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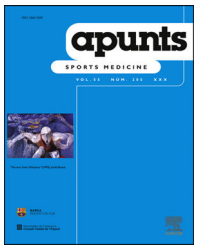

REVIEW

Strength training in relation to injury prevention in professional and semi-professional women's football: A systematic review

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Abstract The increased practice by the female sector makes knowing the causes that can cause pathologies in the musculoskeletal system more important. Various factors are what can trigger motor limitations and generate pathologies in the musculoskeletal system. The objective of this study is to establish methodological bases in relation to the type of work and the parameters that make up strength training towards injury prevention in professional and semi-professional women's football. To do this, a search was carried out using the Google Scholar and Pubmed platforms, including a time frame from 2000 to December 2019. An analysis of 8 studies was carried out, in which positive relationships were observed in the reduction of injuries in different types of training, thus proposing that strength training shows beneficial effects regarding the prevention of injuries of a different nature.

Introduction

Poor execution, overuse of certain muscle groups and possible imbalances between antagonistic muscles can trigger motor limitations and generate pathologies in the locomotor system,[1] increasing the risk of injury in women's football, a sports modality undertaken at high intensity and with contact.[2]

In relation to the magnitude of the problem, in high-performance football, approximately nine injuries occur per 1000 h of exposure, taking training and competition into account.[1] Specifically, in women's football, the rates are 12.6–24 every 1000 h of exposure in matches and 1.2–7 every 1000 h of exposure in training,[3] showing a higher risk of injury. The ratios presented encompass the entire typology of injuries within women's football, highlighting the knee (30.4%) and ankles (17.9%) as the most affected joints.[4]

Regarding the injuries that most affect this sector, it seems that contusions are the most frequent injuries, followed by ankle strains and fibre breakage.[5] Although in relation to the knee joint, the anterior cruciate ligament

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(ACL) is one of the most frequent and severe injuries that affect female football players[6] given their greater predisposition to this injury based on the variation in the size and shape of the pelvis, the width of the intercondylar notch, the Q angle and the ligamentous laxity that may exist in females compared to males, proportionally establishing the incidence of this injury in the female mode at a difference of between 2 and 8 times greater compared to the male.[7]

In order to reduce the number of specific injuries in football players, the bibliography proposes different methods. Some authors indicate that in general, physical activity was shown to reduce sports injuries, although strength work and proprioceptive work were the training types that showed the most improvements.[8] On the other hand, flexibility work does not seem to report improvements in this section. Regarding more specific injuries, it seems that to reduce the number of ACL injuries in athletes, the type of training that reported the best results was neuromuscular training. In addition to including aspects such as plyometrics and training in the so-called ''CORE'' area, since these could be effective methods for reducing injuries of this nature.[9] In terms of ankle ligament strains, it is reported that through the neuromuscular stimuli provided by proprioceptive training, injury incidence is reduced.[10] Finally, in relation to muscle ruptures, it seems that multiple training programmes that include proprioception, functional CORE strength and stability work, knowing that the set of muscles included in the lumbo pelvic and hip complex[11] can help with prevention.[12] It is also specified that eccentric strength work could be the most recommended for preventing posterior chain muscle injuries.[13]

The objective of this systematic review is to establish methodological bases in relation to the type of work and the parameters that make up the strength training that is carried out with an orientation towards injury prevention in professional and semi-professional women's football.

Method

Inclusion criteria

The inclusion criteria of the review were to use only studies that include professional or semi-professional football categories. The studies used are from over the last nineteen years (2000–2019), only including the studies that reported results in relation to football and that showed a control group, without including other bibliographic reviews. Within these criteria, publications in conferences have not been included and only studies that have reported results in relation to the female gender have been used. The languages included in the criteria are Spanish, Catalan and English.

Exclusion criteria

In relation to the exclusion criteria, studies that do not consider a control group or studies included in the ''return to play'' (RTP) process have not been included in this study. Also highlighting the exclusivity of the use of studies, not the use of books.

Information sources

A computerised bibliographic search was carried out in the period between 2000–2019, ending December 2019. The databases used in the review were PubMed and Google Scholar.

