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Review

Physical exercises for preventing injuries among adult male football players: A systematic review

Jorge Pérez-Gómez [a], José Carmelo Adsuar [a], Pedro E. Alcaraz [b,c], Jorge Carlos-Vivas [a,*]

[a] *Health, Economy, Motricity and Education (HEME) Research Group, Faculty of Sports Sciences, University of Extremadura, Caceres 10003, Spain*
[b] *UCAM Research Center for High Performance Sport, Catholic University of Murcia, Murcia 30107, Spain*
[c] *Faculty of Sport Sciences, Catholic University of Murcia, Murcia 30107, Spain*

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Abstract

Background: Football is the most practised sport in the world and is associated with the risk of injuries in the players. Some studies have been published that identify injury prevention programs, but there is no review of the full body of evidence on injury prevention programs for use by football coaches. The aim of this article was to carry out a systematic review of published studies on injury prevention programs for adult male footballers, identify points of common understanding and establish recommendations that should be considered in the design of injury prevention strategies.

Methods: PubMed and EMBASE databases were used to identify relevant published articles using the following keywords: "soccer" AND "injury" AND "prevention".

Results: A total of 2512 studies were identified initially, but only 11 studies met the inclusion criteria, and their outcomes are presented. Results revealed that injury prevention programs in football have focused on strength training, proprioceptive training, multicomponent programs (balance, core stability, and functional strength and mobility), and warm-up programs.

Conclusion: Based on results from the studies analyzed, football players can lower the incidence of match and training injuries by participating in dynamic warm-up programs that include preventive exercises before games or during training sessions, and by adding strength, balance, and mobility training to the training sessions.

Keywords: Balance; Core stability; Injury prevention programs; Soccer; Warm-up

1. Introduction

Football is a team sport with a high incidence of injury.[1] These injuries are common among both professional[2] and non-professional football players,[3] and some players experience extensive time loss associated with an injury.[4,5] The average time to return to play depends on the kind of injury. For instance, obturator muscle injuries need around 12 days of recovery for professional football players to return to competition.[2] However, the time needed to return to play after hamstring injuries is more variable, ranging from around 14 days[6] to more than 28 days for severe hamstring injuries.[7] Specifically, an average of 8 to 28 lost playing days were reported for professional Brazilian football players.[8] The injury time loss ranged from 1 to 752 days among professional Dutch football players, with a median of 8 days.[9] The time needed to return to play ranged from 7 to 24 weeks, with an average of 11 weeks, among professional football players with serious shoulder injuries.[10] Because having a lower number of injuries has been correlated with team success,[11] it is important to reduce them and minimize lost playing time.

Injuries in sports have been associated with intrinsic or extrinsic factors.[12] In football, some extrinsic factors are difficult to control, such as contact injuries.[13–15] However, it is possible to train for certain predictable intrinsic factors that lead to non-contact injuries.[14,16] For example, some epidemiology studies have reported on preventable risk factors in professional football players[17,18] and highlight the need to establish injury prevention protocols.[5,15,18] To prevent injuries is extremely important given that a previous injury is a significant risk factor for sustaining another injury.[19,20] For instance,

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* Corresponding author.
E-mail address: jorge.carlosvivas@gmail.com (J. Carlos-Vivas).

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16% of muscle injuries among professional football players are re-injuries.[21] Having a previous groin injury almost doubles the risk of having another groin injury,[22] and a previous inversion ankle injury can cause persistent symptoms for at least 2 years after the injury.[23] All these types of injuries emphasise the importance of establishing injury prevention programs.

Risk factors and injury rates are affected by different considerations: psychosocial,[24] psychological,[25,26] biomechanical,[27] field surfaces,[28–30] and physical exercise.[31] Some injury prevention programs have been effective in reducing the incidence of injuries[32–41] and decreasing healthcare costs among football players.[42] Therefore, the purposes of this study were to (1) focus on physical exercise factors influencing injuries, (2) identify injury prevention programs and intrinsic factors related to injuries that have been described in the literature, and (3) establish some recommendations for coaches and physical fitness trainers that might reduce the overall number of injuries among adult male football players.

