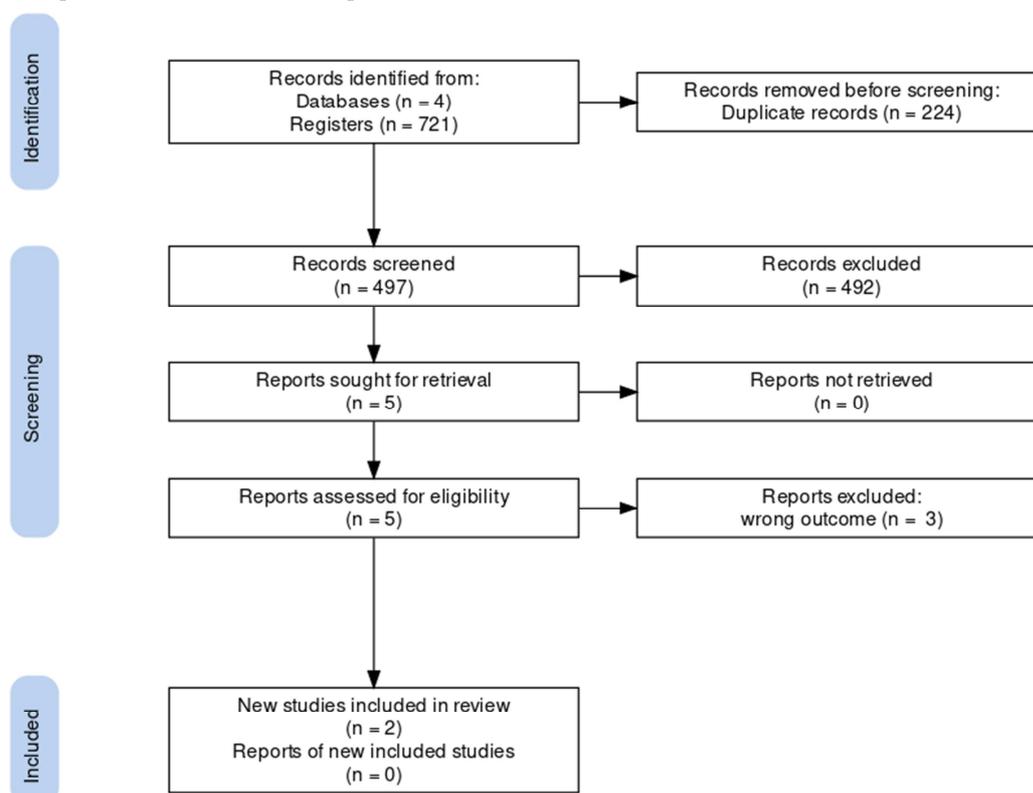


Figure 1. Flow chart for the systematic review

Table 2.
Characteristics of the included studies

Author/Year	Country	Participant Type	Age	Gender	Experimental group size (n)	Control Group size (n)	Protocol exercises	Duration (weeks)	Training frequency (days/week)	Intensity	Sets/repetitions	Measured outcome
Farshid M. (24)/2007	Iran	Professional soccer players	24,6 (DE±2.63)	Male	STG: 20	PTG: 20 OG: 20 CG:20	Strength training for ankle eversion 1. isometric exercises 2. dynamic resistance exercises with weights on the ankles and resistance bands	119	1	Controlling the time that a maximal contraction was maintained ensured that the targeted musculature was being maximally loaded in a pain-free arc.	10 sets of 20 repetitions, with a hold duration of 9 seconds.	Injury incidence (%)
Zouita S, et al. (25)/2016	Tunesia	Young soccer players	13 to 14	Male	STG: 26	26	Progressive resistance training is divided into 3 phases: Familiarization phase: exercises with simple low load (50–60% of 1 repetition maximum [1RM]). Phase 1: The training load was approximately 30–50% of 1RM (15–20 repetitions) and was increased and progression every 2 weeks to maintain the 70% level. Phase 2: 6 weeks interspersed with a 1-week recover of high-intensity resistance training, with 3 training sessions a week, focusing on maximum strength and power gains. The players increased the training load to 80% of 1RM in some of the multiple-joint exercises.	12	3	50–80% of 1 repetition maximum [1RM]	At every training session, the players noted the number of sets, reps, and training load for each exercise in a training diary	Injury incidence (%)

