

## FINAL YEAR PROJECT

“PREVENTION STRATEGIES FOR ANKLE INJURIES IN SOCCER: A REVIEW”



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## Abstract

Epidemiological studies have shown that ankle is the most affected body site in the denominated high-risk sports, such as soccer. Nevertheless, extensive data reported significant reductions in ankle injury rates accomplishing injury prevention programs. Although, to some extent, an unpreventable “baseline” of ankle sprain risk exists, current literature supports and suggests the implementation and performance of such preventive measures. In addition, the importance of acquiring basic motor skills during early ages is increasingly emphasized, as this so called “window opportunity” could be used as a long-term injury prevention strategy.

This review was conducted to evaluate the effectiveness of the current existing evidence about strategies in the prevention of ankle injuries in soccer. The key words used for the search method were ankle injury prevention in soccer, soccer+ankle+injury+prevention, ankle sprain prevention and soccer injury prevention, in order to identify available literature in the databases (PubMed, Google Scholar, Scopus and SciELO). First of all, various theoretical dimensions related to the specific structure, risks, and mechanisms of ankle injury in soccer will be addressed. Afterwards, the diverse preventive measures will be exhaustively analyzed; and, finally, a number of methodological bear-in-mind aspects, practical implications and conclusions are proposed.

In conclusion, this review provides a summary of the commonly implemented ankle injury prevention practices in soccer.

## INTRODUCTION

Soccer, or football, as it is known in much of the world, is without question the most popular participant and spectator team sport worldwide (Surve et al., 1994; Söderman, 2000; Volpi et al., 2004; Soligard et al., 2008; Kirkendall & Dvorak, 2010; van Linschoten, 2015). This game holds the highest participation rate in the world (Ergen & Ulkar, 2008; Junge & Dvorak, 2004), is played in more than 150 countries (Surve et al., 1994) and current data indicates that over 265 million players (Jones, 2014) actively participate in official matches and perform soccer trainings, including both sexes and across all age groups (Larsen et al., 1996). It is estimated that, within this range of people, there are 240 million recreational and amateur-level players engaged in non-registered soccer playing (van Linschoten, 2015), and about 200.000 professionals (Schmikli et al., 2010) affiliated to the International Federation of Football Associations (FIFA) (Volpi et al., 2004). In addition, the number of participants is continuously growing, in particular the number of women players, which is rapidly increasing (Soligard et al., 2008). This current growth is due to the rise in women's soccer as well as the soccer's increasing popularity in countries where it does not have a strong historical tradition such as China, United States or India (Kirkendall et al., 2010). Based on the previously mentioned, it could be affirmed that no other single event comes close to the impact this organized sport has all over the world (Kirkendall & Dvorak, 2010).

Moreover, sports participation is accompanied by risk of injury (Kirkendall & Dvorak, 2010), in the case of soccer, it is about a contact sport associated with a large number of injuries in both male and female players (Söderman, 2000). As Kirkendall et al. (2010) previously mentioned: "any increase in participation within a sport will be accompanied by an increase in the number of injuries and will likely have a public health impact". Since soccer became more popular and attracts many participants (Söderman, 2000), risk of injury substantially increased, leading to high injury profiles (van Linschoten, 2015) besides high sanitary costs (Schmikli et al., 2010).

Sports injuries result in pain, loss of playing, other residual problems such as instability, as well as medical expenditure (Fong et al., 2007). Parkkari et al. (2001) already reported that: “since treating sports injuries is often difficult, expensive and time consuming, preventive strategies and activities are justified on medical as well as economic grounds”. One of the goals of the sports medicine professional is injury prevention, therefore, as a result of these undesired adverse effects, sports physicians and medical specialists should be actively working on minimizing the risk of injury to keep players in a competitive state (Fong et al., 2007; Kirkendall & Dvorak, 2010).

It is important to mention that each specific sport has its own unique injury profile (Kirkendall & Dvorak, 2010). Soccer, while being a typical “lower extremity sport”, presents huge injury rates especially to the ankle (van Linschoten, 2015), many of which are preventable. Although “the recognition of injury patterns and the increasing clinical and radiological knowledge has led to an increased care of the injured soccer player” (van Linschoten, 2015), unfortunately, ankle injury prevention strategies field requires further investigation and supporting evidence.

Definitely, introducing preventive measures is of paramount importance. Nevertheless, actual sports behavior may be conflictive regarding the introduction of these measures because “this implies a change or modification of behavior of the athlete” (Parkkari et al., 2011). Nowadays, many players keep on believing that the preventive behavior will negatively affect their performance (Parkkari et al., 2011). Therefore, when introducing and evaluating the effect of preventive measures one must be based on knowledge, this is, on epidemiological research. Changing this mindset is necessary, and effectiveness demonstration is the way to achieve the goal.

In spite of the non-existing consensus about study design, data collection or injury definitions, it is crucial to continue studying possibilities for injury ankle injury prevention (Söderman, 2000; Öztekin, 2011; Parkkari et al., 2011). In this review, the focus will be pointed in ankle injury prevention strategies in soccer.

## Search Strategy

In order to perform this review, several of the most prestigious scientific searching websites were consulted:

- PubMed
- Google Scholar
- Scopus
- SciELO

It should be pointed out that, as this is not a meta-analysis or a systematic review, a literature search methodology, strictly delimiting dates or following an exclusion criterion, was not established. However, somehow, the following aspects/criteria were considered in order to discard/select the papers included in the review:

- If the study was performed with soccer players or not.
- If the study was related to overall, lower extremities, or ankle injury prevention strategies; or not.
- If the full-text was available for free internet download or not.
- If the articles were written in English, Spanish, or not.
- Any publication date was valid.

## Key Words

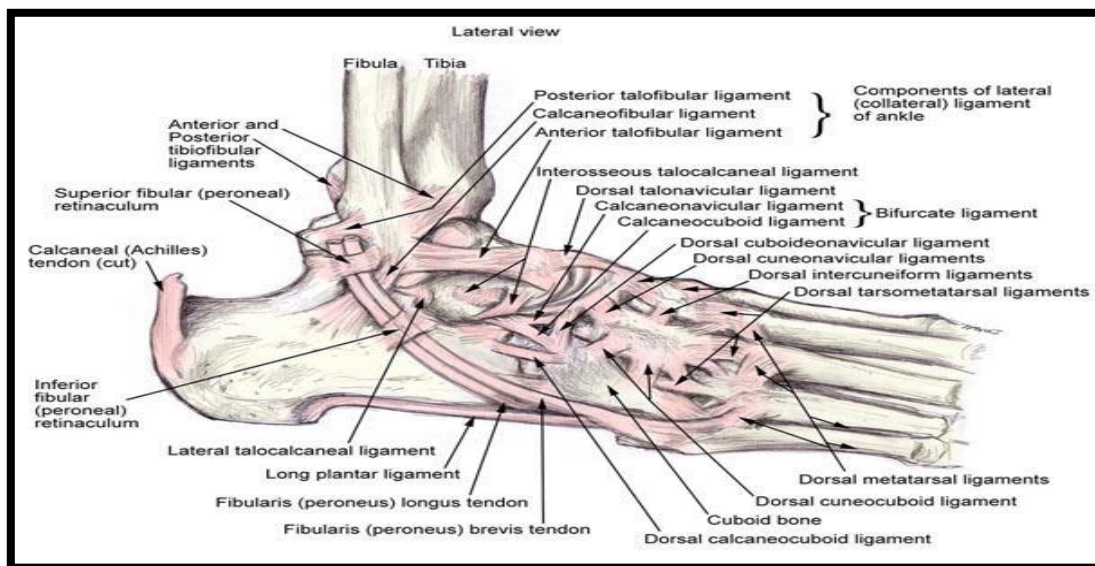
In regards to the key words, the following chart includes the words, as well as the combinations used for the search:

CONCEPT 1	CONCEPT 2	CONCEPT 3
Soccer AND	Ankle injury AND	Prevention
Soccer players AND	Ankle sprain AND	Prevention Strategies

## ANATOMY OF THE ANKLE

A thorough knowledge of the ankle anatomy and biomechanics of the ligamentous complexes is absolutely necessary for prevention, diagnosis and adequate treatment of ankle injury (Golanó et al., 2014).

Golanó et al. (2014) referred to the talocrural or ankle joint as a load-bearing joint formed by the distal tibia and fibula, as well as the superior talus. These surfaces morphology forms a hinge-type synovial joint with single movement axis (bimalleolar axis) that allows two movements in the sagittal plane: dorsiflexion (flexion) and plantar flexion (extension). The range of ankle motion is variable. The bones are connected by a fibrous capsule with a singular characteristic: the anterior capsular insertion in the tibia and talus occurs at a distance from the cartilaginous layer; which belies to talotibial spurs formation. The stability of the ankle is determined by passive and dynamic factors. The passive stability depends on the contour of the articular surfaces, the articular capsule and the integrity of the collateral ligaments, and the retinacula around the joint. The dynamic stability is conferred by the muscle action mainly.

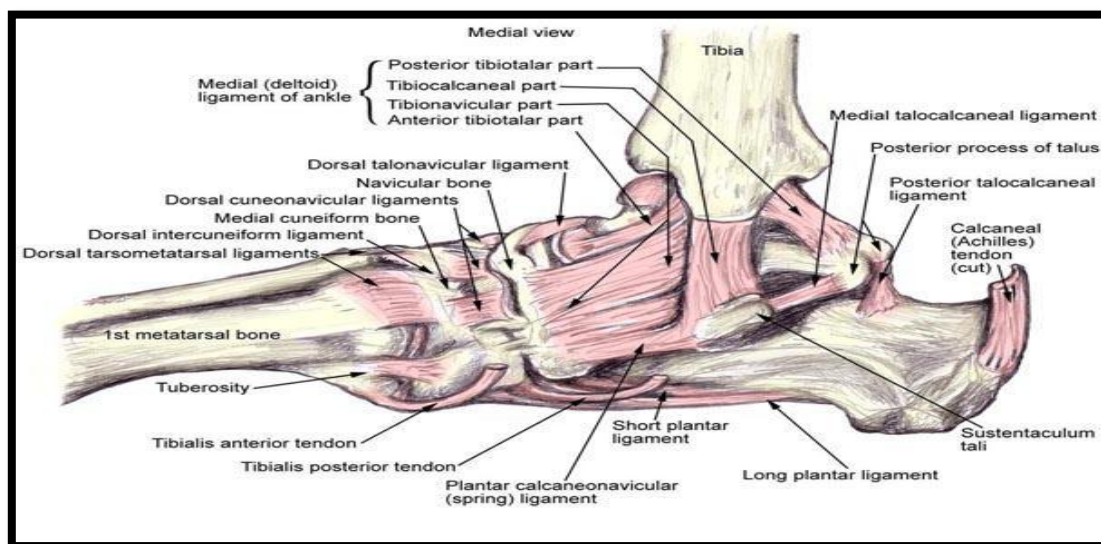


**Figure 1.** Anatomy of the lateral ankle ligamentous complex and related structures (Hoagland, 2013).



In reference to the ligamentous complexes, Golanó et al. (2014) divided the structures involved into two sections, in order to simplify the description:

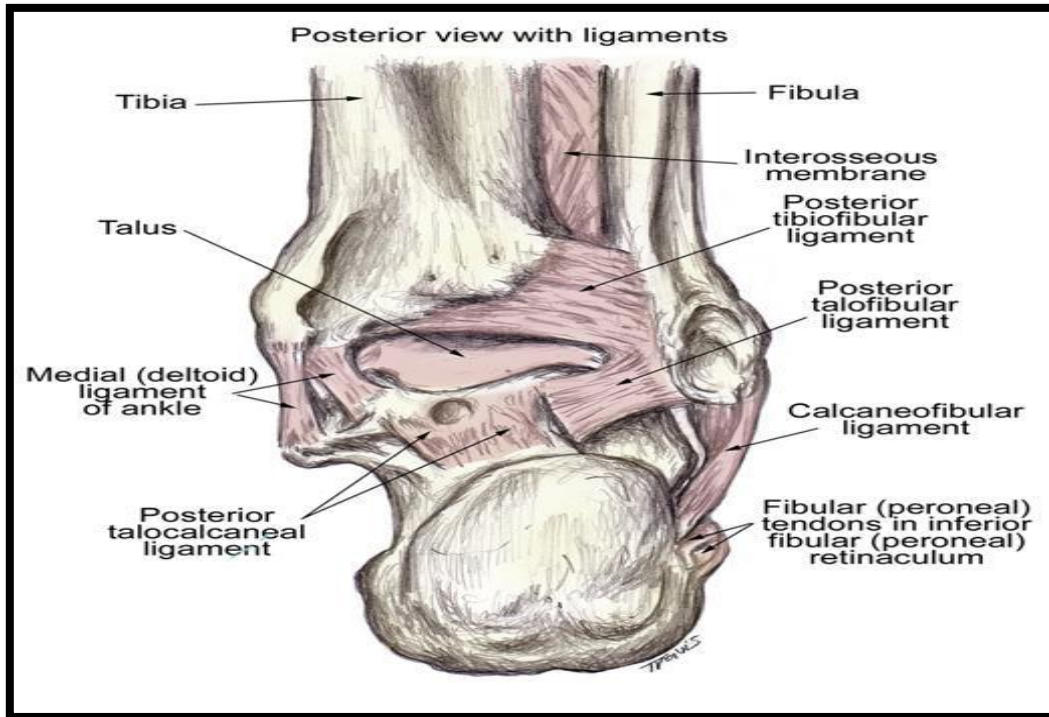
- **Ligaments that join the distal epiphyses of the leg bones (tibia and fibula):** the ligaments of the tibiofibular syndesmosis:
  - Anterior or Anteroinferior Tibiofibular Ligament (AITFL)
  - Posterior or Posteroinferior Tibiofibular Ligament (PITFL)
  - Interosseous Tibiofibular Ligament (ITFL)
- **Ligaments that join the tibia and fibula to the skeletal structure of the foot:** the lateral collateral ligament and medial collateral ligament:
  - **Lateral Collateral Ligament:**
    - Anterior Talofibular Ligament (ATFL)
    - Calcaneofibular (CFL)
    - Posterior Talofibular Ligament (PTFL)
  - **Medial Collateral Ligament:**
    - Superficial Deltoid Ligament
    - Deep Deltoid Ligament



**Figure 2.** Medial ankle view showing the ligamentous anatomy of the deltoid ligament and related structures (Hoagland, 2013).



The anterior talofibular ligament is the main stabilizer on the lateral aspect of the ankle, limiting the anterior translation and internal rotation of the talus. Because most ankle sprains occur by inversion, this ligament is the most frequently injured, and it has been involved in the soft-tissue impingement syndrome and the micro-instability and the major instability of the ankle (Golanó et al., 2014).



