Proprioceptive training methods as a tool for the prevention of injuries in football players: a systematic review

Álvaro Cristian Huerta Ojeda[1,2,4], Diego Alejandro Casanova Sandoval[3], Guillermo Daniel Barahona-Fuentes[1,2]

[1]Facultad de Educación. Escuela de Educación Física. Universidad de Las Américas sede Viña del Mar. Chile. [2]Grupo de Investigación en Salud. Actividad Física y Deporte ISAFYD. Universidad de Las Américas sede Viña del Mar. Chile. [3]Facultad de Ciencias. Magíster Medicina y Ciencias del Deporte. Universidad Mayor. Chile. [4]Centro de Capacitación e Investigación Deportiva Alpha Sports. Chile.

Received: 21.11.2018
Accepted: 25.03.2019

Summary

Introduction: Proprioceptive exercises have been used as a training method in the reduction of injuries' rate on soccer players. However, there is no certainty about the number of researches performed or the results of these methods.
Objective: Investigate out which the training methods were used in lower limbs to prevent soccer players' injuries between 2008 and 2018. The secondary objective was to describe the results of each research.
Material and method: This study is a Systematic Revision of research already published. Articles published between 2008 and 2018 that connected proprioception exercises to injury prevention were reviewed. The electronic search was performed through Web of Science, Scopus, Sport Discus, PubMed, and MedLine. All articles that presented proprioception as exercises to prevent injuries were included.
Results: 11 articles were found which used exercises connected to preventive programs in soccer players. Which were stratified according to the described aim: (i) Proprioceptive program, (ii) Balance training, (iii) Neuromuscular training, and (iv) Posture-control training.
Conclusion: Once the systematic review ended, several preventive programs were found for soccer players based on proprioception, balance, neuromuscular and posture-control. These training methods have proven to have good results in the prevention of injuries, especially in knees and ankles. For the above described, it is necessary to include injury prevention exercises in the training programs developed by soccer players.

Key words:
Prevention. Proprioception. Injuries. Football.

Métodos de entrenamiento propioceptivos como herramienta preventiva de lesiones en futbolistas: una revisión sistemática

Resumen

Introducción: Los ejercicios de propiocepción se han utilizado como método de entrenamiento para disminuir la tasa de lesiones de los jugadores de fútbol, pero no existe certeza de la cantidad de investigaciones existentes ni los resultados de estos métodos.
Objetivo: Investigar cuáles fueron los métodos de entrenamientos usados para la prevención de lesiones en las extremidades inferiores en futbolistas entre los años 2008 y 2018. El objetivo secundario fue describir los resultados obtenidos en cada uno de los estudios.
Material y método: El estudio corresponde a una revisión sistemática de estudios previamente publicados. Se evaluaron artículos publicados entre los años 2008 y 2018 que relacionaron ejercicios de propiocepción y prevención de lesiones. La búsqueda electrónica se realizó a través de Web of Science, Scopus, Sport Discus, PubMed, MedLine. Se incluyeron todos los artículos que utilizaron propiocepción como ejercicios para la prevención de lesiones.
Resultados: Fueron encontrados 11 artículos que utilizaron ejercicios de prevención en futbolistas. Los cuales fueron estratificados según el objetivo descrito: (i) Entrenamiento propioceptivo, (ii) Entrenamiento de equilibrio, (iii) Entrenamiento neuromuscular y (iv) Entrenamiento de control postural.
Conclusión: Al término de la revisión sistemática se hallaron programas de propiocepción, equilibrio, neuromuscular y control postural. Estos métodos de entrenamiento han demostrado tener buenos resultados en la prevención de lesiones, especialmente en rodillas y tobillos. Por lo anteriormente descrito, se precisa incluir ejercicios de prevención de lesiones en los programas de entrenamiento desarrollado por futbolistas.

Palabras clave:
Prevención. Propiocepción. Lesiones. Fútbol.

Correspondence: Álvaro Cristian Huerta Ojeda
E-mail: achuertao@yahoo.es

Introduction

Football is a phenomenon involving mass social participation, prominent in recreational, training and competitive fields alike, and generating benefits including improved cardiovascular performance linked to the health and metabolism of players. It also helps prevent other illnesses such as diabetes and hypertension[1]. The mainstream nature of this sport has not only led to developments in physical, technical and tactical training, but also in methods to prevent injuries[2]. The latter development is due to the fact that all sporting activities entail a certain degree of risk of injury, which is why playing football requires the correct equipment, an optimum level of fitness, controlled training and a good technique in the sport[3]. The aforementioned is more evident in high-performing athletes, as they can increase skeletal-muscular energy with a greater probability of suffering from acute and chronic injuries[4].

Injuries in football occur much more frequently than expected, posing a limiting factor for these athletes[5]. In a study carried out by Carlos-Vivas *et al.*[6], it was concluded that the majority of injuries that occur are to the lower limbs, and are both muscular and articular, specifically the thighs, ankles, groin and knees, generating lengthy recovery times and long periods of leave for both professional and amateur athletes alike. Therefore, injury prevention programmes for footballers should be an integral component of all training sessions[7]. These exercises have led to the creation of programmes such as the FIFA 11+, which includes exercises focusing on running, strength and plyometrics[2]. Jones and Rocha[8], concluded that a major part of the components that make prevention programmes successful are the stretches, lower body muscle strengthening exercises, and increased aerobic capacity.