On the other hand, Farshid's (2007) study was performed on soccer players of a first-division league who presented with an inversion sprain of the right or left ankle but without any other injury in the lower limbs. The subjects were randomly assigned to four study groups: strength training, proprioception training, orthosis, and control. The strength training group performed a specific strength program for the evert muscles and the training introduced isometric exercises with progression to dynamic resistance exercises with ankle weights and resistance bands. For the measurement of injury incidence, the study reported the number, incidence (injury/1000 h of play), and relative risk of injury (95% confidence interval) of ankle sprain in the four groups (Table 2).

Methodological quality and risk of bias

In this review, 21 items (95%) were assessed by agreement between the two reviewers, and the other item was assessed by agreement (Table 3).

Table 3.
Methodological quality of the studies included

Studies	Items											Total PEDro	Total Score Quality
	1	2	3	4	5	6	7	8	9	10	11		
Farshid M.	1	1	0	1	0	0	0	1	0	1	1	5	Moderate Quality
Zouita S, et al.	1	1	0	1	0	0	0	1	1	1	1	7	Good

Items considered for rating: 1. Eligibility criteria were specified (This item is not used to calculate the PEDro score.); 2. Subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received); 3. Allocation was concealed; 4. The groups were similar at baseline regarding the most important prognostic indicators; 5. There was blinding of all subjects; 6. There was blinding of all therapists who administered the therapy; 7. There was blinding of all assessors who measured at least one key outcome; 8. Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups; 9. All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by "intention to treat"; 10. The results of the between-group statistical comparisons are reported for at least one key outcome; 11. The study provides both point measures and measures of variability for at least one key outcome.

Effect of strength training on the incidence of ankle injury

Regarding the incidence of an ankle injury, the results of the research (Zouita et al., 2016) showed that one of the most frequent injuries during the season for the control group was an ankle injury in three injured soccer players, while the strength training group reported only one athlete with an ankle sprain. However, the total injury rate, severity, and absence of training were presented as overall data for lower limb injuries.

Meanwhile, Farshid (2007) reported the incidence (injuries/1000 hours of play) and the relative risk of injury (95% confidence interval [CI]) of ankle injuries by inversion, where it was found that the strength training group presented 4 (20 %) ankle sprains, with an incidence of 0,5 with a CI of 0,11-1,87; on the other hand, the proprioception training group reported 4 (5 %) ankle sprains, with an incidence of 0.13 with a CI of 0,003-0,93; while in the orthosis group, 2 (10%) ankle sprains were found, with an

incidence of 0,25 with a CI of 0,03-1,25; finally, the control group reported 8 (40%) ankle sprains, with an incidence of 0,12-1,91 with a CI of 0,12-1,91.

This study also established that the incidence of ankle sprains in players in the proprioception training group was significantly lower than that in the control group (relative risk of injury [RR], 0,13; 95% CI, 0,003-0,93; P = .02). However, the results for the strength and orthosis groups compared with the control group were not significant (RR, 0,5; 95% CI, 0,11-1,87; P = 0.27 for strength; RR, 0,25; 95% CI, 0,03-1,25; P = 0,06 for the orthosis group) (Farshid, 2007).