**Figure 3.** Posterior view of the ligaments of the ankle (Hoagland, 2013).

## RISK FACTORS

Several studies reported the highest injury percentages in sports involving sudden stops, vigorous jumping and landing, cutting maneuvers... such as soccer, which is known to be associated with relatively high injury rates (Gross & Liu, 2003; Ergen & Ulkar, 2008). It is such the substantial risk of injury that entails playing soccer, from 13 to 35 injuries per 1.000 played-hours of competition (Öztekin, 2011), that is shown to be almost 1.000 times higher than for some regarded high-risk industrial occupations (Ergen & Ulkar, 2008). Researches on elite and non-elite players have reported similar injury rates between men and women, although women are even at a higher risk of severe injuries than men, e.g.: anterior cruciate ligament injuries rate is three to five times higher in girl soccer players (Soligard et al., 2008).

Injury risk is present both during training (pre-seasonal and seasonal) as well as during competitions; being the ankle, knee, thigh and calf muscles the most predominantly affected locations (Öztekin, 2011). Anyway, the literature related to risk factors for ankle injuries, undoubtedly suggests the ankle joint as the most common location of injury (Verhagen & Bay, 2010). This means that the ankle could be considered as the most endangered body site in soccer.

Even though the incidence and pattern of ankle injury in soccer (type, localization and severity) has been described in detail, much less is known about risk factors. As a consequence, targeting players for specific preventive training programs becomes challenging (Engebretsen et al., 2008).

Some of those factors associated with sports injury risk were presented by Parkkari et al. (2001), stressing that “sports injuries are multi-risk phenomena with various risk factors interacting at a given time”. So, in our case, this should be applied to ankle injuries. As a starting point, factors associated with ankle injury proneness can be classified into two groups: intrinsic and extrinsic factors.

Below, most common injury risk factors for ankle injury in soccer will be addressed.

## **INTRINSIC FACTORS**

- 1) History of Previous Injury: this was affirmed by McKeon & Mattacola (2008) to be the primary predisposing factor for suffering an ankle sprain and supported by other many authors (Surve et al., 1994; Gross & Liu, 2003). Soccer players, ankle sprained within the previous 12 months, have two times higher probabilities of sustaining a recurrent ankle sprain compared to non-injured ones (McGuine & Keene, 2006) even five times higher because of an increased frequency of lateral instability (Arnason et al., 2004). Some authors reported another interesting datum, which is that approximately 20-50% (McKeon & Mattacola, 2008) or 30-70% (Hupperets et al., 2009) of the players who suffer a first-time ankle sprain develops chronic ankle instability (CAI), osteoarthritis (Surve et al., 1994) or chronic pain (Osborne & Rizzo, 2003; Verhagen & Bay, 2010). It is usually assumed that soccer players who suffer an ankle sprain will be reinjured to the same ankle, which is mainly common (Verhagen & Bay, 2010). However, as Söderman et al. (2000) glimpsed in their study, re-injured players do not necessarily suffer the same type as the previous ones. Jones (2014) also stated that any previous injury to other muscle groups in the lower extremity increases injury rates, this means that an injury in other body site may affect ankle ligaments and result in first time injuries.
- 2) Inadequate Rehabilitation or Incomplete Healing: this point could be closely related to the previous one, but it has to be said that previous injury as a risk factor is not fully understood (Engebretsen et al., 2008). Various authors supported this observation (Inkelaar, 1994; Dvorak et al., 2000; Ergen & Ulkar, 2008; Öztekin, 2011) suggesting that when joints or muscles, in this case the ankle, are not structurally and/or functionally fully restored, this entails injury risk. Söderman et al. (2000) studies showed that a player having recovered from one injury may be more prone to sustain another one; this warns us that even if a player is asymptomatic from the previous injury he or she might not

be completely healed. It also must be considered that many minor injuries lead to major ones (Söderman et al., 2000; Woods et al., 2003). In conclusion, getting back full physical fitness before returning to competition must be of paramount importance for the soccer player, and not only feeling free of symptoms from the injury.

- 3) Age: various authors identified that the risk of injury seemed to be influenced by the player's age (Engebretsen et al., 2008; Öztekin, 2011). Arnason et al. (2004) confirmed this assumption after carrying out one of the largest cohort studies from elite soccer players, reporting the age as the main risk factor for ankle injuries together with previous injury history.
- 4) Gender: this variable was also identified as an ankle injury risk factor, (Gross & Liu, 2003; Engebretsen et al., 2008; Öztekin, 2011) depending on the population under consideration (Gross & Liu, 2003).
- 5) Level of Competition/Technical Level: players who hold a high technical level seem to present lower ankle injury predisposition (Volpi et al., 2004). Apparently, level of competition also influences ankle injury risk (Gross & Liu, 2003; Engebretsen et al., 2008; Öztekin, 2011; Jones, 2014). As the competition level is greater, technical players level is supposed to be higher too, and consequently lower injury rates would take place. However, as previously mentioned, sports injuries are multi-risk phenomena, and in this case this variable could be positively and negatively influenced by extrinsic factors such as training/playing fields' condition, fixture congestion, speed of play...
- 6) Anatomical or Biomechanical Factors: some variables such as anthropometric values (excessive height or weight) (Parkkari et al., 2001; Gross & Liu, 2003); ankle instability (Ergen & Ulkar, 2008; Öztekin, 2011); joint laxity (Ergen &

Ulkar, 2008) although Thacker et al. (1999) did not associate it with risk; decreased range of ankle joint dorsiflexion (Surve et al., 1994); inflexibility, leg muscle weakness or tightness (Söderman et al., 2000; Parkkari et al., 2001; Öztekin, 2011); dominant side, because the main injury mechanisms generally involve the dominant leg (Woods et al., 2003); postural sway (Woods et al., 2003); anatomic misalignment (Ergen & Ulkar, 2008); predisposing diseases and idiopathic or acquired abnormalities in the joint anatomy or biomechanics (Parkkari et al., 2001); predispose soccer players to suffer ankle injuries. In the case of postural instability and talar tilting more research is needed because Thacker et al. (1999) referred to them as less clear-cut risk factors.

- 7) Reduced Physical Capacities: examples of these factors are reduced lower extremity strength (Ergen & Ulkar, 2008); lack of balance and coordination (Jones, 2014); proprioceptive deficits that may result in slow onset activation of ankle joint crossing muscles (especially evertors – peroneal for example – but also invertors), which results in muscle weakness, chronically unstable ankles and increased re-injury probability (Mohammadi, 2007; Öztekin, 2011). Previously mentioned impairments would be related to lack of training, overtraining, and incomplete recovery and so on.

## **EXTRINSIC FACTORS**

- 1) Playing Surface: uneven ground surfaces suppose a risk factor for lateral ankle sprains in soccer players (Gross & Liu, 2003). On the contrary, safe and well keep fields, free of unnecessary hazards, act as preventive factor (Thacker et al., 1999; Volpi et al., 2004). The difference between playing in grass or artificial turf fields also plays a role (Öztekin, 2011). Other authors like Surve et al. (1994) also supported this factor as influential in ankle sprain recurrence, advocating the necessity to carry out more rigorous scientific review about the matter.

- 2) Speed of Play: modern soccer is characterized by a faster speed of play in comparison with the past, in the sense of higher percentages of quick movements and actions, which inevitably translates into an increased playing intensity (Volpi et al., 2004).
- 3) Protective Equipment: various scientists warned about the importance of wearing protective equipment (e.g.: shin guards) in sports where the frequency of violent contacts is high, like soccer. Improvements in equipment could be traduced into reduced ankle injury rates (Parkkari et al., 2001; Öztekin, 2011).
- 4) Competition: soccer players usually spend more time in training than competing; however, injury risk is six to seven times increased during competition in comparison with training sessions. So it is evident that competitions involve a higher risk of injury per hour than training (Parkkari et al., 2001; van Linschoten, 2015).
- 5) Training: although lower than the competition, training also carries risk of injury. Parkkari et al., (2001) addressed that the type, frequency, intensity and duration of the training session plays a major role in the etiology of overuse injuries.
- 6) Warm-up and Cool down: insufficient warm-up and stretching, irregular cool down and other post-exercise strategies omission could be associated to increased injury possibilities (Öztekin, 2011).
- 7) Game Rules: coaches are responsible for players' preparation in regards to competitive activities (Thacker et al., 1999). However, during competition, the involvement of target groups such as referees and official representatives is desirable to control and minimize unnecessary or violent contacts, making soccer a safer game (Öztekin, 2011). Supervision of the game laws and



changes/improvements in rules are important aspects that can influence the prevention of soccer injury (Öztekin, 2011; Parkkari et al., 2011).

- 8) Foul Play: was found to be a risk factor, as it was associated with 40% of ankle sprains in soccer (Waldén et al., 2013).
- 9) Sport Requirements: the sport requirements, in this case sudden stops, vigorous jumping and landing or cutting maneuvers, place individual risk for ankle sprain injury (Gross & Liu, 2003).
- 10) Footwear: foot type may also be included as an extrinsic factor involved in ankle injuries (Surve et al., 1994; Ergen & Ulkar, 2008).
- 11) Technical and Tactical Innovations: in the line with speed of play; looking at the increasing use of close marking, offside, double marking and other tactics, which are applied at maximal intensity, without question can be affirmed that carries risk of both acute and chronic overuse injuries (Volpi et al., 2004).
- 12) Fixture Congestion/Lack of Training: rest and recovery are vital when related to injury prevention, this means that playing multiple games in shorts periods of time; changes in the quality and quantity of weekly training sessions; unbalanced training/match ratio... appear to be related to higher injury risk (Volpi et al., 2004). However, lack of training is also related to augmented injury risk (Surve et al., 1994). Jones (2014) commented that, in professional soccer players, fixture congestion increased total injury rates but did not seem to affect overall team performance. Therefore, the relationship between team performance and injury is important; because successful teams have lower injury burden – including both incidence (frequency of injury/hours of exposure) and severity – and higher match availability (Jones, 2014).
- 13) Others: there are other aspects that would also carry risk of injury like score celebrations (Zeren & Öztekin, 2005).

It also should be considered that authors like McGuine & Keene (2006) evaluated the effect of some previous mentioned variables on the rate of ankle sprains (e.g.: gender, type of sport, leg dominance or ankle laxity) and did not found any significant effect.

To conclude this section, Parkkari et al. (2001) mentioned in their article that many sports injuries are the result of unavoidable accidents, however many others could be prevented and this is the area we must work in.

**Table 1.** Extrinsic and Intrinsic Factors for Sports Injuries (adapted from Parkkari et al., 2001)

EXTRINSIC FACTORS	INTRINSIC FACTORS
<i>Exposure</i>	<i>Physical characteristics</i>
Type of Sports	Age
Exposure Time	Gender
Level of competition	Somatotype
<i>Training</i>	Previous injury
Type	Physical fitness
Amount	Joint mobility
Frequency	Muscle tightness, weaknesses
Intensity	Ligamentous instability
<i>Environment</i>	Anatomic abnormalities (misalignments)
Type of playing surface	Motor abilities
Indoor vs. outdoor	Sports-specific skills
Weather conditions	<i>Psychological profile</i>
Time of season	Motivation
Human factors (team mates, opponent, referee, coach, spectators)	Risk taking
<i>Equipment</i>	Stress coping
Protective equipment	
Playing equipment (footwear, clothing...)	

## INJURY INCIDENCE

Soccer is considered to be a relatively safe sport because of the low incidence of serious injuries (Froholdt et al., 2009). Nevertheless, only in Europe, taking into account the whole number of sports-related injuries, soccer is responsible for 50-60% (Maehlum & Daljord, 1984). This means that we are truly referring to a risky sport because, as soccer's incidence rate per 1000 hours of exposure varies between 4 and 8 injuries (Ekstrand et al., 2011; Dauty & Collon, 2011), its' injury incidence is located among the highest of all sports (Schmikli et al., 2010).

Garrick & Requa (1988) conducted a review analyzing the prevalence of ankle injuries among 70 different sports. Their results showed how ankle injury was the most dominating type of injury in the majority of sports. In the case of soccer, in terms of 1000 person-hour incidence, 1000 person-season incidence, as well as in general, competition and training; it presented the highest injury incidences. However, as Kirkendall & Dvorak (2010) reported, "it is difficult to measure soccer's ranking in terms of overall injury rate compared with other sports because of different study methods used in defining injury and severity, reporting of rates, and comparing different ages, genders and performance levels".

What it can be affirmed with no doubt is that lower extremities are the most affected body site because of the game nature, in which legs are used to control and advance the ball, with a 70% of injury incidence (Söderman et al., 2000; Junge et al., 2004; Fong et al., 2007). In particular, Ekstrand & Gillquist (1983a) reported that most of the lower limb injuries were to the ankle, with an estimated 10-30% of all injuries (Dizon & Reyes, 2010). Even more specifically, ankle sprains, which involve ligament damage, are the most common injury in both adolescent and adult female and male soccer players (McMaster & Walter, 1978; Ekstrand & Tropp, 1990; Inklaar et al., 1996; Thacker et al., 1999; Osborne & Rizzo, 2003; Mohammadi, 2007; Ergen & Ulkar, 2008; McKeon & Mattacola, 2008; Verhagen & Bay, 2010), followed by sprains to the knee, contusions and muscle strains (hamstrings and groin strains) (Öztekin, 2011; van Linschoten, 2015). Other authors, as Jones (2014), diagnosed contusions

as the most commonly suffered ones, especially by juniors (Schmikli et al., 2010); however, their impact in the time of absence is minimal.