One of the important elements within prevention programmes, is proprioception[9]; this corresponds to the relationship between kinaesthetic components and movements of the body. Well developed proprioception ensures positive stimulus-response synchronisation, achieving good performance in joint stability so as to prevent injuries. Schiftan *et al.*[10] describe that when performing proprioceptive work, the joint must be able to deal with its capacity so that the afferent signals react to the joint position, meaning that each exercise that is performed, regardless of whether the work is active, passive, static or dynamic, achieves a response from the extremities.

Within the important factors, proprioception is fundamental for football players[9]. In a study, Daneshjoo *et al.*[9] reveal that a drop in proprioceptive function determines the prevalence of injuries. Consequently, it is important to obtain and assess information about the athlete to ensure the early detection of any shortcomings in the proprioceptive work; this way individual programmes can be created to meet the needs of each player.

In sporting training therefore, it is extremely important to prevent injuries with proprioceptive programmes, thus maintaining optimum physical condition. Unfortunately, the number of training programmes that have used proprioception to prevent injuries among athletes is not certain, which is why the main aim of this systematic review was to discover the training methods used to prevent injuries in the lower extremities of football players between 2008 and 2018. The secondary objective was to describe the results obtained in each of the studies.

Material and methods

Literary search

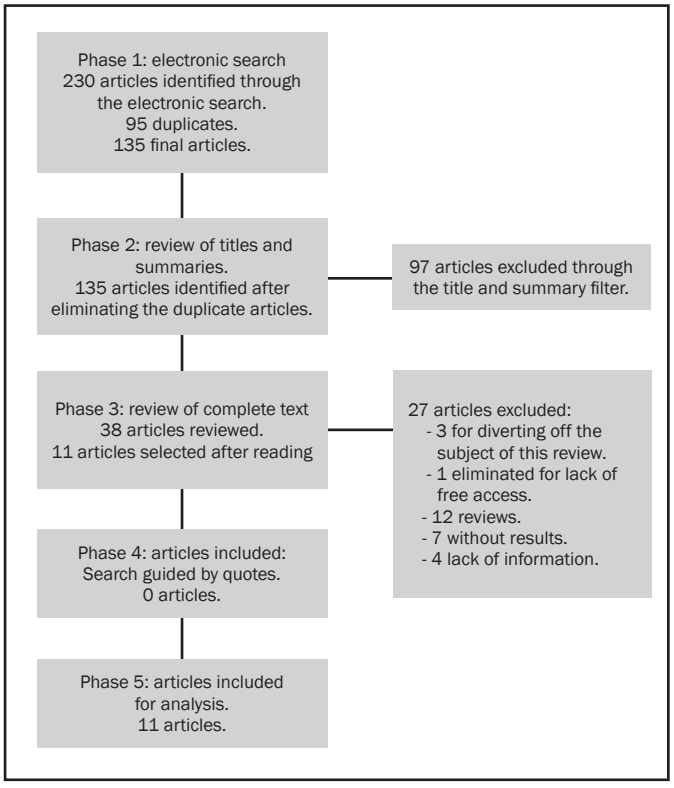
The development of this systematic review was performed using a rigorous search guided by references in different databases and electronic search engines. The combination of key words used for the electronic search can be found in Table 1. The electronic search was performed within the Web of Science (WOS), Scopus, Sport Discus, PubMed, Medline.

The search strategy was split into five stages. Stage one: electronic search of the different databases, identifying 230 articles. Next all

Table 1. Search strategy using selection and combination of key words.

Steps	Strategy	WOS	Scopus	Sport Discus	MedLine	PubMed
1	Proprioception training	4	7	53	83	4
2	Proprioception exercises	3	3	47	2	4468
3	Proprioception	3954	7449	1124	4364	15189
4	Proprioceptive	4325	5056	756	3464	3313
5	Proprioceptivity	2	4	0	1	1
6	#1 or #2 or #3 or #4 or #5	6994	9948	1614	34768	16757
7	Prevention	369112	476731	27917	716536	683295
8	Injury prevention	27906	38160	3868	11292	48732
9	#7 OR #8	369112	476731	27917	716536	683621
10	Soccer	14545	13819	7599	6362	6208
11	Football	16522	16156	10454	6909	6762
12	Soccer players	9319	6656	3756	3044	914
13	#10 OR #11 OR #12	26153	26086	14659	11087	10819
14	#6 AND #9 AND #13	64	41	27	40	58

Figure 1. Identification of studies in the systematic review.



duplicate articles were deleted (95 articles), leaving 135 articles. Stage two: filtering titles and summaries. Next the articles were eliminated using exclusion criteria (97 articles), leaving 38 articles. Stage three: reading and integral analysis of the 38 articles. After reviewing the 38 articles, 27 were eliminated, all for not meeting the inclusion criteria. Stage four: search for articles guided by the bibliography. In this phase no new studies were included. Thereby, the total amount of studies for the systematic review comprised 11 articles (Figure 1).

Inclusion and exclusion criteria

The search restrictions were: articles published in the last 10 years (January 2008 to July 2018), written in English, Spanish, French, Portuguese and German. Only experimental studies were included.

The importance of each study was assessed based on the inclusion criteria in Table 2. The studies that did not meet the inclusion criteria were excluded. Both the inclusion of articles and the discrepancies encountered were resolved through agreement between the three researchers that formed part of the systematic review team.