Discussion

The present systematic review was designed to (I) determine the quality of studies evaluating the effects of strength training on the incidence of ankle injuries in soccer and (II) determine the efficacy of strength training on the incidence of ankle injuries in soccer. The main results of these studies were that: strength training in young soccer players could reduce the risk of injury and improve parameters related to sports performance (Zouita et al., 2016). The main conclusion of this review was that the articles included had a high risk of bias, indicating a low quality of the evidence used. Furthermore, in the two articles included in this review, no statistically significant differences were found for strength training in reducing the incidence of ankle injuries with respect to the proprioceptive training group and the control group.

On the other hand, studies such as that of Menezes et al. (2018) reported a reduction of injuries from 33.3% to 20.4%, performing an intervention twice a week in U-20 soccer players (Menezes et al., 2018). It was also found that in patients with recurrent ankle injury, a strength program for 5 days was adequate for the improvement of eversion and dynamic balance, although it should be noted that patients who underwent balance training reported better results (Wang et al., 2021). Considering the previous results (Wang et al., 2021), which likewise presented better results in the proprioceptive training group, likewise, and despite finding a reduction in ankle injuries between the strength training group and the control group, this result was not significant; instead, the proprioceptive training group reported a statistically significant change in the incidence of ankle injuries (Farshid, 2007).

Likewise, it has been mentioned that, to improve functional outcomes in patients with chronic ankle instability, it is necessary to implement strength training and proprioceptive neuromuscular facilitation (Hall et al., 2015). Furthermore, to prevent ankle injuries, a key element of preventive programs is balance training, although it is important to note that these multicomponent programs often have positive effects on the ankle joint. However, the implementation of strategies based on the strength component can reduce the overall injury risk by 66%, with an average intervention time of eight months; how-

ever, the preventive effect depends on volume, intensity, rest time, speed of execution, and frequency of intervention, as well as on strength programs specific to the context of the sport and population (Lauersen et al., 2018).

Regarding the planning of training for this capacity, the program was divided into three phases (Zouita et al., 2016), which translates to the evidence on optimal prevention strategies developed by Vriend et al. (2016), which recommends the use of the familiarization and technique phase, which contributes to the gradual conditioning of tissues, better technical and psychological preparation, and decreases the occurrence of overload injuries. Additionally, single-component strategies have been reported to have a significant preventive effect on ankle sprains; however, the results of multicomponent training are not conclusive, a situation that should be taken into account to continue developing research to establish the preventive value between single-component programs, such as strength and proposals with several components.

On the other hand, the number of sessions per week can influence the achievement of the objectives in strength training; the studies included in this review performed one session per week (Farshid, 2007) and three sessions per week (Zouita et al., 2016). It has been established that the number of strength sessions may vary depending on the stretch of the season, considering that at least two sessions of strength work should be included in the preseason, although a single strength session is sufficient (Beato et al., 2021).

Regarding the intensity of the load, the percentage of 1RM was used to carry out the progression of the load (Zouita et al., 2016). This strategy has been one of the most commonly used for the control of strength training; however, this practice has the disadvantage of not being dynamic and does not consider variations such as sleep, fatigue, stress, and nutrition, which are factors to be considered in the daily variation of RM (Suchomel et al., 2021; Lopes Dos Santos et al., 2020).

Another aspect related to the load dosage is the rest during the session; however, neither of the two studies (Farshid, 2007; Zouita et al., 2016) reported recovery intervals. In this sense, total work during the session can be affected by short recovery times, which affects the effectiveness and efficiency of training (Andrade-Paz et al., 2020). In turn, rest intervals of 1,5 minutes to 3 min can produce greater adaptations of maximal strength, hypertrophy, and power compared to rest periods between 0,5 to 1 min; therefore, the time periods should not be overlooked at the time of prescribing strength training (Suchomel et al., 2018).

It is also important to highlight that the study conducted by Zouita et al. (2016) involved young soccer players. Regarding strength training in this population, Zwolsky et al. (2017) pointed out that training in this capacity reduces the incidence of injuries by up to 68 %, and it is necessary to implement preventive measures based on strength, as they not only reduce the risk of injury in young people but

also improve physical condition, performance, and well-being (Zwolski et al., 2017; National Committee of Sports Medicine for Children and Adolescents, 2018; Stricker et al., 2020).