Search strategy

Title, abstract and keyword fields were searched in each of the databases used with the following terms: In Pubmed, (''Strength training'' OR ''Resistance training'') AND ''female'' AND (''soccer'' OR ''football'') AND ''injury'' were used; Also, in Google Scholar, ''Strength training'' OR ''Resistance Training'' AND ''female football'' OR ''female football'' AND ''injury'' were used, in addition to using ''female injury'' as implicit words in the title.

Data extraction and study selection process

The records were exported to an electronic database using bibliographic reference management software (Mendeley Desktop, 1.19.4, Mendely Ltd., 2008–2019) in which duplicate references were eliminated. Fig. 1 shows the flow chart used to identify the studies used and the eligibility criteria used for this systematic review. After obtaining the non-duplicate articles, titles, abstracts and keywords were viewed, in which the exclusion criteria were applied and studies not related to the research were excluded. This was followed by a review of the full texts to subsequently definitively exclude studies that did not meet the eligibility criteria or were not related to the objective of the study. Within this section, the references used to include studies not previously viewed and that were of sufficient interest were viewed. Each article was reviewed to obtain information from (1) authorship, (2) sample type, (3) type of training related to the strength used, (4) strength training programming, (5) injury type registered, (6) age of the subjects and (7) competition level.

Synthesis of the results

The texts were reviewed in search of the following study variables: Strength training, prioritised training type, frequency cycle days, number of injuries and type of injuries. The measures and parameters derived from the exposed variables were considered the main result.

Results

Study selection

The search reported a total of 170 results, from eliminating duplicates, previous reviews, theses and books; the search was narrowed to 130 results. From this point, by reviewing the title, abstract and keywords used, a total of 115 studies were eliminated, leaving a total of 15 results as ''possibly eligible''. Next, by observing the full text, there was a final exclusion of eight articles and an inclusion of two articles,