In comparison with other sports soccer shows the highest rates of ankle sprains (Fong et al., 2007), with percentages that fluctuate from 11% to 32% (Lewin, 1986; Nielsen & Yde, 1989; Ekstrand & Tropp, 1990; Arnason et al., 1996; Woods et al., 2003). Due to the particular characteristics of the sport, it takes place a prevalence to suffer ankle inversion sprains (Ekstrand & Tropp, 1990), which suppose approximately a 67-85% of the total sprains (Sandelin et al., 1985; Lewin, 1986; Surve et al., 1994; Hawkins et al., 2001). These injuries tendency is to mainly involve the lateral ligament complex (Seligson et al., 1980), which presents over three quarters incidence, in other words, 77-80% of total sprains (Garrick, 1977; Hawkins et al., 2001), and only 5% being high ankle sprains (Jones, 2014). This previously mentioned complex comprises the anterior talofibular (ATFL), calcaneofibular (CFL) and posterior talofibular ligaments (PTFL). On the one hand, apparently, the most affected portion is the ATFL, with a 73% of the cases, and usually involving ligament's rupture or tear (Woods et al., 2003). However, Jones (2014) reported a threefold-higher incidence of posterior ankle impingement in comparison with anterior ankle impingement. This could be defined both as interesting and surprising, given that anterior ankle affection, also called soccer players' ankle, was expected to be more common and problematic (Waldén et al., 2013). On the other hand, injuries to the medial or deltoid complex accounted for only 10-14% of ankle sprains. This fact was hardly surprising when soccer demands include ball kicking with the foot inside part as well as receiving tackles in this body site (Clanton & Porter, 1997; Woods et al., 2003). Ultimately, the structures which generally constitute the ankle syndesmosis, i.e.: anterior and posterior tibiofibular ligament and interosseous membrane, present a low injury incidence in soccer players (about 3-4%) (Renström & Konradsen, 1997; Woods et al., 2003). For purposes of clarification, if we consider the Achilles tendon injuries within the ankle injuries family, Schmikli et al. (2010) noted that this injuries were not common in soccer but require medical treatment.

Below, a number of typical characteristics usually shown in soccer players' ankle injuries will be displayed.

### **Gender, Age, Exposure & Level of play**

Gender differences in the ankle injury risk are small, while more pronounced in the case of age and level of play (Parkkari, 2001).

- **Gender**: firstly, in relation to gender, Soligard et al. (2008) agreed with the previous mentioned fact, reporting that elite and non-elite female soccer players have shown similar injury rates to those in men.
- **Age, Playing and Exposure Levels**: secondly, in regards to age and playing level, although few researches have been conducted about recreational youth players, where there is the highest level of participation, Kirkendall & Dvorak (2010) affirmed that ankle injuries tend to be more commonly seen in youth and lower levels of play. Sullivan et al., (1980) supported this idea, reporting that, from total injuries, percentage of ankle injuries in youth soccer was even higher than normal values in other sports (41%).

On the contrary, Parkkari (2001) says that injuries are less frequent in children comparing with adults, a fact backed by Schmikli et al. (2010). These authors conducted a study aiming to identify specific target subgroups that would benefit from injury prevention programs and found that age categories and exposure levels were significantly related to the incidence of soccer injuries. Their results concluded that multiple target groups may exist, possibly demanding different preventive strategies; but, primary, senior male soccer players (18-34 years) with highest exposure levels, and secondly, junior players (4-17 years) also with high participation levels, were significantly related to the incidence of soccer injuries.

### **Time of Absence**

Garrick & Requa (1988) described ankle injuries as the ones leading to longest absence from athletic activity comparing to other types of sports injuries. In the same

way, Kirkendall & Dvorak (2010) considered ankle injuries as the top time-loss injuries in soccer, regardless of playing level. As Hawkins et al., (2001) commented “the impact of an injury on a club can be considered in relation to its severity and the number of potential competitive matches missed”. Depending on the author, different ankle injury-related participating absence times have been reported. In the case of Söderman (2000), most soccer ankle injuries were graded as minor (< 7 days lost). By contrast, both Woods et al. (2003) and Schmikli et al. (2010), documented an average absence duration of 18 days and three games missed per ankle sprain, both in junior and senior players; whilst Ekstrand and Gillquist (1982) stated four weeks as the mean absence time from training. Distinguishing between recurrent ankle sprains and primary ones, Woods et al. (2003) did not find any significant difference in the average number of practice days and matches missed per ankle sprain in soccer players (19 days and 4 matches vs. 18 days and three matches).

Finally, based on the FIFA and UEFA’s such large information databases, as well as on the recently injury tracking emphasis, some authors calculated a team’s injury average per season. Ekstrand et al. (2011) reached to the conclusion that a professional 25-player soccer team could expect an average of two injuries per player. In other terms, as Eirale et al. (2013) explained, 12% of the team may be unavailable at any season point due to injury.

### **Time/Moment of the Injury**

Hägglund (2007) reported an injury incidence in adult male soccer players ranging from 1.8 to 7.6 injuries per 1000 training hours and from 10.2 to 35 injuries per 1000 match hours. Undoubtedly, Schmikli et al. (2010) came to the conclusion that most of the injuries occur during competition. In the case of ankle injuries, Woods et al. (2003) concluded from their investigations that more ankle sprains were sustained in soccer matches rather than in training sessions (66% vs. 33%). What is more, although there were no significant differences between the number of ankle sprains sustained in the first and second halves of matches, nearly half of them were observed during the last third of each half (Woods et al., 2003).



## **First-Time Injury or Re-Injury**

Soccer players who suffer an ankle sprain are more likely to sustain a recurrent injury to the same ankle (Ekstrand & Gillquist, 1983a; Mohammadi, 2007; Verhagen & Bay, 2010). Even though Schmikli et al. (2010) concluded from their study that most injuries were new (81.5%) and re-injuries accounted for 18.5% of the total, many authors have reported a high recurrence rate of ankle sprains (Ekstrand & Gillquist, 1983a; Tropp et al., 1985a; Ekstrand & Tropp, 1990). In the case of Woods et al. (2003) the recurrence rate for ankle sprains obtained from their study was of 9%, while Hawkins et al. (2001) found that the 76% of ligament sprain recurrences during a soccer whole season were to the ankle. Although not significant, Woods et al. (2003) registered more non-contact re-injuries than first time injuries (47% vs. 39%). As a last point, re-injuries showed a tendency to be treated medically more often than new injuries (Schmikli et al., 2000). As Woods et al. (2003) commented, “it is the incidence rather than severity of ankle sprains that makes them problematic injuries”; also suggesting that the rehabilitation period is usually shorter than recommended, so the injury might not had enough time to heal completely, which may explain the high expected ankle injury recurrence rate.

## **Acute or Chronic**

Acute injuries chiefly dominated with an 89.6% of all injuries, as Schmikli et al. (2010) pointed out, with gradual and insidious onset injuries accounting for the remainder.

## **Dominant & Non-Dominant Incidence**

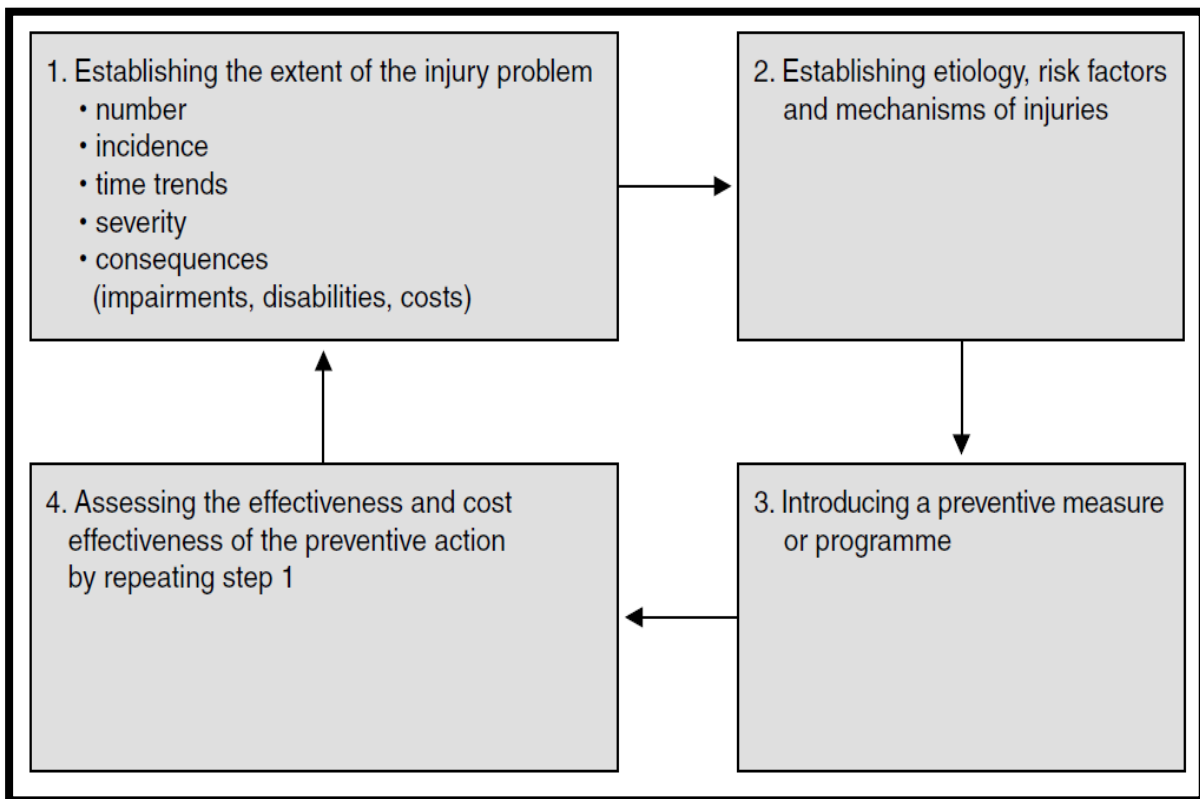
Although some studies have shown not significant differences between dominant and non-dominant leg injuries (Woods et al., 2003), other ones identified these significant differences (Ekstrand & Gillquist, 1982; Ekstrand & Gillquist, 1983a; Surve et al., 1994), not between divisions but extremities (ankle) dominance.

It is important to note that a higher incidence rate does not necessarily mean higher severity of the sports injury; it only reports the frequency of injury occurrence but does not report the severity of each injury (Fong et al., 2007).

## INJURY MECHANISM

The previously displayed sobering numbers about injury incidence in soccer help to highlight the importance of the medical staff in a team. Provided that the medical personnel succeed in reducing injury rates and injury time-off, this could significantly impact on team performance (Jones, 2014). So, in the case of soccer, it is essential, taking into account the high incidence of ankle injuries, to analyze which are the mainly injury mechanisms in order to adopt preventive measures (Fong et al., 2007).

Many authors have echoed this necessity of identifying the mechanisms and factors involved in the injury, just after having defined the extent of the problem (Parkkari et al., 2001). The final step would be introducing and monitoring the effect to the measures likely to reduce the injury risk.



**Figure 4.** The sequence of prevention of sports injuries (adapted from van Mechelen, 1997)

Therefore, in order to achieve our goal of preventing ankle injuries, identifying the mechanisms that provoke these lesions is of paramount importance. Below a comprehensive analysis will be accomplished.

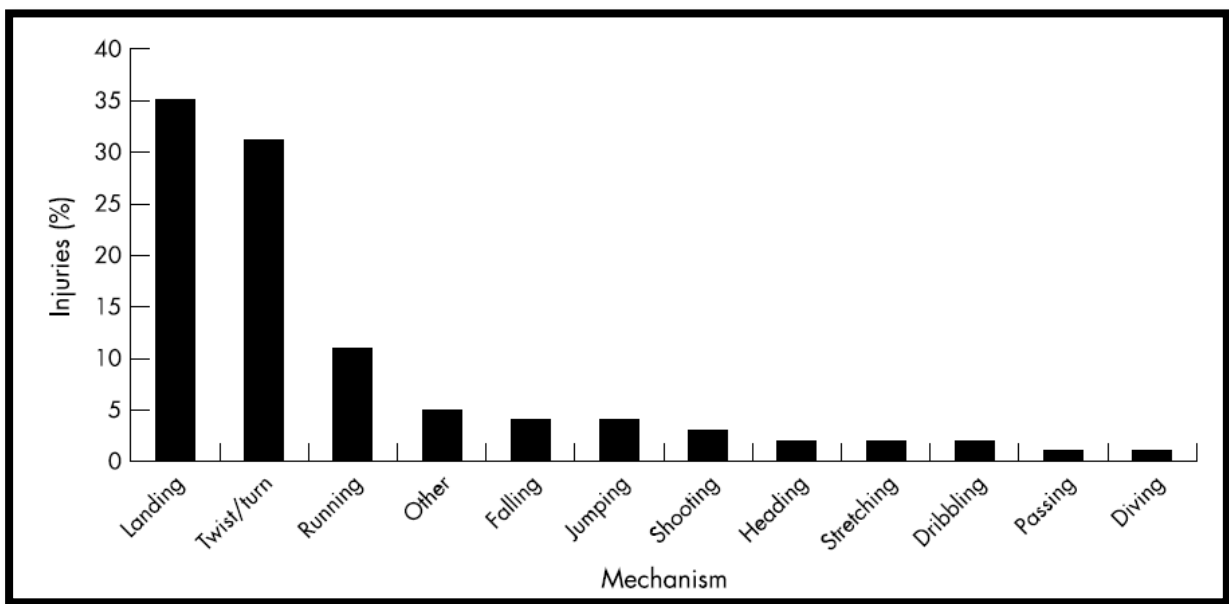
### **Contact vs. Non-Contact Mechanisms**

Soccer's high incidence and mechanisms leading to ankle sprains could be partly explained by the game's nature (Pardon, 1977). Such injuries are normally sustained in sports involving running, cutting and jumping (Barrett & Bilisko, 1995), as well as contact with other players (Garrick & Requa, 1988).

Contact mechanisms were pointed out by various authors as the primary causal factor of ankle injuries in soccer. Schmikli et al. (2010) associated this factor with a 56.3% of soccer injuries, while the remaining injuries caused by non-contact mechanisms. In the case of Junge & Dvorak (2013), approximately 80% of the injuries were result from contact with other players, whilst 47% of these contact injuries came from foul play. Junge et al. (2004) assigned little less than one half of all male and female soccer injuries, or one-third in a following study (Junge & Dvorak, 2007), to foul play. In the same manner as Schmikli et al. (2010), Woods et al. (2003) concluded that more ankle sprains were caused by contact mechanisms rather than non-contact ones (59% vs. 39%), excepting goalkeepers who sustained significantly more non-contact sprains (21% vs. 79%). This would correlate with the goalkeeper's functional profile and positional requirements, as they commonly perform and suffer injuries in activities such as landing (36%), twisting/turning (21%) and diving (10%). Arnason et al. (1996) showed data supporting the fact that contact ankle sprains were more common than non-contact (69% vs. 31%). Referring in a specific way to most common contact-mechanism originated ankle sprains, Woods et al. (2003) mainly observed them during tackles (54%), specifically tackling (36%) and being tackled (18%); just like Arnason et al. (1996), who found the major mechanism during tackling (62%), Fuller et al. (2004) or Tscholl et al. (2007). As Jones (2014) discussed about, contact in soccer cannot be avoided, however, referees and

institutions may aid in decreasing contact resulting injuries by stricter rules enforcement.

Finally, non-contact ankle sprains can occur during landing, twisting/turning and running, which takes place in a 77% of the cases, as Woods et al. (2003) reported; or also when stepping on uneven ground, landing on another player’s foot after jumping and while cutting (Giza et al., 2003; Andersen et al., 2004).