However, mechanical instability of the ankle is related to muscle strength deficit, which in turn is linked to a higher risk of ligament injury in the ankle (How et al., 2020). This has led to an increase in the use of strategies focused on strength training and proprioception, which are the most commonly used in prevention programs (Wang et al., 2020). However, the heterogeneity of the studies and the lack of generalization and reproducibility of variables such as load, speed of execution, type of exercise, frequency, intensity, and duration of training have generated the need for more research on higher quality and precision in the planning, organization, and prescription of exercises in programs for the control and mitigation of injury risk (Brunner et al., 2019).

Similarly, strength training in young people can reduce the residual effects of ankle injury (Cain et al., 2020), improve metabolic profiles, reduce the risk of obesity, prevent the onset of non-communicable diseases, and improve mental health (Falk & Dotan, 2019), demonstrating the importance of developing strength-based programs to promote the overall health of young athletes.

This review could not determine whether strength training was effective in reducing ankle injuries in soccer, which can be explained by the low number of randomized clinical trials that analyzed the incidence of ankle injury through strength training. In addition, we found low methodological quality in the selected articles; however, this study is the first systematic review that establishes the need for research involving strength training and compares it with other work methods to determine the behavior of ankle injury. Additionally, it allowed us to know some aspects and variables of strength training planning used by the selected articles to establish their effect on the incidence of injury.

Different methods of strength training, such as traditional resistance exercises, weightlifting, ballistic and plyometric exercises, or a combination of these, require a methodology based on the needs and context of soccer (Kalaycioglu et al., 2020). Strength training has been related to better performance of the evertors and invertors of the foot, which is related to a decrease in the risk of ankle injury (Keles et al., 2014). Meanwhile, an isokinetic exercise program of the evertors and dorsiflexion of the ankle in a combined eccentric-concentric mode showed that after 6 weeks of this work, the reaction times of the peroneal and tibialis anterior muscles were reduced, which may also benefit the joint (Raya-González & Sánchez-Sánchez, 2018).

Conclusions

In conclusion, few studies were related to the main topic of this review, such as the high risk of bias and low

quality of the evidence used by the included investigations. Likewise, the lack of homogeneity in the variables used for the intervention, added to the differences in the follow-up and evaluation of the effectiveness of the programs, did not allow us to determine whether strength training could effectively reduce ankle injuries in soccer.

However, the current literature suggests continuing to introduce strength training in young soccer players, as it can reduce the risk of injury and improve parameters related to sports performance. However, the elimination of reporting biases in terms of the description of the intervention and the level of compliance with the programs should be considered in future research. Additionally, this review found that proprioceptive training was more effective in reducing ankle sprains than strength training, which should be considered for multicomponent development by sports professionals.

In the near future, it is necessary to guide research to establish the effect of training this capacity; however, it should be taken into account that the projected strength programs should be introduced in their design variables such as specificity, the type of strength method used, individualization, progression, load control, the time of the season, the deficits of the players, and the level of strength, which allow guidance and adaptation to the context of preventive programs based on this capacity. Similarly, the report that future studies will project on the principles of training used, the type and dosage of the load, the methods of strength, and the form of evaluation and monitoring of injury rates, causes, and time of disability can improve the quality of studies that can respond to the gaps in knowledge in the prevention of injuries based on strength training.

In addition, improvements in the quality of intervention studies in future research will allow more options in the scientific literature to generalize and establish common ground in the development of strength-based preventive strategies through systematic reviews and meta-analyses to determine whether strength training can be effective in mitigating the risk of ankle injury in soccer players.

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Institutional Review Board Statement

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Informed Consent Statement

Not applicable.

Conflicts of interest

The authors declare no conflicts of interest.

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