

# **Risk factors for ankle sprain injury in male amateur soccer players: A prospective cohort study**

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“ONDERGETEKENDE

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## **SAMENVATTING**

**Achtergrond:** Enkelverstuikingen beslaan ongeveer 20% van alle voetbalblessures en meer dan 80% van alle enkelblessures. Vierenzeventig procent van de patiënten die een enkelverstuiking hebben opgelopen ervaren persisterende klachten 1.5-4 jaar na het letsel. Enkelverstuikingen hebben ook een hoge recidiefrequentie. In eerdere studies is weinig consensus met betrekking tot de risicofactoren voor enkelverstuikingen door de verschillen in studiepopulatie en definities van blessures. De hoge incidentie en recidiefrequentie van enkelverstuikingen bij voetballers, de negatieve gevolgen na enkelverstuikingen en het gebrek aan consensus voor risicofactoren, geven aan dat prospectief onderzoek naar risicofactoren voor enkelverstuikingen in een grote populatie voetballers belangrijk is voor het ontwikkelen van preventieve maatregelen.

**Doelstelling:** Het identificeren van risicofactoren voor enkelverstuikingen bij amateurvoetballers.

**Studiedesign:** Prospectief cohort onderzoek.

**Methode:** Participanten waren 456 Nederlandse eerste klas amateurvoetballers tussen 18 en 40 jaar. Voordat het voetbalseizoen begon werden alle spelers gevraagd om een vragenlijst in te vullen met betrekking tot baselinekarakteristieken. Tijdens het seizoen werd blootstelling aan trainingen en wedstrijden wekelijks gemeld. Letsels en de ontstaanswijze werden online in een blessure registratie systeem gemeld door de paramedische staf. Intrinsieke en extrinsieke risicofactoren (leeftijd, lengte, gewicht, totale trainings- en wedstrijdtijd, ratio training-wedstrijd, positie, interventie 'The FIFA11' en eerder enkelletsel) werden geanalyseerd in een achterwaartse stapsgewijze multivariate logistische regressie analyse.

**Resultaten:** Tijdens de studieperiode ontstonden 55 (12%) enkelverstuikingen. Van de 55 geblesseerde spelers had 31% een eerder enkelletsel. De meeste enkelverstuikingen ontstonden tijdens de wedstrijd (64.8%). Bij 63.6% van de enkelverstuikingen was contact met een andere speler. In de achterwaartse stapsgewijze multivariate logistische regressie waren leeftijd (OR 0.909,  $p=0.017$ ) en een eerder enkelletsel (OR 1.762,  $p=0.079$ ) significante risicofactoren. De sensitiviteit was 63.6% en de specificiteit 55.1%. The oppervlakte onder de ROC-curve was 0.636.

**Conclusie:** De risicofactoren jongere leeftijd en een eerder enkelletsel moeten met voorzichtigheid geïnterpreteerd worden door het slecht discriminerend model. Voordat preventieve maatregelen ontwikkeld kunnen worden, is aanvullend onderzoek nodig dat modificeerbare en lichamelijke risicofactoren voor een eerste en recidiverende enkelverstuikingen gedurende een langere periode in een grotere populatie voetballers onderzoekt.

**Trefwoorden:** risicofactor, enkelblessure, voetbal, prospectieve studie.

## **ABSTRACT**

**Background:** Ankle sprain injuries account for around 20% of all soccer injuries and more than 80% of all ankle injuries. Seventy four percent of the patients who suffered an ankle sprain injury have persisting symptoms for 1.5-4 years after the injury. Ankle sprain injuries also have a high recurrence rate. In previous studies, there is little consensus with regard to the risk factors for ankle sprain injuries due to the differences in study population and definitions of ankle injury.

The high incidence and recurrence rate of ankle sprain injuries in male soccer players, the negative consequences after ankle sprain injuries, and lack of consensus in risk factors, indicate that prospective research on risk factors for ankle sprain injuries in a large population of male amateur soccer players is important for developing preventive measures.

**Objective:** Identify risk factors for ankle sprain injury in male amateur soccer players.

**Study design:** Prospective cohort study.

**Methods:** Participants were 456 first-class Dutch male amateur soccer players between 18 and 40 years. Players filled in a preseason questionnaire to record baseline characteristics. During the season, player exposure to training sessions and matches was reported weekly by the coaches. The paramedical staff reported injuries and their etiology online in a web-based injury system. Intrinsic and extrinsic risk factors (age, length, weight, total exposure, ratio training-match, position, intervention 'The FIFA11', and history of ankle injury) were determined in a backward stepwise multivariate logistic regression analysis.