**Figure 5.** Mechanisms of non-contact ankle sprains (Woods et al., 2003)

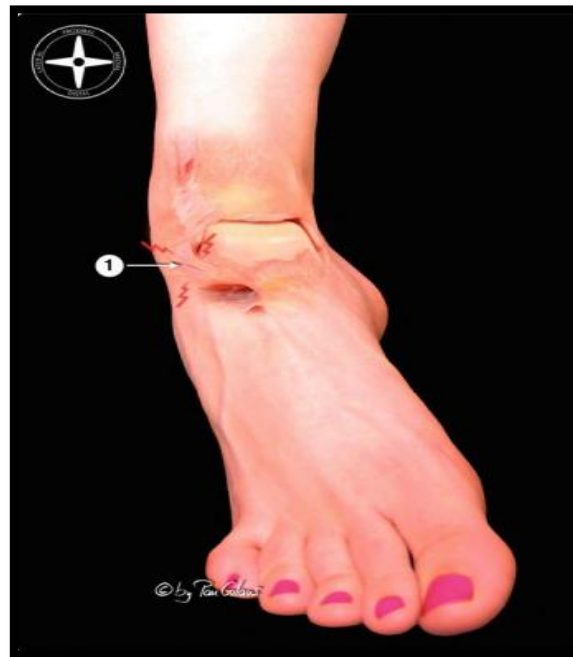
### **Inversion, Eversion, Fractures & Contusions**

On the one hand, without a doubt, forced plantar flexion and inversion of the foot (Wikström & Anderson, 1997), which most commonly entails acute ankle lateral inversion sprains (Ekstrand & Tropp, 1990), is the main reported mechanism of ankle injury in soccer (Mohammadi, 2007). Garrick (1977) suggested the relative shortness of the medial malleolus and the natural tendency for the ankle to go to inversion rather than eversion, as a possible reason. As other authors supported (Giza et al., 2003; Andersen et al., 2004; Kirkendall & Dvorak, 2010), inversion stress is an specific injury mechanism that takes place in soccer during tackling. For example: in the case of a right player, who dribbles the ball with the dominant foot, and an

opponent attempts a sliding tackle from the opposite side. Whether the contact takes place with the player's shin medial area at the time of ground support, an inversion stress on the right ankle can be forced, spraining the lateral complex ligaments. Woods et al. (2003) observed the ATFL to be the most commonly involved ligament in ankle sprains. Barrett & Bilisko (1995) noted that, in comparison with the calcaneofibular ligament (CFL), the ATFL has a lower load to failure, so this could be a possible reason for its high injury incidence. The study conducted by Clanton & Porter (1997) quoted values of 138 N and 345 N for the ATFL and CFL, respectively. In addition, the ATFL is relatively taut in plantarflexion, whereas the CFL is fairly loose; the opposite occurs in dorsiflexion. This assumption fits perfectly with the previously mentioned typical mechanism that involves the foot and ankle with a plantarflexion and inversion force just at the moment of loading (Liu & Jason, 1994; Waddington & Shepherd, 1996; Robbins & Waked, 1998).

On the other hand, we find the eversion injury mechanism. Pure eversion shock, i.e.: blocking the ball, can lead to a partial or complete rupture of the ankle's deltoid complex ligaments. When eversion combines with plantarflexion, in this case, for example: a kick in the ground, this may lead to a trauma of the anterior tibiofibular ligament, in other words, the anterior syndesmosis (van Linschoten, 2015).

Finally, in reference to lower leg fractures, although tibia fractures are less common in soccer comparing to several years ago, if a soccer players experiences ankle injuries this could be related with tibia issues. This is one reason why it is mandatory for soccer players to wear shin guards during matches. van Linschoten (2015) reported several injury mechanisms: firstly, an inversion trauma to the ankle could lead to lateral ankle complex injury including distal fibula fracture; secondly, an stress fracture of the medial ankle could be found as well as an occasional anteromedial stress fracture of the tibia; and, finally, an ankle distortion or direct trauma to the foot may result in fractures at the subtalar joint. As an annotation, foot contusions are very common and may heal slowly due to bone edema and residual synovitis of the subtalar joints.



**Figure 6.** Ankle Inversion Mechanism (Golanó et al., 2013)

### **Is there a Different Injury Mechanism in Non-Previously Sprained Ankles?**

Ankle injury mechanism in previously sprained ankles may differ from that in ankles that have never been previously sprained. This supposition was what Surve et al. (1994) questioned. The report conducted by Tropp et al. (1985a) differentiated between non-injured and previously injured ankles. Although these authors did not mention injury incidences in the non-injured group, Surve et al. (1994), took the raw data tabulated in the study, calculated the seasonal incidence of ankle sprains between groups, performed a Fisher's exact test, and finally got to the conclusion that mechanism could differ because the beneficial effect of an orthosis was limited to the players with a previously sprained ankle.

### **Dominant or Non-Dominant Side**

The main mechanisms of injury previously discussed generally involve the dominant leg (Woods et al., 2003), therefore, it could be expected that most ankle sprains would affect the dominant body side.



## PREVENTION STRATEGIES

The high incidence of ankle injuries, the resulting absence from practice and competition, the associated economic impact (Thacker et al., 1999) and the potential negative chronic consequences call for preventive measures (Verhagen & Bay, 2010). Prophylactic external support (wrapping, taping and bracing), specially designed shoes, proprioceptive or neuromuscular training (e.g., balance board training, coordination...), adequate rehabilitation with sufficient recovery time, emphasis on a comprehensive warm-up, regular cool-down, protective equipment (e.g., shin guards), adherence to revised rules (Junge & Dvorak, 2004; Ergen & Ulkar, 2008), promotion of the fair-play spirit (Öztekin, 2011), changes in the sport environment (such as improved playing fields conditions) (Callaghan, 1997) and instruction of coaches and trainers in methods of injury prevention (Barker et al., 1997) have been postulated as preventive measures against ankle sprains (Verhagen et al., 2000).

In the scientific literature, there seems to be good evidence for the effectiveness of these interventions or programs for preventing both acute and chronic ankle injuries (Ergen & Ulkar, 2008). However, as McKeon & Mattacola (2008) explained, although there has been considerably researched about certain topics associated with ankle sprains, such as risk factors (Beynon et al., 2002), there is not clear consensus on the most appropriate intervention strategies to prevent them.

Below a comprehensive review about the different preventive strategies will be performed. As starting point, because suffering a previous injury supposes one of the most important risk factors for ankles injuries, prevention strategies should be implemented as soon as soccer players start training or playing on an organized level. In addition, these strategies should be targeted towards 3 levels (Öztekin, 2011):

1. Host (soccer player)
2. Injury agent or Potential hazard (ankle)
3. Surrounding environment (injury risks)

## MULTIFACETED/GENERALIZED/COMBINED PREVENTIVE TRAINING

Several randomized controlled trials (RCT) attempted at preventing soccer injuries by the development of preseason-training programs or a more generalized warm-up, coming up to diverse outcomes (Kirkendall et al., 2010).

In the case of soccer players' ankle injury prevention, Osborne & Rizzo (2003) affirmed that “multifaceted ankle sprains prevention programs that incorporate a variety of strategies for prevention of ankle sprains have also been found to be effective”.

The first serious RCT investigations in soccer injury prevention were conducted in the early 1980s (Ekstrand, 1982; Ekstrand & Gillquist, 1983b; Ekstrand et al., 1983a; Ekstrand et al., 1983b). As early as 1982, Ekstrand found a significantly reduction in the number of lower extremities injuries, in male soccer players, through the implementation of a prophylactic program including special warm-up, stretching exercises, use of shin guards, ankle taping and controlled rehabilitation. One year later, Ekstrand et al. (1983a), focused on multifactorial studies of Swedish male soccer players and implemented numerous interventions. The teams were randomized into an intensive season-long prevention program or a standard training program over the course of a 6-month season. These interventions included: training correction, provision of optimum equipment (e.g., use of leg guards), prophylactic external measures (for example: ankle taping for those with prior sprains or instability, which was a 48% of the players in their study), improved warm-up, regular cool-down, agility and flexibility exercises, controlled rehabilitation, exclusion of players with severe knee instability, information about the importance of disciplined play and increased risk of injury at training camps, plus team supervision by a doctor and physiotherapist; using a medically supervised on-field program. The introduction of this intensive sustained conditioning 7-part prevention program, achieved a significant and impressive 75% overall injury reduction in the intervention group. Particularly, the final tally reported a significantly reduced rate of the most common

types of soccer injuries, i.e.: ankle/knee sprains and muscle strains; and, specifically, ankle sprains occurrence reduction was of 82% in comparison with controls.

Years later, Parkkari et al. (2001) conducted a review of 16 RCT published to date about sports injuries prevention. Those studies also supported the idea that general injury rate in soccer can be reduced by a multifactorial injury prevention program. One of them was performed by Heidt et al. (2000), evaluating the effect of a pre-season fitness program on high school female soccer players, in order to assess the potential subsequent injury rates. This multifaceted 7-week training program emphasized on the combination of sports-specific endurance conditioning, plyometric training, sports coordination drills, flexibility exercises, and resistance/strength training designed to improve soccer players' speed and agility. Their results, after a whole playing season, showed a 20% injury reduction in the intervention group comparing with the control (14% vs. 34%).

Shortly after, Junge et al. (2002) designed the first generalized injury preventive programs for young soccer male players. This approach consisted on 10 exercises with the goal of improving endurance, reaction time, coordination, lower extremity stability, as well as flexibility and strength of the trunk, hip and lower extremities. According to their results, the intervention group presented 21% fewer injuries per player.

In 2007, Mohammadi compared three preventive methods (proprioceptive training, strength training and orthoses) aiming to evaluate which one was the most effective in preventing recurrent ankle sprains in adult male soccer players. The participants were randomly divided into four groups: the first group players performed ankle disk proprioceptive training; second group, evetor muscles specific strength training; the third, wore a Sport-Stirrup (Aircast Inc, Summit, NJ) orthosis; and, finally, the fourth group was the control one. Although there were no significant differences among groups in the number of exposures, neither with respect to the strength and orthotic groups in comparison with controls, the incidence of recurrent ankle sprains in the proprioceptive training group showed significantly lower rates than in the control

group. They concluded that proprioceptive training, compared with no intervention, was an effective strategy to reduce the rate of ankle sprains among male soccer players who previously suffered an ankle sprain.

That same year, Häggglund et al. (2007) reported a 66% reduction in re-injury risk by implementing a 10-step rehabilitation program with amateur soccer players. The teams involved in the investigation received information about re-injury risk factors and principles of rehabilitation, on top of the 10-step program. It consisted of nine progressive running and sport-specific exercises and return to play criteria, both based on the injury's severity. These authors also tracked the time between the index injury and a recurrent one, reporting that the intervention was the most effective at preventing injuries in the return-to-play first week.

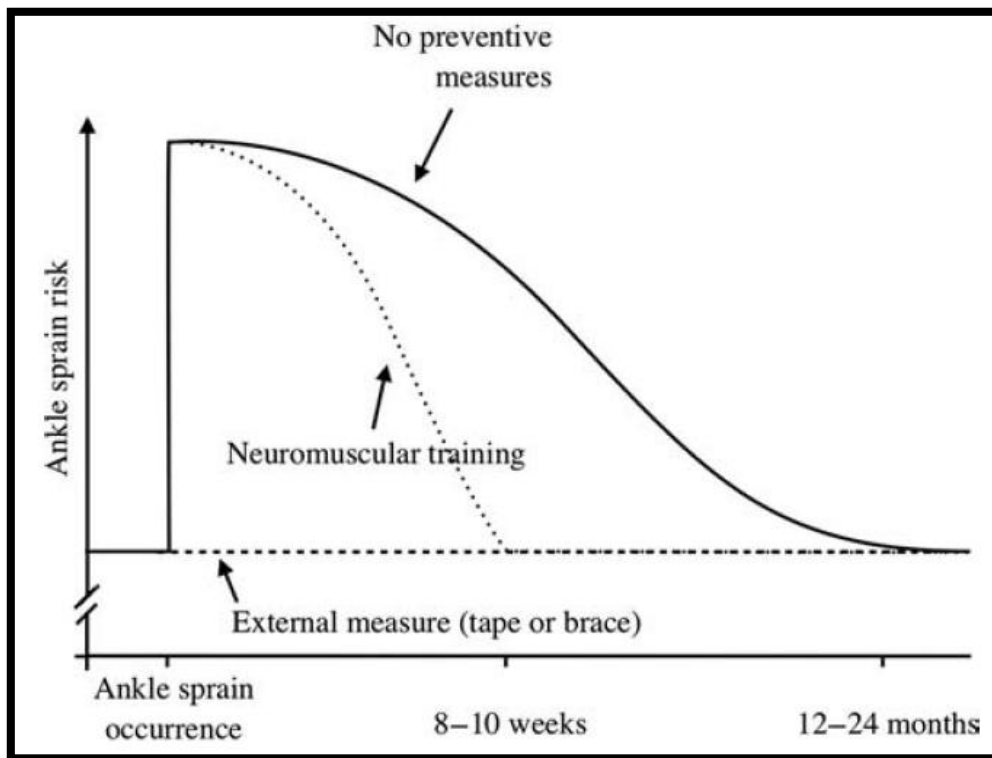
Finally, Engebretsen et al. (2008) designed injury specific progressive programs for professional soccer players who were diagnosed to be at a high risk of an ankle, knee, groin, or hamstring injury. These programs were merged for multiple risk endangered players, performed three times per week for the 10-week preseason period, and then once a week for the competitive season remainder. Considering that only 19-29% of the intervention group players completed 30 or more training sessions, compliance was poor, and with such a poor compliance no effect could be expected on injury rates.

See [Addendum 1](#) in order to go through a detailed overview of the several prevention programs included in this section.

In conclusion to this section, conditioning, both before and during the competitive course of the season, has been emphasized to improve individual and team performance. What is more, this review evidences the protective effect among previously ankle injured soccer players. However, with such extensive strategies to prevention, Ekstrand et al. (1983a) informed about the problematic of distinguishing which approach had the greatest preventive effect; for example, whether the ankle proprioceptive exercises or the external support played the major role in the reduction of ankle sprains. In short, the relative importance of such programs' each

component – this is, which parts of the program were effective and which were not – remains unclear and requires further investigation (Osborne & Rizzo, 2003).