Assessment of the methodological quality

The Physiotherapy Evidence Database (PEDro) was used to assess the quality of the studies. The classification was performed based on three selection criteria (maximum four stars), comparability (maximum three stars) and results (maximum four stars). The articles with scores of eight to eleven were considered to be of high methodological quality, from four to seven moderate, and below four low.

With regards to the scores obtained for the articles using the PEDro scale, two studies received high scores, nine articles were qualified as moderate, and none of the studies were classed as low (Table 3).

Table 2. Inclusion criteria.

Study design	Experimental.
Demographic	Male and female football players (trained - not trained) between 14 and 30 years of age.
Intervention	Training session containing lower body proprioceptive exercises.
Comparator	Studies that generate a certain impact in proprioceptive exercises on preventing injuries.
Results	Incidence rate for injury, changes in sporting performance.
Language	English, Spanish, French, Portuguese and German.
Exclusion	Children and older adults. Studies with other sports. Upper body proprioceptive training. Training sessions that do not contain proprioceptive exercises.

Table 3. List of articles included with scoring based on the PEDro scale.

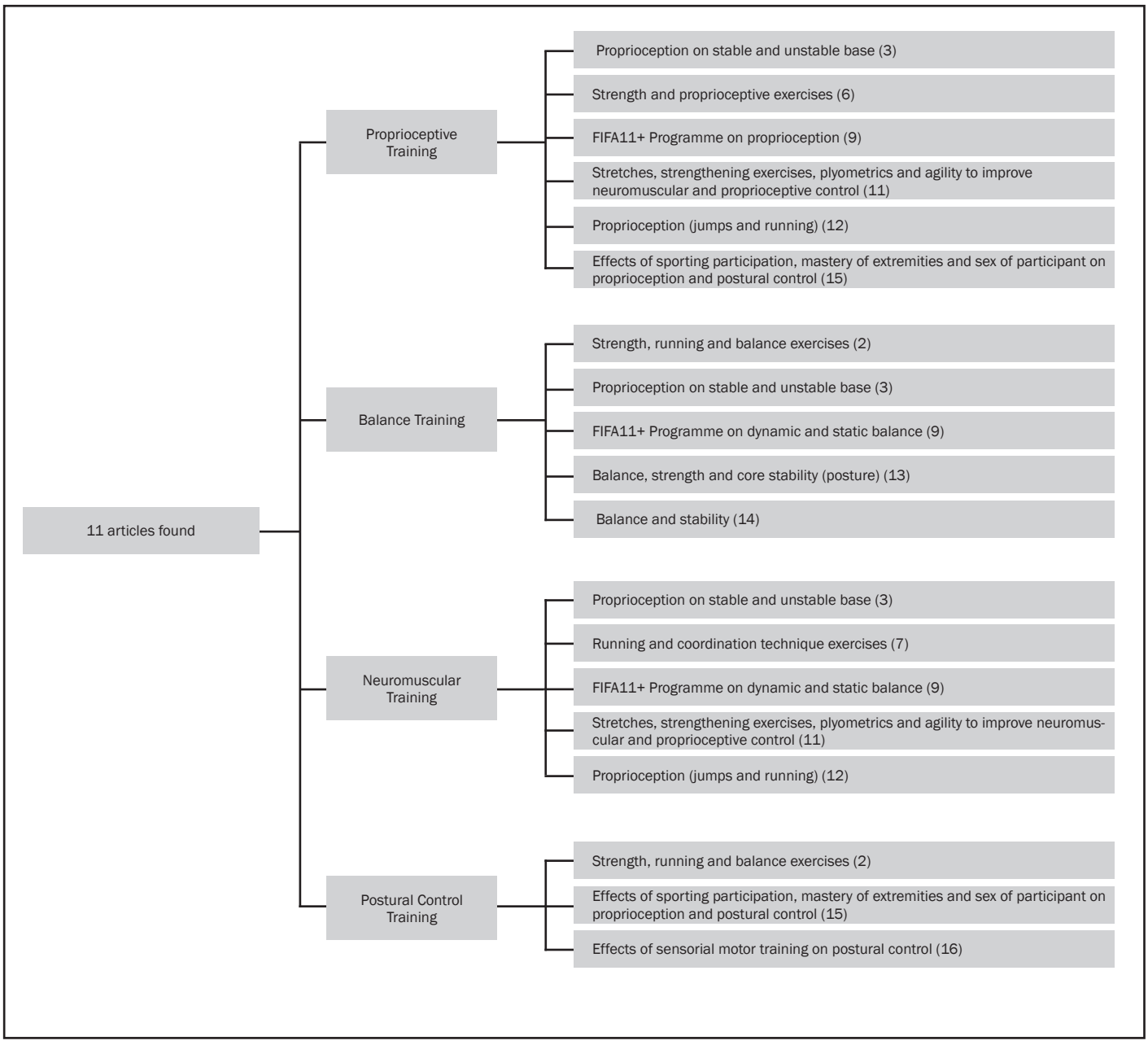
	Selection	Comparability	Results	Total
1 Gilchrist *et al.*[11]	***	****	7	
2 Cameron *et al.*[7]	***		****	7
3 Kraemer & Knobloch[12]	**		****	6
4 Daneshjoo *et al.*[9]	***		****	7
5 Daneshjoo *et al.*[2]	***		****	7
6 Owen *et al.* [13]	***		****	7
7 Donnelly *et al*[14]	****	***	****	11
8 Cug *et al.*[15]	***		****	7
9 González-Jurado *et al.*[3]	***		****	7
10 Heleno *et al.*[16]	****	**	****	10
11 Carlos-Vivas *et al.*[6]	**		****	6

Results

Amount of results available

In the electronic search, 230 articles were identified, of which 95 articles were duplicates. These 135 remaining articles were filtered by title and summaries, leaving 38 articles to be read and analysed thoroughly. After reviewing the 38 articles, 27 were eliminated for not meeting the inclusion criteria. In the search for articles guided by bibliographic

Figure 2. Stratification of the articles in the systematic review.



references, new studies were not included. Thereby, the total amount of studies for the systematic review comprised 11 articles. These articles were stratified depending on the type of intervention:

- Proprioceptive training.
- Balance training.
- Neuromuscular training.
- Postural control training (Table 4 and Figure 2).