**Results:** During the study period, 55 (12%) initial ankle ligament injuries occurred. Of the 55 injured players 31% had a previous ankle injury. Most ankle ligament injuries occurred during match play (64.8%). Player contact was responsible for 63.6% of the ankle sprain injuries. In a backward logistic regression enter-method significant risk factors were age (OR 0.909,  $p=0.017$ ), and history of ankle injury (OR 1.762,  $p=0.079$ ). The sensitivity was 63.6% and the specificity 55.1%. The area under the ROC-curve was 0.636.

**Conclusion:** The risk factors younger age and history of ankle injury should be interpreted carefully because of the poor discriminative model. Before preventive measures can be developed, further research is needed to determine modifiable and physical risk factors for a first and recurrent ankle sprain injury over a longer time in a larger population of male soccer players.

**Key words:** risk factor, ankle sprain injury, soccer, prospective study.

## INTRODUCTION

The incidence of ankle sprain injuries in soccer is high, particularly in male amateur soccer players. Ankle sprain injuries in male amateur soccer players have an incidence of 2.16 per 1000 hours of exposure(1) and during games 11.68(2). Ankle sprain injuries, defined as acute injuries of the ankle ligaments(1,3-8), account for around 20% of all soccer injuries and more than 80% of all ankle injuries(1,2,9-13). Ankle sprain injuries occur during incorrect foot positioning at landing or landing on irregular surfaces such as the foot of another player, due to a tackle from the medial side, or due to delayed reaction time of the peroneal muscles(1,11).

Seventy-four percent of the patients who suffered an ankle sprain injury have persisting symptoms for 1.5-4.0 years after the injury, e.g. pain, swelling, instability, leading to long-time or permanent absence of sports participation(2,11,14). These persistent symptoms are possibly a leading cause of cartilage damage, degenerative changes and early development of osteoarthritis(10,11,14). Despite the persistence of residual symptoms, players return to sport participation(14). Consequently, these residual symptoms increase the risk of recurrent sprain injuries(14). Kofotolis et al. (2007) reported that sixty percent of the ankle sprain injuries occur in players with a history of previous ankle sprains(1). Compared to the initial injury (18 days and 3 matches), recurrent injuries lead to a longer absence in sport (19 days and 4 matches)(13).

Several possible risk factors for developing ankle sprain injuries have been investigated. A distinction can be made between intrinsic (person-related) and extrinsic (environmental-related) risk factors(11,15). In the literature there is consensus that previous ankle sprain injury is a significant intrinsic risk factor for a recurrent ankle sprain injury(1,3,11,16). Soccer players with a previous ankle sprain injury are 4.9 times more likely to sustain a recurrent ankle sprain injury than players without previous ankle sprain injury(11). However, there is no consensus about the intrinsic factors limb dominance(1,3,12,13,17), age(1,3), height, weight and body mass index(1,3,17). Extrinsic factors which are significantly related to an ankle sprain injury are the first months compared to the last months of the season(1,13), matches

compared to training(1,13,16), and the end of the first and second halves of the match(1,13). There is no consensus about the possible risk factors player position(1,3,11), the timing of the injuries either in the first or second half of the match(1,12,13), and artificial turf compared to natural grass(18).

Possible explanations for lack of consensus in the literature with regard to the risk factors for ankle sprains are differences in population and definitions of ankle injury. Most studies investigated ankle sprain injuries in female and male athletes and not specific soccer players(2,9,11,15,17), ankle injuries in general in soccer players and not specific ankle sprain injuries(3,12), or ankle sprain injuries only in professional soccer players(13). Furthermore, most studies investigated risk factors in univariate analysis, while sport injuries are a multirisk phenomenon with various risk factors interacting at a given time and need to be determined in multivariate analysis with a large population(15,19).

The high incidence and recurrence of ankle sprain injuries in male soccer players, the negative consequences after ankle sprain injuries, and lack of consensus in risk factors, indicate that prospective research on risk factors for ankle sprain injuries in a large population of male amateur soccer players is important. As a basis to develop preventive measures, risk factors and soccer players at risk for ankle sprain injuries need to be identified(1,3,9-13,15-17,20). Therefore, the objective of the current study was to identify risk factors for ankle sprain injury in male amateur soccer players.

## **METHODS**

### **Study design**

In this prospective cohort study data were used from a two-armed cluster-randomized controlled trial (RCT) on Dutch male amateur soccer players examining the effect of the injury prevention program 'The FIFA11'(8). This warming-up program included exercises focusing on core stability, eccentric training of thigh muscles, proprioceptive training, dynamic stabilization, and plyometrics with straight leg alignment. Because no significant differences were found in the injury rates between the intervention and the control group, the data of the entire study population

(intervention and control group) were used to identify risk factors for ankle sprain injury.