Based on the current evidence, a combination of an external ankle prophylactic measure (tape or brace) with neuromuscular training, will, theoretically, achieve the best preventive outcomes for the player. The preventive potential of this combined use is based on the different pathways through which both measures achieve their effects. In the case of the external measures, they immediately restrict the abnormal range of motion (Hupperets et al., 2009), providing preventive value, but do not target the neuromuscular impairment. By contrast, neuromuscular training enhances proprioceptive deficits. Through this effect-combination, they are linked to an approximately 50% reduction in ankle sprain recurrence risk (Verhagen & Bay, 2010).



**Figure 7.** Theoretical concept for optimal ankle sprain prevention (Verhagen & Bay, 2010)

## WARM-UP PREVENTION PROGRAMS

Many broad-based sports scientific studies replaced a traditional warm-up by a more generalized one consisting of sport-specific activities to reduce common injuries in that particular event. After considering soccer's injury mechanisms, as well as the most successful activities shown to prevent specific injuries – in this case, one of them being ankle ligament sprains – researchers have designed generalized warm-up programs based on the best available evidence (Kirkendall et al., 2010).

By way of introduction, the study performed by Safran et al. (1988) attempted to provide biomechanical support for the pre-exercise warming-up performance in order to reduce injury incidence. As they initially commented, a warm-up period is known to increase muscle temperature – from the heat of activation, elastic energy, thermoelastic heat produced after contraction ends (Hill, 1961) and from intramuscular blood vessels opening – besides increasing the heart and metabolic rates, improve the range of motion (ROM) and the efficiency of the muscle contractions. Various authors attributed warm-up's protective effect to the increase in ROM (Cureton, 1941; Siegert & Haliski, 1950; Wiktorsson-Möller et al., 1983) or the reduced stiffness due to muscle temperature augmentation (Ciullo & Zarins, 1983). Collagen is the principal component of the muscles' connective tissue and its properties have been meticulously studied (LaBan, 1962). Although collagenous tissues, such as tendons and ligaments, are generally considered to behave as rigid structures (Lehmann et al., 1970), temperature raises have shown to increase the extensibility of these tissues (Gross, 1943). As Safran et al. (1988) remarked “it appears that warm-up stretches the musculotendinous unit (MTJ) and results in an increased length at a given load, putting less tension on the MTJ and resulting in a reduced incidence of injury to the muscle-tendon junction”. Another interesting and sports applicable data is that the warming effect of contraction approximately lasts up to half an hour after the contraction (Hill, 1950), so in certain cases, as non-starting players or after half-time, it should be advisable to re-warm. As a conclusion, the

warm-up may hopefully reduce the risk/incidence of musculotendinous injury, even enhancing performance.

With regard to stretching during warm-up, many measures are commonly thought and taught to prevent sports injuries, however, they lack of consistent scientific evidence. Safran et al. (1988) were specifically interested in determining whether a warm-up or preconditioning period without applied stretch have a protective effect, and so they realized. In addition, Parkkari et al. (2001) revised two well-organized randomized studies which failed to show any positive effect of stretching on individual injury risk (van Mechelen et al. 1993; Pope et al. 2000).

Fully entering into warm-up matters, as Bizzini et al. (2013) mentioned, one cannot discuss injury prevention in soccer without talking about the FIFA Injury Prevention Programs. The wide literature review carried out by Kirkendall & Dvorak and Kirkendall et al. (2010) was of great help to support the effectiveness of a generalized, structured, and progressive warm-up program in preventing common soccer injuries. In general, approximately, considerable reductions in the number of injured players, ranging between 30% and 70%, have been observed among the teams that implemented the FIFA 11+ (Barengo et al., 2014).

Based on the original work of Junge et al. (2002) the FIFA's Medical Assessment and Research Center (F-MARC) brought together a group of international injury-prevention experts and developed, in 2003, a program directed towards youth amateur soccer players. "The 11" consisted of 10 simple, catchy, and time efficient exercises, added to the promotion of fair play, with the goal of reducing injuries from fouls. These evidence-based or best-practice exercises became an every-day routine for players, focusing on core stabilization, hamstrings' eccentric training, proprioceptive training, dynamic stabilization, and plyometric exercises with straight leg alignment (Ergen & Ulkar, 2008). This program's previous version – i.e.: Junge et al. (2002) prospective intervention – reported an overall injury rate reduction of 36% and, when injuries per player were informed, results were even better: 43% fewer-mild injuries, 42% fewer non-contact injuries and 55% fewer training injuries.



Nevertheless, back to “The 11” program, Steffen et al. (2008) conducted a cluster-randomized trial on female youth soccer players (14-18 years old). The issue was that researchers began to appreciate some limitations in those first-time programs, as an example: the absence of progression in exercises. Given this condition, the F-MARC, in cooperation with the research groups at the Oslo Sports Trauma Research Centre, and the Santa Monica Orthopaedic and Sports Medicine Research Foundation, developed a three-part generalized warm-up (Soligard et al., 2008). This latest and more advanced version was termed “The 11+”, a truly complete generalized warm-up program which involves 3 parts:

- Part 1: series of six slow-speed running exercises, dynamic active stretching and controlled contacts with a partner (about 8 min). The running course included six to ten pairs of cones (depending on the number of players) about five to six meters apart (length and width).
- Part 2: the first part was followed by six different exercises of strength, plyometric and balance activities, each with 3 levels of increasing difficulty, to provide variation and progression. This challenges players to improve their abilities such as strength, balance, agility, motor/neuromuscular control (awareness for proper movement biomechanics) and core stability (about 10 min).
- Part 3: finally, to conclude the warm-up, further three more running exercises, combined with soccer specific movements, such as sudden direction changes, are carried out. It must be said that these runs are more demanding than those in part 1 (about 2 min). The increased intensity of work brings the player closer to the running demands of the formal soccer training to follow.

Making a point of performing the warm-up prior to a match, logically, in advance of more soccer-specific pre-match warm-up activities, only running exercises (parts 1 and 3) were performed (Kirkendall & Dvorak, 2010).

Once players are familiarized with the exercises, the entire warm-up program should take about 20 minutes, and trainings' total duration is not affected as this program

substitutes for whatever warm-up program that was being conducted by the team. The “11+” also allows coaches and players to gradually individualize exercises as fitness level improves. The short time commitment, minimal equipment, and minimal training to administer required, are greatly associated to this program’s success. The same as compliance, another success factor of prevention trials, were a compliance rate of 77% was achieved. This was possible due to individualized instruction, communication between the research team and clubs, combined with the expanded set of progressive exercises and the running activities (Jones, 2014).

In regards to this program’s effect, multiple studies have shown its efficacy by improving players’ functional static/dynamic balance, reducing injury risk or enhancing neuromuscular control (Brito et al., 2010; Reis et al., 2013; Steffen et al., 2013). Similarly, Grooms et al. (2013) found a decline in collegiate male soccer players’ overall risk and severity of lower extremity injuries, through the implementation of this soccer-specific warm-up. The results reported by Jones (2014) were also really positive: 32% reduction in overall injury risk in the intervention group, match injury risk was reduced by 28%, training injury risk was reduced by 32% and, the most important one in relation to our review, lower extremity injury risk was reduced by 29%. The risk of overuse injury was reduced by 53% and the risk of serious injury (defined as >28 days lost) was reduced by 45%.

See [Addendum 1](#) in order to go through a detailed overview of the several prevention programs included in this section.

Although it was created as a soccer-specific program, the FIFA 11+ contains principles that would help any athlete regardless of the sport (Jones, 2014).

While the evidence supporting the effectiveness of a generalized warm-up program continues to grow (Kirkendall et al., 2010), other authors have developed new versions. In the case of Soligard et al. (2008), they got to the conclusion that a comprehensive structured warm-up program, designed to improve strength, awareness and neuromuscular control, can prevent injuries in young female soccer players.

**Table 2.** Analysis of warm-up exercise program in young female soccer players (modified from Soligard et al., 2008)

	Intervention group (n=1055)	Control group (n=837)	Intracluster correlation coefficient*	Inflation factor	NNT	Rate ratio (95%CI)†	P value
<b>All injuries</b>	135 (13.0)	166 (19.8)	0.096	2.86	15	0.68 (0.48 to 0.98)	0.041
<b>Match injuries</b>	96 (9.1)	114 (13.6)	0.045	1.87	22	0.72 (0.52 to 1.00)	0.051
<b>Training injuries</b>	50 (4.7)	63 (7.5)	0.044	1.86	36	0.68 (0.41 to 1.11)	0.120
<b>Lower extremity injuries</b>	121 (11.5)	143 (17.1)	0.088	2.70	18	0.71 (0.49 to 1.03)	0.072
<b>Knee injuries</b>	33 (3.1)	47 (5.6)	0.028	1.54	40	0.62 (0.36 to 1.05)	0.079
<b>Ankle injuries</b>	45 (4.3)	49 (5.9)	0.026	1.50	63	0.81 (0.50 to 1.30)	0.378
<b>Acute injuries</b>	112 (10.6)	130 (15.5)	0.070	2.35	20	0.74 (0.51 to 1.08)	0.110
<b>Overuse injuries</b>	27 (2.6)	48 (5.7)	0.040	1.76	32	0.47 (0.26 to 0.85)	0.012
<b>Severe injuries</b>	45 (4.3)	72 (8.6)	0.028	1.54	23	0.55 (0.36 to 0.83)	0.005
<b>NNT = number needed to treat</b>							
<b>*Generalized estimating equation model with clubs as cluster unit</b>							
<b>†Cox model calculated according to method of Lin and Wei, which takes cluster randomization into account</b>							

Their program was developed on the basis of “The 11” program, and the prevent injury and enhance performance (PEP) program (Mandelbaum et al., 2005), as well as combined with initial and final running tasks (Olsen et al., 2005). After having revised and examined the effect of “The 11”, they included more exercises in order to

provide variability and progression of difficulty. As examples: a new set of structured running exercises to make it better suited for training and matches, or, in the first part, they included exercises with a partner, which seemed to appeal to the players. They also included a set of balance exercises, and during single leg balance exercises players were purposely pushed off; this way an additional challenge to their ability to maintain a stable core and proper alignment was provided.

When introducing the program to the clubs, their main focus was on proper biomechanical technique to improve awareness and neuromuscular control during standing, running, planting, cutting, jumping, and landing. Players were encouraged to concentrate on the quality of their movements and to put emphasis on core stability, balance, hip control, and proper knee alignment to avoid excessive knee valgus during both static and dynamic movements; which is a feature of earlier intervention studies (Heidt et al., 2000). Some of these mentioned elements were absent from some previously tested training programs (Steffen et al., 2008), but they already exist in other successful prevention programs (Olsen et al., 2005).

Their findings showed a significantly lower risk of overall injuries (about one-third less), overuse injuries, and severe injuries (as much as one-half) in the intervention group. Furthermore, fewer players in the intervention group had  $\geq 2$  injuries. They also identified an inverse relationship between compliance and injury rates because teams which performed the program more usually had the lowest injury rates.

### **Principles to Follow**

Despite its apparent ease of implementation, some simple but key fundamental principles must be taken into account, in order to achieve effective results and carry out a proper evaluation. These points include compliance, difficulty progression, exercises that replicate the real actions required by the sport (transference from practice to real game situation), and count on the help of a qualified and experienced specialist to evaluate its effectiveness (Grooms et al., 2013).

## PROPRIOCEPTIVE/NEUROMUSCULAR/COORDINATION/BALANCE PREVENTIVE TRAINING

Coordination could be defined as a cooperative interaction between the nervous system and skeletal muscles, which encompasses proprioceptive abilities (Tittel, 1998). Proprioception, as a definition, can be thought of a complex neuromuscular process that involves both afferent input and efferent signals, allowing the body to maintain stability and orientation both during static and dynamic activities (Bunton et al., 1993). So proprioception refers to the inborn kinesthetic awareness of body posture, including movement, and understanding its role is crucial in order to prevent ankle injuries (Lephard et al., 1997). Freeman et al. (1965) first postulated that ankle sprains recurrence was attributable to a proprioceptive deficit caused by partial deafferentation (afferent nerve fibers disruption) of articular mechanoreceptors located in the ligaments of the ankle joint (Refshauge et al., 2000). This may lead to impaired reflex stabilization of the foot during exercise, a decrease in proprioceptive feedback and therefore to an increased risk of injury (Tropp et al., 1984a, 1984b). Proprioceptive exercises may effectively aid stabilization to an unstable ankle and break the vicious cycle of recurrent sprains (Mohammadi, 2007).

Literature contains many reports on various proprioceptive training programs, some of them performed with soccer players (Mohammadi, 2007). Furthermore, as proprioceptive training has been suggested to protect the ankle joint and reduce the re-injury rate in ankle sprains, emphasis has to be placed on these measures (Tropp et al., 1985a; Holme et al., 1999). It should also be noted that for those without an ankle sprain history, injury risk reduction is less clear. Apparently, those who previously suffered an ankle sprain are the ones who most benefit from balance and coordination interventions (McKeon & Mattacola, 2008).

The same scientists, McKeon & Mattacola (2008), realized that balance/coordination trainings typically involve single-limb stance, sports-related activities such as dribbling, passing or shooting; proper take-off and landing technique instruction... It is true that this large variety of activities and programs that have been implemented,

for example: balance board, foam pads, dynamic hopping activities or technical training; mean a major confounding factor in the interpretation of the balance training effects. Anyway, all of these activities have been demonstrated to be effective in reducing the risk of ankle sprains associated with sports such as soccer and improving the functional outcomes of those who have acute and chronic ankle instability.

Mohammadi (2007) sustained the absence of a dispute about the actual benefits of an ankle sprain proprioceptive prevention program; however, there are still many questions about how much it helps and the specific stimulation it generates (Eils & Rosenbaum, 2001), about the relative importance of each component and the isolated effects of proprioceptive-type exercises in primary ankle sprain prevention (Osborne & Rizzo, 2003), or if the number of exposures before an ankle sprain occurs is augmented (McGuine & Keene, 2006).

### **DISK/BALANCE BOARD**

Proprioceptive training usually includes exercises on devices such as balance boards, ankle disks, or tilt boards. These exercises should be performed several times a week, turning this practice in a unique method because gets to stimulate multiple ankle movement planes on a weight-bearing foot (Sheth et al., 1997).

It is known that a certain minimum of exercises must be performed before an effect may be expected (Myklebust et al., 2003). The same way, it takes between 8-10 weeks at least, for more intensive injury prevention programs, to achieve an effect (Holme et al., 1999; Hupperets et al., 2009). This means that reduced injury risk is not immediate, but through those exercises the natural healing process is sped up. After completion of the training, theoretically, the player's increased recurrent ankle injury risk is reduced to the "baseline" level.