It is important to mention that in this stratification, most of the studies found used more forms of training. Despite this, in the description of the programmes, proprioceptive training was reported as the main method used to prevent injuries [3,6,9,11,12,15], as well as balance training[2,3,9,13,14], neuromuscular[3,7,9,11,12] and postural control[2,15,16] (Figure 2).

Significance of the results available

Within the 11 studies selected, regardless of the type of training, sex, level of professionalism, active or sedentary participants, nine revealed significant results in preventing injuries[2,3,6,7,9,11,12,15,16], and in just two there were no significant changes in the prevalence of injuries[13,14].

Table 4. Characteristics and results of the preventive training methods in football players.

Reference	Year	Objectives	Subjects	Variables	Protocol	Results	Performance
Cameron *et al.*[7]	2009	Examine the effect of HamSprint Drills training and conventional Football warm-up on the neuromuscular control of the lower extremities.	M = 26 (EG = 13, CG = 13)	I: PP D: CP	CG: The warm-up performed only comprised stretches, speed work and Football exercises for 30 minutes. EG: During the warm-up, specific HamSprint Drills TP were performed, based on exercises to improve running technique and coordination.	EG ↑ *vs* CG in 0.115 in the area below the curve, equivalent to an improvement of 1.1 in the standard deviation of the programme.	↑
Cug *et al.*[15]	2016	Quantify the effects of sporting participation, the mastery of the extremities, the sex of the subject in postural control and the joint proprioception of the knee.	M = 38 (GFF = 19, GSF = 19) F = 35 (GWF = 17, GSF = 18)	n: TP D: DLA, NDLA, PC	They were assessed with the mSEBT for dynamic control, with 4 trial runs. Participants were asked to place their big toe on the centre of the star and stretch out as far as possible with the other foot, completing the exercise with just one touch. Biodex isokinetic dynamometer for the direction of the joint position at 30°, 45° and 60° from a 90° knee flex.	Within the mSEBT, the posterior medial direction was better in football players compared to sedentary individuals ($p = 0.006$). The anterior direction was better for sedentary individuals than for football players ($p = 0.04$). There were no differences found between sex or dominant extremity.	↑
Daneshjoo *et al.*[2]	2013	Examine the effects of the FIFA11+ and HarmoKnee programmes on performance measurements for professional football players.	M = 36 (EG1 = 12, EG2 = 12, CG = 12)	In:TP D: PhP, Speed, Agility	EG1 (FIFA11+): Exercises comprising 1st run, 2nd Strength, PC and Balance, 3rd advanced run, 3 times a week + normal training. EG2 (HarmoKnee): Exercises of (warm-up, strength, balance and muscle activation) 3 times a week + normal training. CG: Normal training.	EG1 and EG2 ↑ vs. CG in Speed, and Speed with and without ball and Illinois agility tests ($p < 0.005$). Therefore, EG1 improved in jumps, agility and football skill, whilst EG2 improved skills used in football.	↑
Daneshjoo *et al.*[9]	2012	Research the effects of FIFA11+ and HarmoKnee on proprioception and the dynamic and static balance of professional football players.	M = 36 (EG1 = 12, EG2 = 12, CG = 12)	In:TP D: Balance, Flexibility, Proprioception,	EG1 (FIFA11+): Exercises comprising 1st run, 2nd Strength, PC and Balance, 3rd advanced run. EG2 (HarmoKnee): Exercises of (warm-up, strength, balance and muscle activation). Both performed TP 3 times a week with 20 minutes of specific exercises. CG: regular training work. Biodex isokinetic dynamometer for the direction of the joint position at 30°, 45° and 60° from a 90° knee flex.	The proprioception error of the dominant leg ↓ in EG1, in knee flex of 2.8% and 1.7% compared to 3.0% and 2.1% in EG2. Static balance was significantly greater with the eyes open compared to with the eyes closed ($p < 0.000$). There are improvements in SEBT EG1 (12.4%) and EG2 (17.6%).	↑
Donnelly *et al.*[14]	2015	Establish if the technique and balance exercise implemented along with the footballer players' training influences the activation of the muscle that crosses the knee during a planned and unplanned side pass.	M = 28 (BTT = 12, ST = 16)	In: BT D: TE, T, Tec	The training interventions were employed for 20 minutes as a warm-up, twice a week for the first 18 weeks, then once a week until week 28. The BT included ball balance exercises using just one leg, balance discs, and Swiss stability balls.	Non-significant changes in the muscle activation of ST and BTT. At the end of the season, the knee extensor ($p = 0.023$) and semimembranous muscle ($p = 0.006$) increased in both planned and unplanned muscle activation.	=
Gilchrist *et al.*[11]	2008	Examine if the use of an alternative warm-up improves neuromuscular and proprioceptive control and can reduce the number of ACL injuries.	M = 1435 (EG = 583, CG = 852)	In: PP D: I, %I, ACL	EG: They included an alternative warm-up to their work, which included (stretching, strength, polymetric exercises, agility), 3 times a week. CG: They only performed their regular warm-up.	The ACL injury rate was 1.7 times lower in the EG than in the CG (representing ↓ 41%). The non-contact ACL injury rate was 3.3 times lower in the EG than in the CG (representing ↓ 70%).	↑
González-Jurado *et al.*[3]	2016	Compare two proprioceptive training programmes on stable base (EG1) and unstable base (EG2)	M = 18 (EG1 = 9, EG2 = 9)	In: PT D: PC	EG1: Exercise with stable base. EG2: Exercises with unstable base, the same PP was followed, only the work base was changed. The SEBT was tested 3 times for 3 repetitions.	Differences were found in EG1 variables front left; front left side; posterior right and antero-medial right ($p < 0.005$). EG2 front right; front left; right medial posterior; left medial posterior and right medial ($p < 0.005$).	↑
Heleno *et al.*[16]	2016	Assess the benefits of a sensorial motor training programme lasting five weeks on the functional performance and postural control of young football players.	M = 22 (EG = 12, CG = 10	In: TP D: PC, agility, coordination	EG: Football training plus the sensorial motor programme for 5 weeks, 3 times a week (static support exercises for the legs, hops, moving position, exercises with a ball, work sequences and exercises on stable and unstable surfaces). CG: Normal training. Functional tests were carried out: SEBT, SHT and F8 as previous training.	EG obtained significant results in the postural control tests SEBT ($p > 0.05$), agility and coordination examined using the F8 and the SHT ($p > 0.5$ to 0.8) compared to the CG.	↑