2. Methods

The Preferred Reporting Items for Systematic review and Meta-Analyses (PRISMA) guidelines[43] for search procedures, study selection, data collection, and data analysis were followed in this systematic review.

2.1. Search strategy and eligibility criteria

A systematic review of studies identified in the PubMed and EMBASE electronic databases was conducted up to 24 January 2020. The relevant articles were searched using the terms "soccer" AND "injury" AND "prevention". The search and study selection were performed by 2 independent reviewers (JPG and JCV). Disagreements between the 2 reviewers were resolved by discussion; if necessary, a third reviewer (JCA) was consulted to reach a consensus.

The inclusion criteria for the articles selected included the following: (1) longitudinal research studies, (2) studies that showed a reduction in the number of injuries as a consequence of a physical exercise intervention program, (3) studies that included professional or amateur male football players as participants, (4) original research studies, (5) research conducted with adults males ≥18 years old, and (6) studies published in either English or Spanish.

There were 2 exclusion criteria: (1) protocol studies (i.e., those that only provided a detailed account of the hypothesis, rationale and methodology of the study but not the study outcomes) and (2) studies having only women participants.

2.2. Methodological quality of studies

Two reviewers (JPG and JCV) independently assessed the methodological quality of the eligible studies using the Physiotherapy Evidence Database scale (PEDro).[44] The average score of all included studies for this systematic review was 5 points on the PEDro scale.

3. Results

3.1. Search and selection of publications

Initially, 2512 studies were identified in the 2 databases. After duplicates were removed, a total of 1597 articles were screened. After reading the titles and abstracts, 1505 articles were excluded. The remaining 92 full-text articles were read and assessed for eligibility, and 81 studies that did not fulfill the eligibility criteria were excluded. Thus, 11 articles were included in our review (Fig. 1).

The studies were excluded for the following reasons: (1) no exercise for injury prevention or injury assessment ($n = 23$), (2) sample different to soccer players ($n = 4$), (3) no male participants were involved ($n = 19$), (4) the age of participants was less than 18 years old ($n = 28$), and (5) the intervention did not show a significant effect on injury prevention ($n = 7$).

3.2. Characteristics of studies included

Table 1 shows the main characteristics and outcomes of the included studies. The sample of all studies was composed of adult male football practitioners aged 18 to 65 years old. The interventions included training frequencies from 1 to 6 times per week and durations from 10 weeks to a full season. The main injury prevention practices included the Nordic hamstring exercise, YoYo Flywheel Ergometer activity, adductor strengthening activities, proprioceptive activities, a multicomponent program and warm-up protocols.

3.3. Data organization

For the purposes of our review, the studies were grouped into 4 broad areas according to the type of physical exercise used in the intervention program. These areas include (1) strength training, (2) proprioceptive training, (3) multicomponent programs,

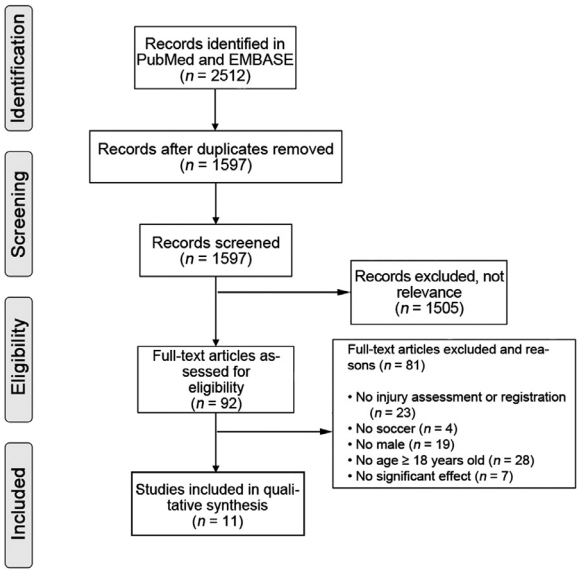

Fig. 1. Flow diagram of study selection process.

Table 1
Main characteristics of the studies included in the systematic review.