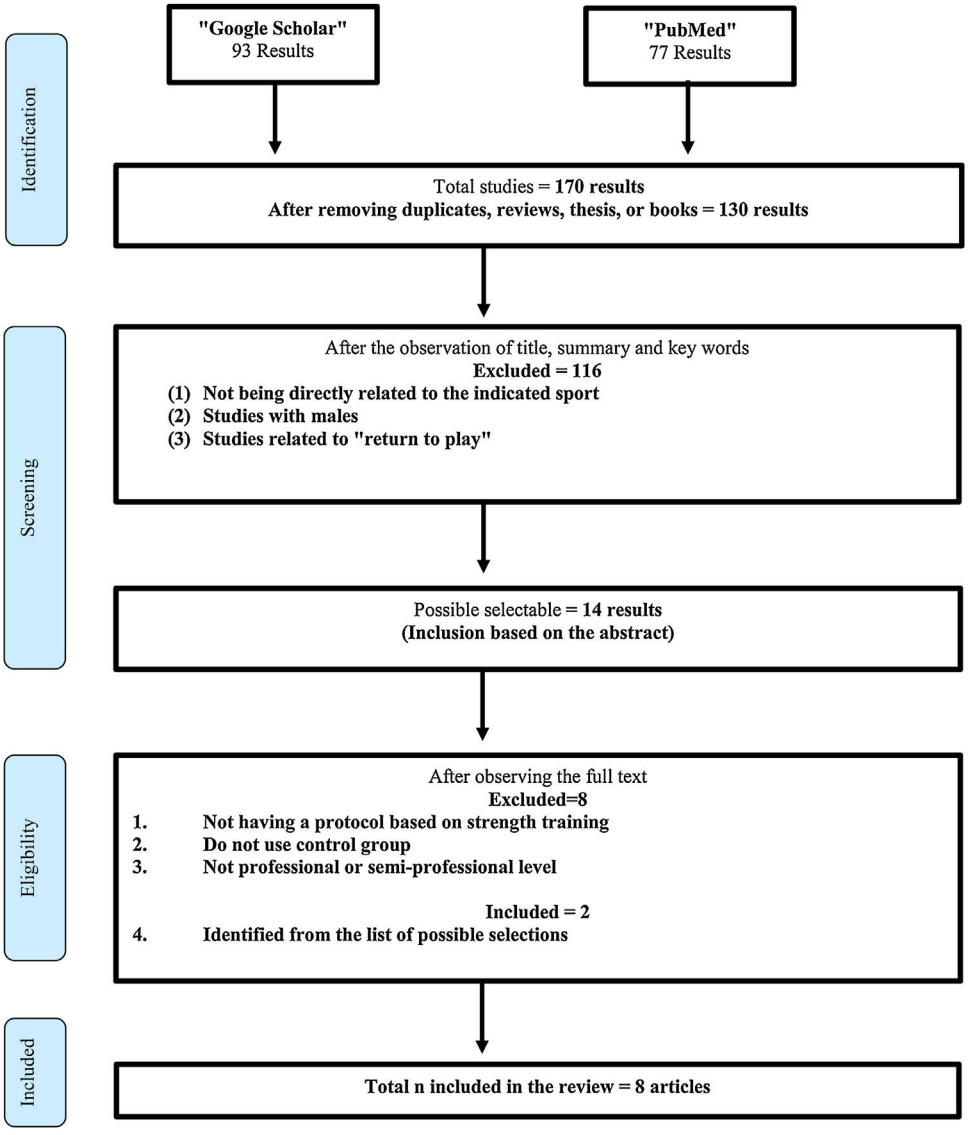

Figure 1 Flowchart in relation to search.

ultimately reporting a total of nine studies in the final selection (Fig. 1).

All the chosen studies are distributed among the range of years proposed. This shows how it has been an important research topic for years.

Participants

Regarding the sample type, more than half of the studies reported a non-randomised sample of the participants, with the rest reporting randomised samples.

Study specifications

Reported results

In many of the different studies, the injury researched was the ACL.[6,7,14,15] In the remainder, no specific injury was specified. Also, the methods used were primarily exercises oriented to neuromuscular aspects in relation to strength training, although many of them also presented eccentric work, plyometric training and, finally, three of the reviewed studies presented exercises in their proposal with the use of disturbing elements of the movement (Table 1).

In relation to the reported results, studies indicate that combining injury prevention programmes that include motor control actions are effective in relation to ACL injuries[7,14,15]; and even in the prevention of all injuries.[16] Other studies also report the non-usefulness of the ''11+'' programme in injury prevention and in improving variables related to physical conditioning in women's football.[3,17] Finally, a study reports favourable results regarding the usefulness of programmes in improving stability[17] (Table 2).

Discussion

Application of strength work in reducing injury

In relation to the reported results, most studies report positive results in the use of strength training in reducing ACL-related injuries and other ligamentous injuries,

Table 1 Variables analysed in the selected studies.

Authors	Sample	Training type	Training schedule	Injury type	Age	Competition level
Söderman et al. (2000)	Not randomised	Balance board exercises	For 30 days each day + the rest of the season 3 days (10–15 min)	ACL	20.4 ± 4.6	Swedish 2nd and 3rd division
Greska, Cortes, Van Lunnen & Oñate (2012)	Not randomised	P: Olympic lifting FV: Plyometry + specific skills	10 weeks P: 6 weeks × 2 days (60 min) FV: 4 weeks × 2 days (60 min) + 6 weeks × 2 days (30 min)	ACL	19.2 ± 0.8	1 NCAA division
Steffen, Myklebust, Olsen, Holme & Bahr (2008)	Randomised	Plyometry + Eccentric Work + Stability Training	15 min × 8 months	General	13–17	Semi-professional
Gilchrist et al. (2008)	Randomised	Neuromuscular-oriented exercises	3 times per week for one season	ACL	14–18	1 NCAA division
Maldembaum, Silvers & Watanabe (2005)	Not randomised	Neuromuscular Orientation + Eccentric Work + Stability Training + Plyometry	For two years	ACL	14–18	Semi-professional
Steffen, Bakka, Myklesbust & Bahr (2008)	Not randomised	Plyometry + Eccentric Work + Stability Training	15 min × 10 weeks	General	16–18	Professional
Emery & Meeuwise (2010)	Randomised	Neuromuscular training + eccentric work	15 min warm-up + 5 strength exercises + at home 15 min strength (every day) for 20 weeks	General	U13–U18	Semi-professional
Eisen, Danoff, Leone & Miller (2010)	Randomised	Exercises on unstable platform	12 Sessions	Ligament injuries	18–22	Semi-professional

although the same favourable results are not found with respect to injuries caused by contact mechanisms.[6,15] These results could indicate its efficiency in reducing ligamentous injuries in the knee joint.[19,20] The orientation of most studies are focused on the injuries specified above, specifically ACL. This can be explained because the knee is the most affected joint in the female gender in this sport[20] and normally in non-contact situations.[4]