(follow)

(continuation)

Reference	Year	Objectives	Subjects	Variables	Protocol	Results	Performance
Kraemer & Knobloch[12]	2009	Establish the effect of proprioceptive training on patella and Achilles tendinopathy	M = 24	In: TP D: I, IT	The first 2003/2004 season was the control period with normal training. In the second 2003/2004 season, BT was applied, consisting in jumping forwards on a base, an obstacle race forwards and back, an obstacle race, side jumps, hopping backwards, among others.	The hamstring injury rate without contact dropped from 22.4 to 8.2 / 1000 hours (p = 0.021), patella tendinopathy from 3.0 to 1.0 / 1000 hours (p = 0.022), and Achilles tendinopathy from 1.5 to 0.0 / 1000 hours (p = 0.035). + training, – general injury rate (r = -0.185, p = 0.001) lower body.	↑
Owen *et al.*[13]	2013	Assess the effectiveness of a muscular injury prevention programme and the total number of injuries in professional football.	M = 26 – 23 (1st season = 26, 2nd season = 23)	In: PP D: I, IT	1st season (2008-2009) with intervention: Multicomponent PP twice a week comprising 4 work stations (balance, functional strength, core stability and mobility). 2nd season: control, without PP.	Intervention season (n = 88 total injuries) > control season (n = 72 total injuries); there is no significance between them (p = 0.21).	=
Carlos-Vivas *et al.*[6]	2017	Verify the effectiveness of a prevention programme on reducing lower body injuries among Amateur Footballers	M = 84 (EG = 40, CG = 44)	In: PP D: T, IT	EG: PP after warm-up twice a week, including strength and proprioception exercises on the main leg muscle groups. CG: Regular practice.	↑ injuries in CG 82.9% vs. 17.1% in the EG, furthermore for every 1000 hours of play the EG obtained 8 injuries vs. 41 in the CG. PP after warm-up, ↓ risk of suffering injuries in the lower extremities.	↑

In: Independent; D: Dependent; M: Male; F: Female; PP: Prevention programme; I: Injury; %I: Percentage of injury; s: Significant; ns: Not significant; CG: Control group; EG: Experimental group; PC: Postural control; p: People; TP: Training programme; PhP: Physical performance; DLA: Dominant leg angle; NDLA: Non-dominant leg angle; NMT: Neuromuscular training; PT: Proprioception training; BT: Balance training; TE: Type of exercise; T: Time; IT: Injury time; Tec: Technical; ACL: Anterior Cruciate Ligament; SF: Sedentary female; SM: Sedentary male; ST: Simulated training; BTT: Balance and technique training; mSEBT: Modified Star Excursion Balance Test; SEBT: Star Excursion Balance Test; : Increase; ¯: Reduce; GMF: Group of male footballers; GSM: Group of sedentary males; GFF: Group of female footballers; GSF: Group of sedentary females; SHT: Side Hop Test; F8: Figure of 8.