Study	Exercise program	Duration	Frequency	Sample	Age (year)	Conclusion
Arnason et al. (2008)[32]	NHE + WU	3 sets/8–12 rep., 1–2 seasons	1–3 times/week	17–30 elite teams		↓ risk of hamstring strains
Askling et al. (2003)[33]	YFE	4 sets/8 rep., 10 weeks	1–2 times/week	30 elite players	24–26	↓ occurrence of hamstring strain injuries and ↑ concentric and eccentric maximal voluntary strength of hamstrings, as well as, maximal speed running
Grooms et al. (2013)[34]	FIFA 11+	20 min, 1 season	5–6 times/week	41 collegiate players	18–25	↓ overall risk and severity of lower-extremity injury (72%)
Harøy et al. (2019)[45]	ASP	Preseason: 6–8 weeks In-Season: 28 weeks	Preseason: 2–3 times/week In-Season: 1 time/week	339 semi-professional players	22.0 ± 4.3[a]	↓ prevalence and risk of groin problems (41%)
Junge et al. (2011)[35]	FIFA 11+	20 min		3265 amateur players	14–65	↓ incidence of match (12%) and training (25%) injuries
Mohammadi (2007)[36]	Proprioceptive	30 min,1 season	Every day	80 male soccer players	25	↓ rate of ankle sprains
Owen et al. (2013)[37]	Multicomponent	1 season	2 times/week	23 elite players	27–28	↓ number of injuries
Petersen et al. (2011)[38]	NHE	2–3 sets/5–12 rep., 10 weeks	1–3 times/week	942 professionals/amateurs	23	↓ rate of overall, new and recurrent hamstring injuries
Silvers-Granelli et al. (2017)[40]	FIFA 11+	15–20 min, 1 season	2–3 times/week	61 NCAA football teams	18–25	↓ rate of ACL injuries
Silvers-Granelli et al. (2015)[39]	FIFA 11+	20 min, 1 season	3 times/week	61 NCAA football teams	18–25	↓ injury rate (46%); decreased time loss to injury (29%)
van der Horst et al. (2015)[41]	NHE	2–3 sets/5–10 rep., 13 weeks	1–2 times/week	40 amateur teams	18–40	↓ risk of hamstring injuries

[a] Data were presented as mean ± SD.

Abbreviations: ACL = anterior cruciate ligament; ASP = adductor strengthening programme; FIFA = Federation Internationale de Football Association; NCAA = National Collegiate Athletic Association; NHE = nordic hamstring exercise; rep. = repetitions; WU = warm up with stretching; YFE = YoYo Flywheel Ergometer.

and (4) warm-up programs. Study characteristics are presented in Table 1.

3.3.1. *Strength training*

Most of the studies that involved strength training for the prevention of injuries focused on eccentric exercises specifically for the hamstring muscles. The most common eccentric hamstring exercises used were the Nordic hamstring exercise (NHE) and the Nordic hamstring lowers.[32,38,41]

The NHE has been an effective exercise for both amateur[38,41] and professional football players.[32,38] In 1 study, the inclusion of 27 sessions of NHE during 10 weeks in the midseason break decreased the rate of new and recurrent hamstring injuries among professional and amateur football players.[38] In another study, fewer sessions of NHE (25) performed over a longer period of time (13 weeks) and incorporated into regular amateur football training significantly reduced the incidence of hamstring injuries but not the severity of those injuries.[41] Another study combined NHE with a warm-up and stretching protocol once or twice per week during both the preseason and regular season and was shown to be effective in reducing hamstring strains among elite football players.[32]

Another study analyzed a strength training program for the hamstrings that included concentric and eccentric action performed on the YoYo Flywheel Ergometer during the preseason for 10 weeks.[33] The program was found to be beneficial in that it lowered the occurrence of hamstring strain injuries among elite football players.[33]

Another study included a strength training protocol called the Adductor Strengthening Programme (ASP).[45] This protocol was included 2–3 times per week during the preseason (6–8 weeks) and once per week during the competitive period (28 weeks) and was shown to be effective in reducing (41%) the prevalence and risk of groin problems in male football players.[45]

3.3.2. *Proprioceptive training*

Only one study involved proprioceptive training.[36] This training employed an ankle disk that was used for 30 min a day. The training was shown to be effective in reducing the rate of ankle sprains among football players.[36]