On the other hand, the remaining studies are related to reducing injury in more general aspects[3,16,21] reporting beneficial effects in half of the studies of this orientation, with respect to the injury index.[8,16] Although on the contrary, reporting non-benefit effects through the use of standardised protocols (FIFA 11+).[3,17]

Neuromuscular orientation of strength training

In relation to this orientation type, this aspect was used in all the studies to achieve the objectives set. Thus it can be seen that no positive effects were reported with respect to the injury rate in only two of the cases.[3,17]

The use of strength protocols to promote this quality could be related to the influence of changes in the strength of the athletes and in the biomechanics of certain movement patterns, such as landing, causing a direct influence on the parameters indicated above that could influence the ligamentous injury mechanism. The importance of the perceptual mechanism in a complex and changing environment must also be taken into account, which with respect to the

Table 2 Results of the selected studies.

Authors	Practical applications	Statistical variables
Söderman et al. (2000)	An unsteady workout is insufficient to prevent contact injuries to the lower extremities. The same training is not effective in relation to preventing ACL injuries.	Minor injuries (CI = 0.49–2.17) Moderate injuries (CI = 0.33–1.86) Severe injuries (IQ = 2.10–57.3)
Greska, Cortes, Van Lunnen & Oñate (2012)	Combining injury prevention programmes to alter the dynamics of movement in the hip and knee, combined with strength programmes, reduces the risk of ACL injury.	Improvements in isometric strength in the Left hip ($p < .00.1$) and in the Right hip (p: .028), in adductor strength (p: .036), improvements in jump reception tasks and improvements in hip rotation (p: .002) and finally improvements in knee flexion moment (p: .051).
Steffen, Myklebust, Olsen, Holme & Bahr (2008)	There are no effects of the ''11+'' preventive programmes regarding the range of injuries.	Regarding all injuries, the relation between the control group and the intervention group (CI 0.8–1.2, p: 0.94).
Gilchrist & et al. (2008)	Neuromuscular and proprioceptive training can aid in preventing ACL injuries in non-contact situations.	Injuries for ACL in second for the season ($z = -2.24$; p: .025); injuries for players with ACL in the past ($z = -2.00$; p: .046).
Maldembaum, Silvers & Watanabe (2005)	Neuromuscular training can aid in preventing ACL injuries.	Team ratio (0.191; $p < 0.001$) Exposure ratio (0.181; $p < 0.001$)
Steffen, Bakka, Myklesbust & Bahr (2008)	There are no relevant effects of an ''11+'' prevention programme regarding performance variables.	Improvements in Q iso 90° ($p < .001$); no differences in the Q:H ratios; no differences in jump; No differences in specific skills.
Emery & Meeuwise (2010)	Neuromuscular training can help to prevent all injuries, especially in adolescence.	Control group (CI = 2.65–4.17) Intervention group (CI = 1.54–2.74) p value = 0.045
Eisen, Danoff, Leone & Miller (2010)	Relationship between balance ability and risk of ligament injury.	Rocker board group (0.046 ± 0.076) Dynadisc Group (0.031 ± 0.08) Control (0.021 ± 0.059)

male gender, shows greater capacity for intuition and analytical processing, although less training for perception and combined actions.[22] Therefore, the use of exercises of this orientation that include jumps, receptions and deceleration techniques[23] can help to improve these cognitive mechanisms.