Discussion

Prevention programmes

Upon finishing the systematic review, various prevention programmes were found. The vast majority of these programmes focused on the reduction of the injury rate in sport[17,18], especially for knees and ankles[19], but even though the majority of the programmes aimed to prevent injuries, each of the research studies consulted had a different approach[3,9,11,12,15]. As such, Schiftan *et al.*[10] concluded that proprioception training programmes are effective in reducing the rate of ankle sprains, whilst Owen *et al.*[13] recommended a preventive training programme entailing multiple components, which could be appropriate for reducing the amount of muscle injuries sustained in a season. However, and regardless of the detailed description given by the authors mentioned above, preventive programmes must be complemented by recording the movement, with feedback and with constant repetition of the works included in the session, as this set of methodological tools led to changes in the neuromuscular response of the athletes studied[7]. Consequently, some researchers have established that athletes should carry out this kind of training every day[13]. According to Ladenhauf *et al.*[20] and Hottenrott *et al.*[21], for preventive programmes to be successful they should include strength exercises, plyometrics, agility, proprioception, balance and neuromuscular training. In turn, Liebert[22] describes how these kinds of prevention programmes should last for between 15 to 20 minutes, how they should be low cost and easy to implement. According to Rahnama[23], by performing more research studies on the risk factors linked to football, solid advice could be given to players, the team's medical body, the coach and even the referees. This would help reduce injuries, keep players healthy and improve sporting performance. One example of the aforementioned is the FIFA11+ prevention programme (this warm-up methodology lasts for around 20 minutes and comprises three well-defined parts with a total of 15 exercises. It should be applied before training and competition); this prevention programme has proven to be effective in reducing injuries, demonstrating its positive effect on athletes[24].

Neuromuscular training

The main aim of this kind of training is to improve neuromuscular control, based on an increased stability of the joint, and producing muscle co-activation triggering greater stability in the joint[25,26]. It has been proven that neuromuscular programmes have a positive effect on preventing injuries and muscular imbalances. Furthermore, by integrating plyometrics, changes take place in the neural and muscular-skeletal system, increasing sporting performance[27]. Some researchers such as Huebscher *et al.*[28] and Acevedo *et al.*[29], have described how neuromuscular training should contain a combination of balance exercises, plyometrics, agility and strength in the specific sport, and these exercises should allow for feedback from the body mechanics. Adding to the previous description, Huebscher *et al.*[28] and Gilchrist *et al.*[11], mention that proprioception and neuromuscular training have an impact on athletes' injuries, which due to the continued adjustments through the trial-error repetition of the nervous system, have revealed

promising results in terms of reducing injuries. Unfortunately, and based on existing evidence that present a large number of exercises and types of proprioceptive programmes that could be applied, it would be bold to suggest a single routine or proprioceptive programme to follow[11,28]. However, the proposal made by Ergen & Ulkar[30] allows exercises to be performed that do not pose any degree of complexity, for example, working on different surfaces open or closed eyes, and on alternate legs; these exercises - as they are complemented with stretches, muscle strengthening, plyometrics and agility works - could help reduce knee injuries.

Balance training

The core objective of these kinds of training sessions is to develop the athlete's capacity to maintain and control his/her centre of gravity[31]. In turn, postural balance is necessary for the harmonious and adequate development during the game; this is established as multi-sensorial integration[32]. On the other hand, balance training refers to exercises that improve postural stability and promote the mechanisms responsible for the contraction of agonist and antagonist muscles[32]. After finishing the systematic review, no training programmes were found that focused exclusively on the development of balance, rather a collection of preventive exercises that included work on different surfaces with varied degrees of stability[3,14,31], strength exercises, running and balance[2], the FIFA11+ programme on dynamic and static balance[9], balance, strength and core stability (posture)[13]. Once again, it would be bold to suggest a specific routine or balance programme to follow. However, and based on the results given by the authors of the FIFA11+ programme regarding dynamic and static balance[9], it appears to be a preventive training alternative.

Proprioceptive training

Proprioception is a process via which the body takes information provided by the nervous system through afferent and efferent channels[34,35], generating a motor response[36] and thus revealing consistent and unconscious effects on postural balance, stability and muscle sense[37]. Proprioceptive training can be analysed using two channels: the first is linked to the types of activities that can be done, including stretches, strengthening exercises, plyometrics and agility; the second analysis is that these kinds of exercises should be repetitive to achieve correct execution associated with the practice[30]. In this respect, Daneshjoo *et al.*[9] described proprioceptive programmes as a main component of prevention methods for football players, as by reducing the proprioceptive function there is an increased tendency to suffer injuries more easily, which is why it is key to assess and obtain information about the footballer to observe any shortcomings in proprioceptive work, and from that point create prevention programmes tailored to that player. Based on existing information, strength and proprioceptive exercises[6], the FIFA11+ programme on proprioception[9], and others such as stretches, strengthening exercises, plyometrics and agility to improve neuromuscular and proprioceptive control[11], are specific alternatives to be incorporated within preventive programmes for footballers. Unfortunately, not all proprioceptive training programmes have a significant effect on this variable[3]. In a study presented by González-Jurado *et al.*[3], it was reported that after five weeks of applying a training programme using an unstable and stable base, no significant differences were found in a football team ($p > 0.05$). Despite this, evidence reveals that incorporating specific exercises to prevent injuries in the lower extremities after a warm-up reduces the injury rate[6,9,11].

Postural control

Postural control refers to maintaining the centre of mass against the forces of gravity. Postural control is achieved via muscle contractions[38]. Postural control integrates three afferent channels: vestibular, visual and motor sensory[39]. These channels play a fundamental role in the athlete's activities, with particular emphasis on all movements that require keeping balance, which becomes important in the performance of the player[40]. Despite existing evidence not claiming specific tests for postural control, there are claims for an increase in agility, leg strength and football skills after incorporating the FIFA11+ programme as part of the warm-up for football players[2]. Furthermore, Heleno *et al.*[16] assessed the benefits of a motor sensorial training programme lasting five weeks on the functional performance and postural control of young football players. The tests used by the researchers were: the Star Excursion Balance Test (SEBT), the Side Hop Test (SHT) and the Figure-of-Eight Test (F8); after finishing the intervention, the experimental group improved in all the tests[16]. Consequently, postural training programmes revealed improvements in performance. They can also be implemented using readily available equipment and at a low cost.