Number of exercises: 2–5  
Number of repetitions of exercises: 10–15  
Number of sets: 1–3  
Duration of total proprioceptive training: 5–15 minutes (shorter for prevention, longer for rehabilitative purposes), preferably every training day (at least 3–5 days a week).

**Figure 8.** Exercise prescription for proprioceptive training (Ergen & Ulkar, 2008)

At any rate, focusing on proprioceptive training in soccer players:

Tropp et al. (1985a) examined the effects of an ankle disk training program in 65 Swedish male soccer players. The program duration was of 10 weeks, performing balance board training exercises, and the authors reported significantly decreased injury rates. They found an 80% decrease in the incidence of recurrent ankle sprains.

Years later, Söderman et al. (2000) implemented other balance board training program with Swedish female soccer players. The plan contained five exercises with progressively increasing difficulty degree, and were performed at home for 10-15 min, initially each day for 30 days and then three times per week during the rest of the season. After one season of intervention results showed no preventive effects on ankle injuries in female soccer players from second and third Swedish divisions.

McGuine & Keene (2006) hypothesized whether a balance training program, could reduce the risk of ankle sprains in male and female high school soccer and basketball players. The program consisted of 5-pases, the first four phases implemented during the preseason (5 sessions per week during 4 weeks), and the maintenance phase throughout the competitive season (3 times per week for 10 minutes). Each exercise was performed for 30 seconds, and legs were alternated during the 30-second rest interval. Exercise program focused on maintaining single and double-leg stance, as well as performing functional activities, in different surfaces (flat surface or balance board) and alternating eyes open and closed. It is important to mention that on-site trainers did not observe or report any injuries from



players who fell off the board. In view of the results, these authors concluded that a balance training program will significantly reduce by a 38% the risk of ankle sprains in high school soccer players. Apart from the previously mentioned main goal, their study sought to determine other questions, and those are the results: (1) it is suggested that a balance training program would reduce the rate of ankle sprains in players without a previous history of a prior sprain, although none of the prior studies neither this one have been able to document a significant reduction in this population; (2) sustaining an ankle sprain within the previous 12 months more than doubled the risk of another sprain, a finding which is consistent with other publications (Thacker et al., 1999); and (3) they also found that the balance training program did not affect the severity of the sprain.

In the comparative survey conducted by Mohammadi (2007), the proprioceptive training group used the ankle disk each day, 30 minutes a day. The soccer player was instructed to stand on the ankle disk on the injured leg and shift his or her weight, causing the disk's edge to follow a continuous circular path. Progression is to move from eyes open to eyes closed and from firm surfaces to soft and moving surfaces (Tropp, 1986; Mattacola & Dwyer, 2002).

Engebretsen et al. (2008) also implemented an ankle training program with male soccer players, during the preseason (3 times per week for 10 weeks) and the rest of the season as maintenance (1 time per week). In order to assess players' ankle functionality, they were asked to fill out a 5-part ankle questionnaire, which in this case was the Foot and Ankle Outcome Score (FAOS) (Roos et al., 2001). Depending on the results, players were divided into 3 "risk" groups. Although authors were able to identify players with an increased injury risk through a simple and comprehensive questionnaire, because the addition of more elaborate functional tests did not increase the predictive value of the screening, there was no effect of the targeted intervention on injury risk. The most likely explanation for this is the low compliance and the big contamination risk existent, because many teams already did team-based preventive exercises.

See [Addendum 1](#) in order to go through a detailed overview of the several prevention programs included in this section.

It is also recommended to perform wobble board training after return-to-play in order to prevent possible re-injuries (Tropp et al., 1985b; Woods et al., 2003). Furthermore, this training may also help to improve postural equilibrium in balance testing (Tropp & Odenrick, 1988), avoid the development of functional chronic ankle joint instability (CAI) (Karlsson et al., 1993) or minimize deficits/symptoms in players who already suffer from it (Gauffin et al., 1988). Some studies in other sports have shown how ankle disk training may act to improve dynamic ankle stability by altering ankle muscle onset latencies (Hale et al., 2007); because, decreased ankle joint proprioception may result in a slow onset of activation of muscles across the ankle joint (especially evertors) and, thus, a failure to correct excessive ankle positions (Sheth et al., 1997; Osborne et al., 2001). The reduction reported by Eils & Rosenbaum (2001), after a 6-week and 12-exercise multi-station balance training program, was of 60% in episodes of ankle giving way. Joint position sense, postural sway and muscle reaction times were also significantly improved. The exercises implemented were performed: on mat, swinging platform, air squab, eversion-inversion boards, ankle disk, mini trampoline, step, uneven walkway, hanging and swinging platforms, and with exercise bands.

Although many companies sell fairly complex computerized equipment to help improve proprioceptive input and balance, such training can also be accomplished through various simple drills done on various surfaces with eyes open and shut, progressing from a double to a single limb stance. If available, however, such technologically advanced devices can also be used in proprioceptive trainings and rehabilitation programs. Exercises should include repetitive, consciously mediated movement sequences performed slowly and deliberately, and sudden, externally applied perturbations of joint position to initiate reflex, “subconscious” muscle contraction. Some of the proprioceptive proposed exercise types are: balance training (one-legged standing balance exercises, wobble board exercises, tandem

exercises with postural challenge such as perturbations), plyometric exercises, isokinetic exercises (with and without eccentric or concentric loads), closed and open kinetic chain exercises, reaction time exercises or sport-specific maneuvers (Ergen & Ulkar, 2008).

To sum up, implementing long-term injury-prevention strategies (proprioceptive and coordination activities) into training sessions should be fundamental, especially in the preseason preparation stage, and preferably from very early ages in order to reduce ankle injuries, as well as other soccer related ones.

## STRENGTH/RESISTANCE TRAINING

Resistance training has become the basis, or at least an overriding component, of year-round training programs for many sports, as in soccer's case. Scientific evidence states a large variety of effects achieved through strength training such as muscle fiber hypertrophy, improved muscle fiber recruitment, increased strength of tendons and ligaments or increased bone density. However, there is little research documenting the positive relationship between strength training and improved tolerance to physical injury in soccer (Lehnhard et al., 1996).

There is also limited available literature regarding to soccer ankle injury prevention by performing muscle strengthening exercises. Although several studies have shown their effectiveness in short-term programs, it is unclear whether these programs have long-term effects.

Below, the evidence to date will be briefly displayed in different topics:

### **Evertor Muscles & Ankle Sprain**

It has been usually suggested the ligamentous injury prevention role that evertor muscles play (Mohammadi, 2007). One possible reason was postulated by Willems et al. (2002), proposing that evertor muscles eccentric contraction supports to the lateral ligament complex and resists ankle inversion sprains. In such a way that, as Tropp et al. (1985a) first showed, evertor muscle weakness is a component of recurrent ankle sprain. The method employed in order to reach this result was via measuring muscle torque at the ankle with an isokinetic dynamometer, also getting to the conclusion that strength training of evertor muscles was another part of preventing ankle sprains.

Lehnhard et al. (1996) conducted a RCT/time-series analysis with 20 college men soccer players over a 4-year period. During intervention's last 2 years, participants performed a strength training regimen, achieving an all-type injury reduction in the incidence rates.

More recently, in the study carried out by Mohammadi (2007), one of the intervention groups performed specific strength training of evertor muscles. The program involved 10 sets of 20 repetitions, with 9 seconds duration per repetition. The first part consisted of isometric exercises performed against an immovable object, which progressed to dynamic resistive exercises using ankle weights and resistance bands. It is important to mention that the time maintained at a maximal contraction was controlled ensuring that the targeted musculature was being maximally loaded in a pain-free arc (Mattacola & Dwyer, 2002). The results reported in the study showed no significant difference in ankle sprain re-injury frequency between the strength group and the control group, however, they appear to be clinically significant. The problem of low study power due to relatively group small sizes, suggests that strength training might be proved to be effective in a larger study.

Konradsen et al. (1998) monitored changes in ankle eversion strength and sensorimotor control functions after acute ankle inversion injury. Although the study was not conducted with soccer players, they found that, 12 weeks after ankle injury, an increased accuracy error of ankle positioning was still present in comparison with the non-injured ankle. In view of the results, six weeks of strength training were needed to normalize evertor muscles “baseline” status.

See [Addendum 1](#) in order to go through a detailed overview of the several prevention programs included in this section.

### **Strength Training & Chronic Ankle Instability (CAI)**

Undoubtedly, after an acute ankle sprain, one of the most common residual disabilities is ankle functional instability. In order to understand this fact better, ankle instability could be defined as either mechanical (objective measurement of ligament laxity) or functional (feeling of giving way) instability (Ergen & Ulkar, 2008). Muscular weakness, as well as a proprioceptive deficit or coordination absence, can be included as one of the chronic ankle instability causal factors (Eils & Rosenbaum, 2001). Fortunately, those who suffer CAI also have been shown to benefit from

general strengthening, apart from balance, single-limb stance or other functional activities (Richie, 2001):

- Evertor/Pronator Muscles Weakness: many investigators also found a relationship between evertor muscle weakness and chronically unstable ankles (Bosien et al., 1955; Hartsell & Spaulding, 1999; Willemns et al., 2002). An interruption of the muscle's nerve supply or a selective inhibition of the invertor muscles ability to start moving in the initial injury's direction, have been suggested by Ryan (1994) as possible reasons for evertor muscle weakness. Docherty et al. (1998) conducted a 6-week progressive ankle strengthening program, using elastic tubing, with 20 functionally unstable ankle subjects. They examined the effects on joint position sense and strength development, reporting improvement in those parameters. They suggested that this training protocol may have increased the gamma motor activity, improved motor control, or produced a combination of central or spindle mechanisms; confirming their believed mechanism of changes in muscle spindle sensitivity or in central mechanisms related to the spindles rather than joint mechanoreceptor sensitivity. Tropp (1986) also found that pronator muscle strength, in patients with ankle functional instability, could be improved through daily 10 minutes wobble board training during a 10-week period.
- Invertor Muscles Weakness: similarly, other authors found a significant invertor weakness in chronically unstable ankles (Ryan, 1994; Hartsell & Spaulding, 1999). However, in the case of Willems et al. (2002), for example, they found no relationship between ankle sprains and these muscles strength.

### **Strength & Noncontact Ankle Sprains**

McHugh et al. (2006) evaluated the role of hip strength and balance ability, in high school athletes, where soccer players were included, studying the risk factors for noncontact ankle sprains. Some tests were performed during the preseason stage,

assessing hip flexion, abduction and adduction strength, with a handheld dynamometer. Anatomical/Anthropometrical data was also documented, such as body mass, height, ligamentous laxity, previous sprain history and so on. The results showed that hip strength, as well as balance (measured on a balance board), were not significant indicators for noncontact ankle sprains.

Science has shown how both proprioceptive and strength training go together in the task of preventing injuries. Giving an example: the addition of plyometric exercises to a program of these characteristics is after near-normal strength in all targeted muscles has been achieved (Ergen & Ulkar, 2008). On the one hand, it seems as if strength programs alone do not have such effectiveness as proprioceptive training, which is considered the most effective part of the injury prevention programs (Verhagen & Bay, 2010). Nevertheless, on the other hand, strength and other specific training activities, such as flexibility or agility, should always be included during proprioceptive exercises workouts.

It was suggested by Willems et al. (2002) that a possible cause of recurrent sprains is the combined action of diminished proprioception and evertor muscle weakness. In conclusion, somehow, previous findings justify keeping on implementing proprioceptive and strength type ankle injury preventive training, even after players have returned to play (Woods et al., 2003).



## EXTERNAL PROPHYLACTIC MEASURES

The use of prophylactic external measures is fairly common in ankle injury prevention sports field (Shapiro et al., 1994). In addition, it has been shown to have the most consistent effect on reduction of ankle sprains induced by exercising (Struijs & Kerkhoffs, 2006). The critical evaluation published in the Cochrane Database of Systematic Reviews (Handoll et al., 2001), evaluating the effectiveness of ankle supports in reducing the frequency of ankle injury, concluded that external support to the ankle yields a significant reduction in the number of ankle sprains (51%).

In high-risk sports, such as soccer (Parkkari et al., 2001), orthoses were also usefully proven to prevent ankle sprains (Ekstrand et al., 1983a; Tropp et al., 1985a; Engebretsen et al., 2008). This preventive benefit was principally observed in soccer players with a prior history of ankle sprains; however, their role in primary prevention of ankle sprain is less evident (Surve et al., 1994; Ubell et al., 2003).

As we know, a large variety of different ankle supports is available (taping, adhesive taping, cloth wrapping, strapping, rigid and semi-rigid orthoses, air-cast braces, lace-up braces, flexible braces...), presumably, providing different preventive outcomes. The existent current literature effects about external supports in soccer's ankle injury prevention will be analyzed in this section:

### **External Support's Proposed Mechanisms of Ankle Sprain Reduction**

As starting point, it is relevant to analyze the pathways that possibly take part in lowering ankle injury risk. Although Hume & Gerrard (1998) reported at the time that little information was available describing the precise mechanisms to through which ankle supports reduce ankle injury, conventionally, "the ability of a brace to physiologically restrict ankle motion has been the presumed predominant mechanism of action". In the case of taping, other mechanisms of effect were postulated such as the enhancement of proprioceptive function of the injured ankle (Hume & Gerrard, 1998), by stimulating the contraction of peroneus brevis muscle during the swing phase of running (Glick et al., 1976). In general, one possible rationale is that through the use of taping or bracing kinesthetic awareness of ankle positioning and ankle

joint supporting are enhanced, by limiting hindfoot motion, and specifically, inversion movements (Dizon & Reyes, 2010).

The role of mechanical support as the only effective mechanism in reducing ankle injuries through the use of external devices was questioned (Firer, 1990). Following investigations, such as the one by Caulfield & Garrett (2004) proposed that ankle injury mechanisms are based on both kinesthetic and mechanical factors. As recurrent ankle injuries result in chronic ankle instability (CAI) and lead to joint hypermobility, proprioceptive deficits, muscle weakness, slow reflex response and ligaments' anatomical variations; this instability can either be considered functional (loss of static and dynamic support) (Karlsson & Andreasson, 1992; Vaes et al., 1998) or mechanical (joint laxity) (Hertel, 2000).

Surve et al. (1994) postulated that the main effect of the ankle support (brace/tape) is to improve proprioceptive function, rather than mechanical support alone, in previously injured ankles. This effect occurs as a result of cutaneous mechanoreceptors stimulation, when tape/brace is firmly attached to the skin (Simoneau et al., 1997).