Use of plyometrics in strength training

Training through plyometrics was the most used in the studies analysed. Most of them showing positive results regarding the injury rate. In relation to preventing ACL, a great incidence is also shown on this type of training regarding ACL rupture prevention,[24] indicating that this type of exercise is essential in any prevention programme in relation to the specified injury. This fact can be defined by the decrease in the maximum reaction force on the ground, the decrease in hip abduction and adduction during the landing phase, in addition to increasing the muscular power of the lower extremities,[24] always taking the use of this into account on multiple planes is considered, with the aim of imitating competitive demand and specific muscular activation.[24]

The use of plyometry work does not seem to help in reducing other injuries.[3,4] Although the interventions have been contextualised in a standardised protocol (FIFA 11+) without taking the individualisation principle into account.

Eccentric work in strength training

Differences have been found with respect to injury prevention in relation to eccentric training, in which the results report improvements in prevention with respect to ACL[7] and with respect to reducing injury in general.[16] In relation to ACL, it is known that the quadriceps and hamstring muscles help to protect the knee. It must also be considered that the braking action of the hamstrings prevents anterior displacement of the tibia. Therefore, reporting that an asymmetry between the two named muscles could lead to an increased risk of ACL rupture,[25] indicating that a ratio >0.6 between quadriceps and hamstrings (Q:H ratio) increases the risk of injury to the lower extremities.[27] In relation to other types of non-ligamentous injuries, eccentric training also seems to be beneficial in reducing muscular injuries related to the

quadriceps and the hamstring muscles, which seem to be the most affected by this injury type in football players.[26]

Proprioception in strength training

In the various studies analysed, the use of exercises with this orientation was reported, with discrepancies in the conclusions drawn from them. While authors report that there are no benefits on preventing ACL through traumatic mechanisms,[6] the use of protocols focused on this type of training also indicated that it does not show benefits on dynamic balance.[18] In relation to ligamentous strain of the ankle joint, this type of training shows insufficient evidence for subjects who have not had previous injuries. Although its use is indicated in subjects with underlying deficiencies arising from previous injuries, since this type of training can maintain or enhance the afferent pathways and protective reflexes around the joint.[10]

Parameters related to training scheduling and frequency cycle

In relation to the intervention time in the studies analysed, it can be seen as a minimum that the studies that report benefits are used for four weeks up to a maximum of two seasons, with a duration of six to eight weeks being the most appropriate.[18] If the volume is taken into account, the analysed studies report a duration of 10–60 min, thus indicating a huge variety in relation to this parameter. The weekly frequency reported by the studies of interest shows a minimum frequency of three days in the protocols that reported positive influences up to a daily frequency in studies of the same nature,[19] although other authors show a frequency of one to three days per week is sufficient,[27] warming up being the most used execution phase,[19] coinciding with the results presented; although the use of exercises within the session should be taken into consideration. Finally, it should be noted that the exposed parameters are related to general parameters, without going into the specific aspects of each injury type.

Limitations of the study

The main limitation was the limited bibliography. Referring to the specific problem posed, therefore, more research is required into the problem in order to be able to offer more relevant data regarding the question posed. The selection of two sources of information also possibly restricted access to relevant unidentified information.

Finally, it is worth highlighting the scant scientific evidence that relates strength work to injury prevention, taking the risk of bias into account in the studies analysed, which would affect the usefulness of the strategies shown.[27]

Conclusions

It seems that strength training is beneficial in reducing injuries in professional and semi-professional football players. Although the orientation type used must be taken into account, since it is influenced due to its nature. Within this concept, neuromuscular training seems to offer the best benefits regarding ligamentous injuries such as ACL rupture, indicating the use of plyometric exercises to help in reducing them. On the other hand, proprioceptive training does not seem to report the indicated benefits for reducing injuries related to the ankle joint, establishing that this improvement in joint dynamic balance could be achieved through the use of controlled physical activity itself. Finally, if the goal is to reduce muscle injuries in the muscles most involved, eccentric training seems to be the one with the best benefits. On the contrary, it seems that simply using standardised protocols such as FIFA 11+ seems to have no beneficial effects on them.

In relation to the parameters that encompass frequency cycle and training programming, studies indicate that a duration of four weeks through the use of protocols for three days a week with a duration of approximately 15 min is sufficient to reduce the injury likelihood index. Finally, in relation to the intensity used, this parameter needs to be studied in future research in order to establish safe protocols that are directed towards these objectives.

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Conflict of interest

The authors declare that they have no conflict of interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.apunsm.2020.100342.

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