Conclusion

Upon finishing the systematic review, it was clear that the main methods of preventing injuries in the lower extremities of football players, were proprioceptive training, balance training, neuromuscular training and postural control training. Within these programmes, proprioceptive training stands out as the main or secondary element in preventive programmes, which have been fundamental in reducing the injury rate and in rehabilitating football players following trauma. As such, evidence shows that preventive programmes are easy to apply, short in duration (15 to 20 minutes) and are not necessarily costly to perform[22]. For all the above, injury prevention exercises must be included within training programmes developed for football players.

Practical applications

- In practical terms, and having performed the systematic review, exercises to prevent injuries are a highly useful tool, and offer a wide variety of functions to reduce the risk of injuries in footballers. However, certain aspects must be taken into account:
- Integrate proprioceptive exercises into every preventive programme, as evidence proves that they have good results in preventing injuries, in particular in the knees and ankles of footballers.

- When it comes to implementing a prevention programme, the type of player, his/her history of injuries and the types of exercises that could be applied should be taken into account.
- If it is a proprioceptive preventive programme for a group of footballers, develop a methodological sequence that is suitable to generically cover all the team's needs. Likewise, the types of exercises used should be varied in different sessions.
- Each of the programmes that can be applied should have specialised personnel that possess the skill set needed in order to perform each of the exercises correctly, without risking the integrity of the player.
- Finally, researchers are encouraged to establish new preventive programmes, applying proprioception to the lower extremities of football players so as to reduce injury rates.

Conflict of interest

The authors do not declare a conflict of interest.