3.3.3. *Multicomponent training: balance, core stability, and functional strength and mobility*

Used during the competitive season, a multicomponent training program that included a total of 58 sessions (twice weekly) focusing on balance, core stability, and functional strength and mobility exercises produced a significant reduction (43%) in the number of muscle injuries among elite professional football players.[37]

3.3.4. *Warm-up programs*

Warm-up programs used to prevent injuries included the "FIFA 11+" program.[34,39,40] It has been shown that when the FIFA 11+ program was implemented correctly, 2–3 times per week during training sessions, it decreased the rate of anterior cruciate ligament (ACL) injuries among male football players.[40] Previous studies have reported that the FIFA 11+ program

utilized 3 times per week throughout the competitive season reduced the injury rate by 46% and time lost to injury by 29% among male competitive collegiate football players.[39] Another study analysed the use of the "FIFA 11+ program" 5−6 times per week during a competitive season and found that it reduced the overall rate and severity of lower-extremity injuries by 72% among male collegiate football players.[34]

In 1 study that analyzed the "11" warm-up program (a previous version of the "FIFA 11+ program"), amateur football teams whose coaches implemented the 11 program (or most of it) once or twice a week as part of the warm-up protocol decreased the incidence of match injuries by 11.5% and training injuries by 25.3%.[35]

4. Discussion

The purpose of this study was to review the physical exercise training programs that have been effective in lowering the injury incidence among male football players. Our discussion is organized into the same 4 broad areas used in the Results section: (1) strength training, (2) proprioceptive training, (3) multicomponent programs, and (4) warm-up programs.

4.1. Strength training

Muscle injuries in male football players constituted 31% of all injuries, with the hamstrings being the most affected muscles (37%), followed by the adductors (23%), quadriceps (19%), and calves (13%).[21] This explains why most of the studies on muscle injuries in football have been conducted on the hamstring muscles.

Several risk factors for hamstring injuries have been described. These include age, body mass, core stability, delayed recovery, muscle fatigue, muscle flexibility, muscle activity, playing position, previous hamstring injury, thigh muscle imbalance, and hamstring muscle weakness.[7,46−50] Physical exercise programs used to prevent hamstring injuries should consider hamstring muscle weakness or imbalance with respect to quadriceps strength.

Hamstring injuries occur when the load exceeds the strength of the tissue, and, according to biomechanical studies, hamstring rupture usually happens in the last part of the swing phase during sprinting.[51−53] Hamstring injuries have been linked to insufficient eccentric strength in the hamstring.[54] Thus, according to the principle of training specificity and strength training,[55] it is not surprising that using eccentric exercises to train the hamstring muscles can improve eccentric hamstring strength, thereby reducing the incidence of hamstring injuries. This is one explanation for why preventive programs that include exercises in which the hamstring muscles perform eccentric contractions have been effective in reducing hamstring injuries.[32,33,38,41] In well-trained football players, eccentric exercises are more effective for developing maximal eccentric hamstring strength than comparable hamstring concentric contractions.[55] It is also known that eccentric exercises produce a shift in the optimum angle of the muscle, which can be considered as a protective mechanical change that prevents injuries.[56]

In our review, most of the programs in which a reduction in hamstring injuries was observed used the NHE.[32,38,41] The NHE is a partner exercise; the partner stabilizes the legs of the person who is exercising. The exerciser is on his knees, with the back and hips kept straight, and then leans forward with the hamstrings working eccentrically until the exerciser lands on the floor with support from the hands. The NHE has some advantages for being incorporated into football training because it is easy to perform, is safe, does not require additional equipment and does not take very long.

In regard to the optimal time during the training session when the NHE should be performed, some studies found that it was left to the coaches to choose when to perform the NHE. It was sometimes performed before,[57] after,[41] or even during[38] the session. However, some studies found that performing the NHE before the training session exacerbated eccentric fatigue and could increase the predisposition to hamstring strain injuries.[58] Future studies are needed to elucidate the optimal scheduling of the NHE.