It is in this context where external ankle supports show their injury prevention potential; however, total prevention of ankle sprains has not been achieved among those with previous injury history. Those two are the most probable reasons for this fact (Arnold & Docherty, 2004): the first one is that ankle joint's range reduction may not be enough to withstand injury leading forces, because, even though taping/bracing has been shown to reduce about 46-84% the range of motion following exercise, the normal range value remains above this one. The second likely reason is that whilst tape slows down ankle inversion velocity during an ankle sprain (from 196 ms to 156 ms), some injuries occur at 10-80 ms, as revealed by some field measurements, making tape less effective. As peroneal muscles do not have enough time to contract and prevent injury (Anderson et al., 1995), the torque generated by braces is not capable to counteract the inversion movement that typically leads to injury (Thonnard et al., 1996).

Finally, apart from the previous ones, it might be worthwhile to consider the feedforward mechanism postulated by Beckman & Buchanan (1995) in the central set model. The general idea consists in the activation of gamma motor neurons because the central nervous system (CNS) detects an ankle's inability to withstand high velocity ankle inversion movements. There is also an increased signaling in the sensitivity to disturbance in balance and position. As a consequence, hip musculature acts prematurely due to an insufficient ankle response, thereby preventing excessive motion which can predispose to a recurrent sprain.

### **Ankle Taping**

Over the years, ankle taping, adhesive taping or ankle strapping has been arguably considered one of the standard measures in preventing ankle sprains (Thacker et al., 1999). Due to this extensive use of ankle taping in sport, some research has examined the real effect tape has on ankle injuries preclusion (Dizon & Reyes, 2010), which seems to be particularly effective for previously injured players (Verhagen & Bay, 2010). Taping-induced prophylaxis is associated with sensory feedback (Ergen & Ulkar, 2008). As tape unites ankle skin with plantar surface of the foot, Robbins et al. (1995) suggested that this may increase sensory input to the CNS, allowing an accurate foot placement, reducing excessive ligamentous strain, and summarizing, facilitating proprioception (Karlsson & Andreasson, 1992).

Although some studies emphasize that ankle tape rapidly loosens after exercising approximately 10 minutes, losing its initial resistance level, and provides little or no support after 30 minutes (Garrick & Requa, 1973); it seems as a residual restraining effect is provided (Manfroy et al., 1997). On the one hand, moisture accumulation under the tape, tape weakening, increased extensibility of the ankle connective tissue and skin mobility, are some possible reasons that account for tape loosening (Dizon & Reyes, 2010). On the other hand, this increased protection may be associated with range of motion (ROM) restriction (Verhagen et al., 2001), which enhances mechanical ankle stability and shortens peroneal muscles reaction time, affecting proprioceptive function of ligaments, joint capsule and lower limb musculature

(Shapiro et al., 1994). As peroneal muscles react more rapidly, this allows inhibiting extreme ankle inversion (Nawoczinski et al., 1985); however, some authors questioned this fact, arguing that reflex contraction was too slow to prevent sprains (Isakov et al., 1986).

As Hume & Gerrard (1998) mentioned, it is important to mention that taping effectiveness depends upon the material properties, application method, ankle stability status and previous injury.

In conclusion, despite the fact that some studies indicate that taping does not maintain mechanical support during exercise, at least not as well as semi-rigid orthoses, epidemiologic evidence showed how taping is effective in reducing ankle sprain incidence in previously injured soccer players (Surve et al., 1994). Nevertheless, as Woods et al. (2003) noted in their study, the 32% of players sustained an injury wearing some form of ankle support. This may be explained because some players are keen to return-to-play or train without having completed the rehabilitation process, and may request to have their ankles strapped in hope that this will provide extra support and protection from re-injury.

### **Ankle Bracing**

Prophylactic ankle braces (rigid and semi-rigid stabilizers, lace-up braces and stirrups) have been introduced as an alternative to ankle taping (Thacker et al., 1999), and were found to reduce recurrent ankle injury risk when return to participation (Gross & Liu, 2003). The application of ankle support seems to improve proprioception and sensorimotor function through stimulation of cutaneous mechanoreceptors near and around the ankle (Feuerbach et al., 1994). This, in addition to mechanical properties of the devices, such as placing the ankle in a neutral position and increasing rotational stiffness of the joint (to resist inversion of talus and calcaneus before impact) (Ubell et al., 2003); display braces ability to reduce injury risk.

Several studies investigated ankle bracing effect on ankle sprain injury incidence, reporting that to be a good preventive method among soccer players (Gross & Liu, 2003):

One of the first injury prevention researches with soccer players was implemented by Tropp et al. (1985a). The participants were Swedish adult male soccer players, who were divided into three groups, one of them consisting on wearing a semi-rigid ankle orthosis. Their results reported significantly lower rates of ankle sprains among the orthoses group (cloth and plastic ankle brace) in comparison with the control group.

Surve et al. (1994) evaluated the effect of an Aircast Sport-Stirrup (Aircast, Inc., Summit, NJ) ankle brace, during one season, among senior male soccer players from South Africa. The results demonstrated a significantly lower incidence of ankle sprains among players with a previous history of ankle sprain compared with the control group, but no difference was noted in players who reported no previous injury.

Sharpe et al. (1997) evaluated the effect of taping, bracing and the combination of both among varsity female collegiate soccer players over a 5-year period. The best effects were achieved in the group wearing a canvas-laced brace (Swede-O Universal Ankle Support; Medical Specialties, Inc., Charlotte, NC), with no sprain recurrence, but incidence was also reduced in the taped and combination groups (25% recurrence).

One of the most recent studies is the one conducted by Mohammadi (2007), comparing three preventive methods. The external support training group wore the same ankle orthosis as the one used by Surve et al. (2004). Although the findings with respect to the strength and orthosis groups in comparison with the control group are not statistically significant, they appear significant clinically. This could be a problem of low study power attributable to the relatively small sizes of the groups, so these 2 modalities might prove effective in a larger study.

In conclusion, it was high-evidenced that the use of ankle stabilizers (chiefly semi-rigid and those consisting of relatively stiff cloth ankle braces) reduces the risk of

ankle sprains, especially among those with previous ankle instability problems (Parkkari et al., 2001). The injury preventive ability of the new manufactured generation of braces needs to be assessed (Dizon & Reyes, 2010).

See [Addendum 1](#) in order to go through a detailed overview of the several prevention programs included in this section.

### **Which is the Best Type of Ankle Support?**

On the one hand, some authors defend the idea that some supports provide more stability to the ankle, bestowing injury preventive properties, and therefore, are more effective:

The review conducted by Hume & Gerrard (1998), as well as Rovere et al. (1988), found that rigid and semi-rigid orthoses were more effective in limiting ankle motion rather than taping, which, after exercising 20 minutes, lose much of its restrictive characteristics.

On the other hand, given the etiology of ankle injuries, it seems logical to believe that the support system that provides the best mechanical restriction would be the superior in preventing ankle injuries (Verhagen & Bay, 2010). However, even though braces' mechanical properties are superior to ankle taping, some authors advocate a non-existing difference in preventive effects (Verhagen et al., 2000). Their investigations sustain that all ankle external support types are equally effective and there is superiority between them (Mickel et al., 2006):

As an example, Olmsted et al. (2004) found an equal effectiveness of taping and bracing at preventing ankle sprains among community-based soccer players who had a history of sprain.

Similarly, Dizon & Reyes (2010) conducted a systematic review evaluating the effectiveness of external ankle supports in the prevention of inversion ankle sprains. Ankle taping, bracing and orthosis applied to the ankle were compared, but they found that no type of ankle support was superior to the other. All of them were effective in reducing ankle injury incidence among previously injured athletes. Proof

of this was that study results showed considerably similar reductions between taping and bracing methods (69% vs. 71%).

### **Ankle Support Choice & Application Compliance**

It must be noted that depending on the particular characteristics of the external support, players would differently choose which one to use and could also pose a compliance issue (Olmsted et al., 2004).

Rosenbaum et al. (2005) and Gross & Liu (2003) proposed that external support's choice should be based on comfort, skin irritation avoidance (blisters), perceived instability, evidence or perceived impact on performance, cost, as well as the advantages of one over the other. These same factors affect compliance. On the one hand, ankle taping is the most common intervention, less bulgy and prevents joint mobility without impairing the normal biomechanics motion. However, tape slackens during exercise, requires skilled personnel for application, the cost may be 3 to 25 times higher compared with bracing and can sometimes cause an allergic skin reaction. On the other hand, ankle bracing provides stable restriction to ankle movements, which may enhance proprioception; are less costly in the long term, can be self-applied and adjusted at any time without assistance (more adjustable than tape), besides that stands for longer periods (Sprigings et al., 1981; Johnson et al., 1994). Differentiating between bracing options, semi-rigid stirrup orthoses (stirrup-type braces) usually have a less complicated design than lace-up braces, which makes them easier to be applied, but are expensive and may decrease performance (Greene & Roland, 1989). Lace-up braces are inexpensive, reusable but may be uncomfortable and do not provide uniform compression (Rosenbaum et al., 2005). Anyway, in the case of Surve et al. (1994) they recommend the use of semi-rigid orthosis, such as the Sport-Stirrup orthosis, in soccer players with previous ankle injury in conjunction with a comprehensive rehabilitation program.

Elastic wrap or bandages are inexpensive, reusable, and effective in reducing acute injury's edema; however, there is no evidence that wrapping effectively supports the ankle (Vaes et al., 1985).



To the question of which measure should be preferred for the prevention of ankle sprain recurrences, Verhagen & Bay (2010) answered that the player's favorite method will achieve the best results.

Secondary incidences to other joints, such as the ankle, are possible, but require further investigation (Sitler et al., 1994).

### **How Long Ankle Orthosis Should Be Worn?**

Recent reviews deemed preferable to carry out an ankle functional rehabilitation, rather than immobilization or early surgery, for initial treatment of acutely injured ankles. Thereby, recovery of the ankle's functionality is accomplished, as well as a preventive training is performed, thus reducing possible relapses (Osborne & Rizzo, 2003).

In the same sense, the external supports critical evaluation of their effectiveness, recommends wearing an ankle orthosis for at least 6 months following injury, above all in players who sustained a moderate or severe ankle sprain (Thacker et al., 1999; Osborne & Rizzo, 2003).

As McKeon & Mattacola (2008) pointed out, long-term reliance on external support may be appropriate for those at high injury risk such as participants in cutting and jumping sports (i.e.: soccer). This means that, in order to fully benefit from any preventive effects, the support should be worn for the entire 1-2-year period during which an increased risk is present (Verhagen & Bay, 2010).

### **External Supports & Performance**

Parkkari et al. (2001) noted that "any potential prophylactic effect should be balanced against the baseline injury risk at the activity performed, the supply and cost of the particular device, and for some, the possible or perceived loss of performance".

In this respect, some authors reported that external supports did not improve athletic performance, and in some cases were found to cause impairment (Thacker et al., 1999; Osborne & Rizzo, 2003; Dizon & Reyes, 2010). Gross & Liu (2003) evidenced

that semi-rigid ankle braces do not adversely influence functional performance in tasks such as vertical jump height, sprinting or agility (rapidly direction changes). However, other studies, although not being conducted with soccer players, reported adverse effects of ankle bracing on functional performance (Burks et al., 1991; MacKean et al., 1995).

In contrast, Hals et al. (2000) are probably one of the first investigator groups who found a performance enhancement resulting from ankle brace us in subjects who had a history of ankle sprain. Previously, Jerosch et al. (1997) found that performance on the mentioned tasks, of those who have post-acute or recurrent sprains, could be improved by wearing external ankle support.

The placebo effect of ankle taping was also demonstrated in functional activities among chronic ankle instability participants (Sawkins et al., 2007).

### **Shoe Type & Ankle Injury Prevention**

Robbins & Waked (1998) concluded that human foot position sense is precise when barefoot; however, athletic footwear triggers a distortion, accounting for the high injury rates of ankle sprains. Their suggestion was the use of more advanced footwear to retain maximal tactile sensitivity, thereby, maintaining an awareness of foot position, as the best solution for reducing ankle injury frequency.

Some studies have evaluated the role of shoe type on ankle sprain risk in different sports; nevertheless, it remains unclear whether any effect exists on ankle sprain incidence (Verhagen & Bay, 2010). As Barrett & Bilisko (1995) commented, although biomechanical studies have demonstrated an improvement of mechanical ankle stability by using high-top shoes, clinical studies were inconclusive in regards to their effectiveness in reducing ankle sprains. This positive effect was only found in studies that implemented a combination of shoe height with tape (Garrick & Requa, 1973) or brace (Rovere et al., 1988).

Two authors who directly investigated the effects of shoe design on the incidence of ankle sprains were Barrett et al. (1993) and Curtis et al. (2008). None of them were performed with soccer players. Besides, neither study found any significant difference in injury risk depending on the shoe type (high-top vs. low-top), suggesting that shoe height does not play an important role in ankle injury prevention. On the contrary, it was the footwear newness which influenced the shoe efficacy.

In the case of Cameron & Davis (1973) demonstrated that the use of swivel shoes in football provoked a 2.7-fold decrease in ankle injury recurrence comparing with players wearing cleats, heelplates (aluminum studs) or soccer shoes.

Finally, Gillespie & Grant (2000) calculated that lower limb stress fractures can also be reduced nearly a 53% by the use of shock-absorbing insoles in footwear.

## LIMITATIONS/PROBLEMATIC IN PREVENTION PROGRAMS

In this section, a number of aspects that may influence results in an ankle injury prevention program will be mentioned. Ergen & Ulkar (2008) informed that several important factors must be considered in performing intervention studies and those interventions should be handled carefully because of inherent limiting factors:

### Low Compliance

This limitation takes place when players complete few sessions from the injury-prevention training program.

Several injury prevention studies conducted among soccer players did not find any preventive effect due to poor compliance with the training program (Söderman et al., 2000; Engebretsen et al., 2008; Steffen et al., 2008). As Engebretsen et al. (2008) showed in their study, adequate supervision is necessary, considering that prevention training cannot be left to the players themselves. In the same way, Soligard et al. (2008) indicated that not all of the players seemed to fully concentrate on the exercises performance, even if the technical nature of many tasks required players to focus, in order to gain the intended benefit.

Moreover, as Ergen & Ulkar (2008) noted, in many intervention studies concrete information on how coaches and players complied with the program is not readily available.

### Contamination

Intervention studies dealing with ankle injuries prevention, such as proprioceptive training, should be carefully designed to overcome contamination limitations (Verhagen et al., 2004). Contamination should be controlled and reduced by means of the randomization procedure (Ergen & Ulkar, 2008). As an example, the fact that some teams already performed similar preventive exercises regularly throughout the pre-season meant a potential risk of contamination in the study implemented by Engebretsen et al. (2008).