Bibliography

1. Márquez Arabia JJ, Ramón Suárez G, Quiceno Noguera C. Lesiones en futbolistas de un equipo sudamericano durante 1 año de seguimiento. *Rev Cuba Ortop Traumatol.* 2016;30(1):65-75.
2. Daneshjoo A, Mokhtar AH, Rahnama N, Yusof A. Effects of the 11+and Harmoknee Warm-Up Programs on Physical Performance Measures in Professional Soccer Players. *J Sports Sci Med*. 2013;12(3):489-96.
3. Gonzalez-Jurado JA, Romero Boza S, Campos Vazquez MA, Toscano Bendala FJ, Otero-Saborido FM. Comparison of a Proprioceptive Training Program on Stable Base and Unstable Base. *Rev Int Med Cienc Act Fís Deporte*. 2016;16(64):617-32.
4. Villaquirán AF, Portilla-Dorado E, Vernaza-Pinzón P. Caracterización de la lesión deportiva en atletas caucanos con proyección a Juegos Deportivos Nacionales. *Univ Salud.* 2016;18(3):541-9.
5. Adalid Leiva JJ. Propuesta de incorporación de tareas preventivas basadas en métodos propioceptivos en fútbol. *Retos.* 2014;7(26):163-7.
6. Carlos-Vivas J, Martín-Martínez JP, Chavarrias M, Pérez-Gómez J. Preventive exercises after warming help to reduce injuries in soccer. *Arch Med Deporte.* 2017;34(1):21-4.
7. Cameron ML, Adams RD, Maher CG, Misson D. Effect of the HamSprint Drills training programme on lower limb neuromuscular control in Australian football players. *J Sci Med Sport.* 2009;12(1):24-30.
8. Jones H., Rocha P.C. *Prevention in ACL Injuries. Sports Injuries*. Berlín, Heidelberg. Springer; 2012. p. 33-42.
9. Daneshjoo A, Mokhtar AH, Rahnama N, Yusof A. The Effects of Comprehensive Warm-Up Programs on Proprioception, Static and Dynamic Balance on Male Soccer Players. *Plos One*. 2012;12;7(12):e51568.
10. Schiftan GS, Ross LA, Hahne AJ. The effectiveness of proprioceptive training in preventing ankle sprains in sporting populations: A systematic review and meta-analysis. *J Sci Med Sport*. 2015;18(3):238-44.
11. Gilchrist J, Mandelbaum BR, Melancon H, Ryan GW, Silvers HJ, Griffin LY, *et al.* A Randomized Controlled Trial to Prevent Non contact Anterior Cruciate Ligament Injury in Female Collegiate Soccer Players. *Am J Sports Med.* 2008;36(8):1476-83.
12. Kraemer R, Knobloch K. A Soccer-Specific Balance Training Program for Hamstring Muscle and Patellar and Achilles Tendon Injuries An Intervention Study in Premier League Female Soccer. *Am J Sports Med.* 2009;37(7):1384-93.
13. Owen AL, Wong del P, Dellal A, Paul DJ, Orhant E, Collie S. Effect of an injury prevention program on muscle injuries in elite professional soccer. *J Strength Cond Res.* 2013;27(12):3275-85.
14. Donnelly CJ, Elliott BC, Doyle TL, Finch CF, Dempsey AR, Lloyd DG. Changes in muscle activation following balance and technique training and a season of Australian football. *J Sci Med Sport.* 2015;18(3):348-52.
15. Cug M, Wikstrom EA, Golshaei B, Kirazci S. The Effects of Sex, Limb Dominance, and Soccer Participation on Knee Proprioception and Dynamic Postural Control. *J Sport Rehab*. 2016;25(1):31-9.
16. Heleno LR, da Silva RA, Shigaki L, Araujo CG, Coelho Candido CR, Okazaki VH, *et al.* Five-week sensory motor training program improves functional performance and postural control in young male soccer players - A blind randomized clinical trial. *Phys Ther Sport.* 2016;22:74-80.
17. Donnell-Fink LA, Klara K, Collins JE, Yang HY, Goczalk MG, Katz JN, *et al.* Effectiveness of Knee Injury and Anterior Cruciate Ligament Tear Prevention Programs: A Meta-Analysis. *Plos One.* 2015;4;10(12):e0144063.
18. Grimm NL, Shea KG, Leaver RW, Aoki SK, Carey JL. Efficacy and Degree of Bias in Knee Injury Prevention Studies: A Systematic Review of RCTs. *Clin Orthop.* 2013;471(1):308-16.
19. Meurer MC, Silva MF, Baroni BM. Strategies for injury prevention in Brazilian football: Perceptions of physiotherapists and practices of premier league teams. *Phys Ther* Sport. 2017;28:1-8.
20. Ladenhauf HN, Graziano J, Marx RG. Anterior cruciate ligament prevention strategies: are they effective in young athletes - current concepts and review of literature. *Curr Opin Pediatr.* 2013;25(1):64-71.
21. Hottenrott K, Gronwald T, Neumann G. Neuromuscular movement control as a predictor for injury prevention. *Sport Orthop Sport Traumatol.* 2011;27(4):274-82.
22. Liebert R. Establishment and Evaluation of an Anterior Cruciate Ligament Injury Prevention Program. *Orthop Nurs*. 2016;35(3):161-71.
23. Rahnama N. Prevention of football injuries. *Intl J Prev Med*. 2011;2(1):38-40.
24. Palazón FJR, de Baranda, MP. Programas de entrenamiento neuromuscular para la prevención de lesiones en jóvenes deportistas: Revisión de la literatura. *Sport TK*. 2017;6(2):115-26.
25. Brito J, Soares J, Rebelo AN. Prevention of Injuries of the Anterior Cruciate Ligament in Soccer Players. *Rev Bras Med Esporte.* 2009;15(1):62-9.
26. Sankaravel M, Lee JLF, Boon OK, Jeganathan S. Effect of Neuromuscular Training on Balance among University Athletes. *Int J Phys*. 2016;3(3):385-9.
27. Medina JÁ, Lorente VM. Evolución de la prevención de lesiones en el control del entrenamiento. *Arch Med Deporte.* 2016;33:37-58.
28. Huebscher M, Zech A, Pfeifer K, Haensel F, Vogt L, Banzer W. Neuromuscular Training for Sports Injury Prevention: A Systematic Review. *Med Sci Sports Exerc*. 2010;42(3):413-21.
29. Acevedo RJ, Rivera-Vega A, Miranda G, Micheo W. Anterior Cruciate Ligament Injury: Identification of Risk Factors and Prevention Strategies. *Curr Sports Med Rep.* 2014;13(3):186-91.
30. Ergen E, Ulkar B. Proprioception and ankle injuries in soccer. *Clin Sports Med.* 2008;27(1):195-217.
31. Eisen TC, Danoff JV, Leone JE, Miller TA. The Effects of Multiaxial and Uniaxial Unstable Surface Balance Training in College Athletes. *J Strength Cond Res.* 2010 07;24(7):1740-5.
32. Soto EM, Álvarez ÉH, Salinas FH, Mondragón LP, Díaz LQ. Efecto de un programa de entrenamiento físico basado en la secuencia de desarrollo sobre el balance postural en futbolistas: ensayo controlado aleatorizado. *Rev Fac Med.* 2013;61(4):339-47.
33. Brachman A, Kamieniarz A, Michalska J, Pawlowski M, Slomka KJ, Juras G. Balance Training Programs in Athletes - A Systematic Review. *J Hum Kinet*. 2017;58(1):45-64.
34. Ogard WK. Proprioception in Sports Medicine and Athletic Conditioning. *J Strength Cond Res.* 2011;33(3):111-8.
35. de Paiva M. Prevenção de lesões em futebolistas através do treinamento neuromuscular e proprioceptivo em membros inferiores. *Rev Bras Prescr Fisiol Exerc.* 2014;8(43):5-13.
36. Rivera MJ, Winkelmann ZK, Powden CJ, Games KE. Proprioceptive Training for the Prevention of Ankle Sprains: An Evidence-Based Review. *J Athle Train*. 2017;52(11):1065-7.
37. Franco NR, Martínez-Amat A, López EJM. Efecto del entrenamiento propioceptivo en atletas velocistas. *Rev Int Med Cienc Act Fís Deporte*. 2013;(51):2-15.
38. Petrocci KE. La medición del control postural con estabilometría - una revisión documental. *Esc Col Rehab*. 2011;1:1-27.
39. Alves BMO, Silva Jr, Rubens Alexandre da, Rosa LM, Mesquita TRd, Oliveira PRd, Burigo RL, *et al.* Postural control analysis during a standardized kick task in soccer athletes. *Rev Bras Med Esporte.* 2018;24(2):89-96.
40. Guimaraes-Ribeiro D, Hernández-Suárez M, Rodríguez-Ruiz D, García-Manso J. Efecto del entrenamiento sistemático de gimnasia rítmica sobre el control postural de niñas adolescentes. *Rev Andal Med Deporte.* 2015;8(2):54-60.