Another important aspect to consider before using the NHE is the potential for muscle damage. It is recommended that an introductory period of around 5 weeks be used, during which the load is increased gradually.[55] This helps avoid delayed onset muscle soreness (DOMS), and some studies in which this recommendation was followed did not observe any complaint about DOMS from the players.[32]

Exercises using the YoYo Flywheel Ergometer for the hamstring muscles has also been described in the scientific literature.[33] A study by Askling et al.[33] used this ergometer to generate both concentric and eccentric actions for exercising the hamstring muscles. In this study, elite football players performed bilateral knee flexor movements in a prone position and the concentric hamstring action accelerated the flywheel. With the subsequent eccentric hamstring action, the flywheel was decelerated. This training not only had positive effects in reducing hamstring injuries but also improved concentric and eccentric maximal voluntary strength in the hamstrings, as well as maximal running speed. Unfortunately, most of the players using this method experienced DOMS. Thus, more research is needed on training programs where the YoYo Flywheel Ergometer is used in order to determine if an introductory period is required to avoid muscle soreness.

Another important issue in hamstring injury prevention is related to muscle injury location. Injuries to hamstring muscles are not equally distributed in the muscle group; the biceps femoris muscle is the most frequently injured (66% of all hamstring injuries), while the semitendinosus muscle represents 33% of all hamstring injuries.[59] More research is needed in order to develop specific hamstring exercises for preventing injuries to individual hamstring muscles.

We found only one study[45] that focused on injury prevention strategies for the adductor muscles, despite these muscles being the second most injured muscle group in soccer.[21] The study by Harøy et al.[45] showed that the implementation of ASP could be effective in reducing (41%) the prevalence and risk of groin injuries in male football players during the competitive season. More studies are needed to confirm the findings of Harøy et al.[45]

4.2. Proprioceptive training

Ankle inversion sprains are a common injury in football,[15] with a high probability for reinjury[60] or the player experiencing persistent symptoms after the injury.[23]

Proprioception is a neural process by which the body gets information by sensory input and integrates it in order to determine the body position or movements in space.[61] Proprioception is fundamental for balance control.[62] Proprioceptive training is crucial in reducing the risk of ankle sprains or recurrent injury.[63] Proprioceptive training programs usually include exercises using devices such as ankle disks, balance boards, and tilt boards. These kinds of exercises improve the sensorimotor system's ability to adapt to the changing environment and safeguard the body from injury.[63] Improvement in proprioceptive control can produce better movement control[64] during jumping or landing in soccer, which reduces the mechanical stress and, consequently, the incidence of injuries in the lower limbs. The forces applied during the proprioception training counteracts unbalanced situations and can improve the resilience of ligaments and tendons.[65] Ligaments and tendons can adapt to exercise by changing the cross-sectional area and strength due to increased or decreased loading,[66] thus allowing adaptations in passive structures and the sensorimotor system. This explains why proprioceptive balance training has been effective for the prevention of ankle sprains in adult[36] and high school football players.[67]

4.3. Multicomponent training: balance, core stability, and functional strength and mobility

Some reasons for using strength training (eccentric movement specifically) and balance training to prevent injuries have been explained previously. But strength training involving concentric movement is also important in order to minimize the strength imbalance between legs. It has been observed that muscular imbalance between the preferred and non-preferred leg in sub-elite football players can be an injury risk factor,[68] so it is logical that a multicomponent program that includes functional strength would be effective in reducing injuries.[37]

It is known that the number of injuries can be reduced by improving flexibility.[69] Core stability is important for controlling the position and movement of the trunk over the pelvis in order to allow for the efficient transfer of force to the limbs, and greater core stability can help sports performance by providing greater force production in the extremities,[70] thus reducing the incidence of injuries.[70,71] It has been found that training programs that include mobility and core stability exercises can help to reduce the incidence of muscles injuries.[37]

4.4. Warm-up programs

FIFA 11+ is a complete, dynamic warm-up program that includes physical exercises involving agility, plyometrics, proprioception, and strength and is designed to prevent or reduce injuries in football players. It is performed on the field for 15−20 min before games or training sessions. Developed in 2006, the program does not require additional equipment and consists of 15 exercises performed in 3 different stages. The first stage (lasting around 8 min) includes slow-speed running exercises and active stretching. The second stage (lasting around 10 min) focuses on exercises designed for agility, balance, plyometrics and strength (in the core and legs). The last stage (lasting around 2 min) includes running exercises at moderate to high speed, combined with changes of direction (cutting movements).[72]