## **“Real” Injury-Preventive Component**

Many authors have referred to this fact, especially in the case of generalized or multifaceted prevention-training programs (Ekstrand et al., 1983a; Soligard et al., 2008; Kirkendall et al., 2010). Such expansive approaches hinder to determine exactly which factors might have been responsible for the observed effects.

## **Blinding the Recording & Biases**

Petajan et al. (1996) referred to blinding as “the practice of keeping members of the research study unaware of which group a participant is assigned to (treatment or control) in the study”. As an example, the injury blinding absence limiting factor was reported by some authors in their injury prevention studies with soccer players (Ekstrand et al., 1983a; Thacker et al., 1999).

In addition, studies in which blinding does not occur can have significant biases. Engebretsen et al. (2008) reported that physical therapist contact with intervention and control groups was different in their study, as well as this person also was responsible for reporting injuries. This could lead in attention bias. Furthermore, selection bias may result when players are allowed to select their own protective method (Rovere et al., 1988).

## **Lack of Exercises Progression**

Some authors have detected this limitation in earlier programs, such as Steffen et al. (2008) with “The 11” injury prevention warm-up, which helped to start with development of “The 11+”.

## **Methodological Differences**

Inklaar et al. (1996) reported similar injury characteristics between top-level and lower-level soccer clubs in the Netherlands. However, they also postulated that highly trained subgroups in Dutch soccer players were associated with the highest injury risks, in the same way as other studies support that high-level players sustain more injuries compared to low-level ones (Nielsen & Yde, 1989; Ekstrand & Tropp,

1990). Such lack of consensus may be related to methodological differences that could range from injury definition (Lüthje et al., 1996) to injury registering methods. These differences make difficult to compare studies and gives place to differences in results (Woods et al., 2003). Below, some examples are presented:

- Exercise Performance Technique: the balance board training implemented by Söderman et al. (2000) was performed with the knee in a flexed position, which may not influence ankle joint stabilization. However, Tropp et al. (1985a) indicated their players to stand in the board with the knee extended, which may be better for training ankle stabilization.
- Injury Definition: depending on the study different definitions can be found. Woods et al. (2003) defined a recordable injury as “one sustained during training or competition and which prevented the player from participating in normal training or competition for more than 48h (not including the day of the injury)”. Therefore, in their case, any injuries where players missed training for less than this stipulated time were not included; whereas other studies defined injury as any incident that causes a player to miss the next scheduled game or practice session (Lewin, 1986; Ekstrand & Tropp, 1990). On consultation with doctors and physiotherapists working in professional soccer, they felt that the definition used in Woods et al. (2003) study was more appropriate.
- Injury Incidence Index: studies differ in the denominator they use for the injury index. Some researchers use as denominator the exposure time (Junge & Dvorak, 2000), others use the size of the population at risk, or the number of player’s exposures (Yard et al., 2008).

It would be desirable to express ankle sprains incidence both as an incidence by soccer players, as well as an incidence by ankles (Surve et al., 1994). The distinction is important because a previously injured player may sustain an injury in either the previously injured one or in the non-injured ankle.

- Methods to Quantify Relative Injury Risk: it is difficult to compare the relative risk for ankle sprain across sports because of the different methods used to quantify risk (Gross & Liu, 2003). Some of these methods include number of injuries per 1000h of participation (Peterson et al., 2000), number of players injured over a year or season (Tropp et al., 1985a), use absolute terms if exposure is not recorded (Woods et al., 2003) and so on.

### **Study Power and Group Size**

Ergen & Ulkar (2008) commented that before implementing any study, a statistical power analysis must be performed to determine the sample size needed to detect a certain reduction in the injury frequency.

Mohammadi (2007) attributed the problem of not finding statistically significant differences between strength and orthosis group in comparison with the control group to the low study power, which was prompted by the relatively small sizes of groups. Those preventive methods appeared to be clinically significant, so might prove effective in a larger study.

### **Concept Denomination & Controversial Aspects**

Eriksson (2001) commented the difficulty of comparing results and reading articles when different studies name differently to a similar concept. That is the case of “proprioceptive training”, or “balance training” or “coordination training”.

Fong et al. (2007) referred to some aspects that could generate controversy, so it would be appropriate to clarify them. On the one hand, regarding to the weighted percentage of the injured body sites, a higher percentage does not necessarily mean a higher injury incidence to this site. Therefore, high incidence rates do not give all the information about sports injury. In short, the popularity of a specific sport (total participants in this sport) should be considered, in order to make comparisons and decide which sports should be selected to implement injury prevention measures. On the other hand, it is also important to note that a higher incidence rate does not



necessarily mean higher severity of the sports injuries; it only reports the frequency of injury occurrence.

For example: in Holland, although lacrosse showed a higher ankle-sprain incidence than soccer, as soccer is more popular and registers more participants, the total number of ankle sprains sustained in lacrosse may be fewer because this sports is not as popular. However, injury severity could be similar between those sports, even greater in any of them.

### **Limitations in the Laboratory Settings**

Ergen & Ulkar (2008) found that some studies have limitations in the laboratory settings because some measurements do not resemble the actual movement pattern. This happened in the study conducted by Linford et al. (2006), who examined the influence of a 6-week neuromuscular training program on the electromechanical delay and reaction time of the peroneus longus muscle. The failed to mimic more closely the dynamic mechanism of an ankle sprain injury and the motor patterns active during gait.

### **Injury Awareness**

Injury awareness is generally believed to be a major confounding factor in sports injury research because, in some way, forces players have to adjust their sports behavior (Ergen & Ulkar, 2008).

### **Study Design**

The design selected for some studies may give rise to questioning the validity of the results (Callaghan, 1997).

## CONCLUSIONS

As a general conclusion, although cannot be completely avoided, it is possible to prevent ankle injuries in soccer players. From this point, prevention measures should receive considerable attention in high-injury risk sports such as soccer.

The present review displays comprehensive evidence of effective prevention programs at lowering common soccer injuries such as ankle ones. Extensive literature data shows significant reductions in ankle ligament sprains when performing different generalized, multifactorial or joint-specific prevention strategies. Several examples of those protocols are the following ones: generalized warm-up plans that incorporate injury-specific program aspects, proprioceptive training programs, muscle strengthening, prophylactic ankle supports, endurance to avoid fatigue, a combination of methods; as well as the use of protective equipment, adequate rehabilitation process or injury awareness educational interventions.

It must be emphasized the significance of collecting detailed information about risk factors, injury incidence, injury mechanisms, targeted body site structure and other factors; previously to develop any prevention program. Furthermore, it is also of paramount importance to put all efforts in identifying injury-prone individuals, so as to tailor specific preventive approaches.

In spite of the current available bibliography, further well-designed randomized controlled studies on preventive methods and devices are necessary, in order to improve already existing measures and to achieve larger injury-reduction outcomes.

Finally, the sports medicine community needs to be conscious and diligent in promoting simple and effective preventive programs as a primary educational effort. On-the-field coaches, as well as the technical staff, need to be encouraged to implement injury prevention measures as an essential component of their team's training routine. In the same manner, beneficial proven steps should be taught to players since young stages, regardless of gender or level play. Thereby, time lost to injury would be effectively reduced, and players' physical condition could be ensured.

## PRACTICAL IMPLICATIONS

The majority of the researchers usually dedicate a brief part of their investigations to show their observations about topics of interest, such as the role of training/match ratio to injuries (Ekstrand et al., 2004); as well as other practical implications. Below, some of the compiled interesting proposals are listed:

### Future Possible Study Lines

- Injury risk associated with the combination of previous ankle sprain history and being overweight in male players (Ergen & Ulkar, 2008).
- Possible evidence connecting local instability with global disability (McKeon & Mattacola, 2008).
- Female soccer players benefited from injury prevention training on hip and knee kinematics during a landing task. It was effective in altering lower extremity motions that may play a role in female predisposition to ACL injury (Pollard et al., 2006). A line of work could be investigating whether this alteration indirectly has an influence on ankle injury risk, in both male and female players.

### Topics Requiring Further Investigation

- Return-to-Play Protocols/Criteria: definition consensus, threshold for return to play (not just pain absence or gain strength), clinical indicators, more systematic evaluation (such as looking at the complete kinetic chain), and so on (Jones, 2014).
- Preventive Training Programs and Follow-up Length Accuracy: the time ankle braces should be worn after an injury to decrease recurrence risk (Gross & Liu, 2003); which balance/coordination training offers better outcomes, type of activities for players with ankle instability or osteoarthritis and substantial improvements, whether progression of low-impact activities or just single-limb stance activities result in greater prophylactic effect, length of the follow-ups

after proprioceptive training, as well as optimal time to introduce it, programs' optimal length, number of sessions per week, duration of each session... need to be more precisely determined (McKeon & Mattacola, 2008).

- Potential Effects of Ankle Support: on joint kinetics, joint kinematics during dynamic activity (i.e., a cutting maneuver), and various sensorimotor measures are not well known (Cordova et al., 2002). In the same line, other aspects from orthoses need further research (Thacker et al., 1999; Gross & Liu, 2003):
  - Does prolonged use of ankle braces has adverse effects on muscle strength?
  - Do ankle braces place more injury risk on proximal joints?
  - Is it cost-effective and practical to provide ankle supports to all injury high-risk considered players?
  - Should the orthosis selection be given by the degree of ankle joint instability?
- Nationwide Retrospective Surveys on Sports Injuries: can deliver valuable information to set more specific preventive strategies focused on population at risk, exposure time or current use of braces by soccer players (Schmikli et al., 2010).
- Preventive Programs Adaptability to other Populations: differences between gender, differences between orthoses or players with previous history of ankle sprain and non-injured ones; although already analyzed, future studies should take those aspects into account (Thacker et al., 1999).
- Natural and Artificial Turf Concern: there is a debate about injury risk between surfaces and is under the spotlight of some studies (Stanitski et al., 1974).

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## ADDENDA

### Addendum 1. Overview and Summary of Ankle Injury Prevention Programs in Soccer

Author (Year) (Country)	Study Design	Population (N) and Follow-up	Study groups	Outcomes
<b>Ekstrand et al. (1983)</b> (SWE)	RCT	180 male adult soccer on 12 teams (divided into 2 groups of 6 teams) observed for 6 months	1) Intensive season-long prevention program 2) Control (standard training program)	13 ankle sprains: 1) 2 sprains 2) 11 sprains  75% overall less injuries
<b>Tropp et al. (1985)</b> (SWE)	RCT (of teams)	439 male senior soccer players on 25 teams during 1 pre-season	1) Controls (171) 2) Offered cloth orthosis (60 used and 64 did not) 3) History of sprain (ankle balance board training), no history of sprain (control)	1) 30/171 (17%) 2) 2/60 (3%) 3) 7/142 (5%)  Significantly lower recurrent ankle-sprain incidence in the balance board and braced groups
<b>Surve et al. (1994)</b> (S. AFR)	RCT	Senior male soccer players during 1 season:  258 with history of ankle sprain (H) wore a semi-rigid ankle orthosis (Ankle Stirrup)  371 with no history of ankle sprain (NH).	1) H-AS (127) 2) H-Control (131) 3) NH-AS (117) 4) NH-Control (129)	123 sprains  1) 16 (0.46/1000 player hours) 2) 42 (1.16/1000 player hours) 3) 32 (0.97/1000 player hours) 4) 33 (0.92/1000 player hours)  Significantly lower recurrent ankle sprain recurrence density in the braced group
<b>Lehnhard et al. (1996)</b> (EEUU)	RCT/time-series	20 college men soccer players over a 4-year period	1) Intervention group during last 2 years (strength training regimen) 2) Control group	All-type injury reduction in the incidence rates
<b>Sharpe et al. (1997)</b> (EEUU)	Retrospective review	38 varsity female college soccer players, previously ankle sprained, over a 5-year period  1) n=19 2) n= 12 3) n= 8 4) n= 17	1) Taping group 2) Laced ankle group (brace)  1) Combination of measures group 2) Control group	Best effects were achieved in the group wearing the brace (no recurrence), but the incidence of ankle sprain was also reduced in the taped and combination groups (25% recurrence)
<b>Heidt et al. (2000)</b> (EEUU)	RCT	300 high school female soccer players (14-18 years) for 7 weeks	1) Pre-season fitness program 2) Control group	1) 14% injured 2) 34% injured

<b>Söderman et al. (2000)</b> (SWE)	RCT	221 Swedish female soccer players (13 teams) during 1 season - IG (7 teams and 121 players) - CG (6 teams and 100 players)	1) Intervention group (balance board training program) 2) Control group	No significant differences in ankle-sprain risk
<b>Junge et al. (2002)</b> (CHE)	Prospective controlled intervention	194 youth male amateur soccer players (14 teams divided into 2 groups of 7 teams) over 1 year	1) Intervention group with a generalized injury prevention program 2) control group	21% fewer injuries in the intervention vs. control
<b>McGuine &amp; Keene (2006)</b> (EEUU)	RCT	765 high school soccer and basketball players (523 girls and 242 boys) with unknown follow-up - IC (27 teams and 373 players) - CG (28 and 391 players)	1) Intervention group (balance board training program) 2) Control group	Significantly lower ankle-sprain incidence density in intervention group per 1000h of exposure.  No difference between groups without previous ankle sprain
<b>Mohammadi (2007)</b> (MAR)	RCT	80 adult male soccer players (20 in each group) over 1 season	1) Proprioceptive training 2) Specific strength training of evertor muscles 3) Orthosis 4) Control	1) 1 (5%) 2) 4 (20%) 3) 2 (10%) 4) 8 (40%)  Significantly lower ankle-sprain recurrence in the balance-board training group
<b>Hägglund et al. (2007)</b> (SWE)	RCT	24 amateur soccer players during 1 season	1) 10-step rehabilitation program 2) Control group	75% reduction in lower limb recurrent injury risk
<b>Engebretsen et al. (2008)</b> (NO)	RCT	508 professional soccer players at increased injury risk (31 teams and 76% of the players in the intervention group) during 1 pre-season	1) Injury specific progressive programs were designed for players with high risk of multiple injuries 2) Control group	No significant differences in ankle sprain incidence  Poor compliance
<b>Steffen et al. (2008)</b> (NO)	Cluster RCT	2010 female youth soccer players during an 8-month season: - IG (59 teams and 1091 players) - CG (54 teams and 1001 players)	1) Intervention group ("The 11" warm-up program) 2) Control group	No significant difference in ankle sprain incidence  Poor compliance
<b>Grooms et al. (2013)</b> (EEUU)	Prospective Single-Cohort Study	41 collegiate male soccer players aged 18-25 (1 team) followed for 2 seasons  Control group was formed by previous season players	1) Intervention group (F-MARC 11+ warm-up program) 2) Control group	72% reduction of lower extremity injury risk