Several studies have investigated the implementation of FIFA 11+ as a warm-up program in the training sessions of adult male football players, and these studies reported a positive effect in that the program reduced the number of injuries.[34,39,40] One possible explanation for why FIFA 11+ reduces the number of injuries is that this warm-up program can improve muscular strength. It has also been shown that FIFA 11+ improves the hamstring to quadriceps ratio (H/Q) in young male professional football players,[73] which is important because low values in the H/Q ratio are considered a risk factor for knee injuries.[74]

FIFA 11+ has some additional benefits apart from injury prevention. For example, it can prepare football players for competition from a physiological point of view.[75,76] One study has shown that FIFA 11+ is an appropriate warm-up program in, using Level 3 for 20 to 25 min, as that it increased resting oxygen uptake (14%), core temperature (1%), and lactate levels (1.5 mmol/L) in amateur male football players.[76] It has also been shown that the use of FIFA 11+ for 9 weeks improved neuromuscular control in male amateur football players.[75]

Some advantages of using FIFA 11+ as a preventive program for injuries is that, aside from football balls, no other special material or equipment is needed. The program can also be implemented in a short time frame, and some coaches have used a lack of time as a reason why they cannot implement a prevention program.

Another injury prevention program is the 11 program, which was developed before the FIFA 11+ program. The 11 program includes 10 physical exercises and the promotion of fair play. It was developed to reduce the most common football injuries to the hips, knees and ankles among amateur football players. The only materials needed for the 11 program are football balls. If used, it should be performed during every training session for 10 to 15 min.[35]

Although some studies have shown that the 11 program is effective in preventing injuries among male football players,[35] other studies have not observed a reduction in injuries when it has been used.[77−79] One study found that 11 did not reduce the injury rate in male amateur football players in one season, but it significantly reduced injury-related costs per player in favour of the intervention group, with a mean difference of 201 euros per player.[77] Another study found that the 11 program did not decrease the overall injury incidence or injury severity among adult male football players; however, the study did find a significant reduction in knee injuries.[78] A third study of the 11 program found only minor effects on the injury rate among intermediate-level amateur football players.[79] Several reasons could explain these contradictory results: (1) low compliance[80,81] (it has been shown that players with higher compliance

had a lower risk of injuries),[80] (2) lack of supervision, (3) previous injuries were not accounted for, (4) small sample sizes, (5) low injury rates,[82] and (6) lack of progression. For example, the NHE protocol has been shown to be effective in preventing injuries,[41] but the NHE comprises only a single set of 5 repetitions in the 11 warm-up program, and this protocol does not vary throughout the season. Thus, the intensity of some of the exercises in the 11 program may not be sufficient to decrease the injury rate among football players. Another explanation is that the 11 program is complex and focuses on several injury factors; therefore, it could have a different affect depending on the football population using it.

4.5. Strengths and weaknesses

This study collects all longitudinal studies that have analysed the effect of different physical exercises on injury prevalence in football. This review presents several exercises that have shown to be effective to reduce injury prevalence in football. However, it could be interesting that future reviews in this topic include searches in more databases and including manuscripts in more languages, different than Spanish or English.

5. Conclusion

It is essential that coaches and physical trainers have a solid understanding of how to prevent injuries in football. Given the scientific research analysed in our review, some recommendations can be made for reducing injuries among adult male football players: (1) incorporate 15−20 min of a dynamic warm-up program into the training regimen (the FIFA 11+ or the 11 program), (2) perform 2−3 sets of 5−12 repetitions of an eccentric exercise such as NHE, and (3) perform balance, mobility and strength training at least twice a week during football training sessions.

Authors' contributions

JPG developed the outline of the review, reviewed the literature, and wrote the manuscript; JCV also reviewed the literature, contributed to figure preparation and data extraction, and provided suggestions to the original draft and revisions; JCA and PEA read the manuscript and provided suggestions to the original draft and revisions. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare they have no competing interests.

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