### **Participants**

Two regional districts, with 12 teams per district, were invited to participate in the RCT-study. Players were included at the start of the soccer season of 2009-2010. The inclusion criteria were first-class male amateur soccer players between 18-40 years of age. There were no exclusion criteria.

Two regional soccer districts in the Netherlands with 23 teams, 456 players, participated in this study. All teams had training sessions two to three times a week. Written informed consent was obtained from all soccer players at the start of the cluster-randomized study.

### **Data collection**

Before the soccer season started (August 2009) all players were asked to fill in a questionnaire to record baseline characteristics (date of birth, length, height, body mass index, nationality, years of experience as a soccer player, dominant leg, position, and injuries during the last year). During the season, player exposure to training sessions (team-based and individual physical activities under the control or guidance of the team's coaching(4)) and matches (games played between teams from different clubs(4)) was reported weekly by the coaches using an exposure form(8). Injuries and injury characteristics were prospectively recorded during the 2009-2010 competitive season from the first competition match (September 2009) until the last regular competition match of the season (May 2010).

Of each team, a member of the medical staff was responsible for recording baseline characteristics, exposure, and the injuries and etiology of injuries using the Web-Based Injury System (BIS)(8). The system is capable of gathering epidemiological information on injuries (date of occurrence, occurrence during training session or match play, location, type, and duration), etiology (intrinsic and extrinsic factors; shoes, weather, field, position, dominant/non-dominant leg, contact/non-contact mechanism), consequences of injuries (e.g., work/school/sports absenteeism), and the volume and type of medical treatment, and residual complaints.

An ankle sprain injury was defined as an acute injury of the ankle ligament(s)(1,3-8). When repeated ankle sprain injuries occur during the season, only the initial ankle sprain injury was used for analysis.

Age, years of experience as a soccer player, length, weight, body mass index, and history of ankle injury were considered as potential intrinsic risk factors.

Position, warming-up program 'The FIFA11', exposure to training sessions and/or matches, and ratio training-match were considered as potential extrinsic risk factors.

### **Statistical analyses**

Data were collected in a quantitative manner using continuous and categorical data and analyzed using SPSS version 20.0.

Descriptive statistics were obtained for baseline characteristics of the players, player exposure during training and matches, and the characteristics of the ankle sprain injury.

To examine the contribution of the possible risk factors to ankle sprain injuries, risk factors were determined in a backward stepwise multivariate logistic regression analysis(3,16,21,22). Dependence between risk factors was determined with Pearson Correlation Coefficients. For the backward model the level of significance was set at  $p < 0.10$ (3,21,22).

$X^2$ -tests were used to compare observed and predicted ankle sprain injuries and to calculate sensitivity and specificity(23). To distinguish between players who do or do not sustain an ankle sprain injury, a ROC-curve (Receiver Operating Curve) was calculated(21).

## Sample size calculation

Ankle sprain injuries account for 20% of all soccer injuries(12). With a OR of 1.5 (ln 0.41), a power of 0.80 and alpha at 5%, a sample size of 291 players is needed in a simple logistic regression(24). With a correction factor for multiple regression  $R=0.6$ , a sample size of 455 players is needed(19).

## RESULTS

### Participants

Participants were 456 male soccer players, on average 24.7 years (yrs) of age (table 1). Almost all players (95%) were Dutch. The positions of the players were: 9.9% goalkeepers, 32.2% defenders, 32.5% midfielders, and 25.4% attackers. Twenty-two percent of all players suffered at least one ankle injury the last year.

TABLE 1: Baseline characteristics and training and match exposure

	n	Mean (standard deviation)
<b>BASELINE CHARACTERISTICS</b>		
Age (yrs)	456	24.7 ( $\pm$ 4.2)
Years experience (yrs)	447	17.5 ( $\pm$ 4.5)
Length (m)	449	1.83 ( $\pm$ 0.06)
Weight (kg)	449	78.2 ( $\pm$ 7.5)
Body Mass Index ( $\text{kg}/\text{m}^2$ )	448	23.3 ( $\pm$ 1.8)
<b>TRAINING AND MATCH EXPOSURE</b>		
Total individual exposure (hrs)	456	97 ( $\pm$ 29)
Training exposure (hrs)	456	69 ( $\pm$ 21)
Match exposure (hrs)	456	28 ( $\pm$ 11)
Ratio training/match exposure	456	3.0 ( $\pm$ 6.1)

## **Ankle ligament injuries**

During the study period, 55 (12%) initial ankle sprain injuries occurred. In total, 60 ankle ligament injuries occurred in 55 players, but five were recurrent injuries.

The average age of the injured players was 23.4 ( $\pm$  3.8). The average age of the uninjured players was 24.9 ( $\pm$  4.2).

Of the 55 injured players, 17 (31%) players had a previous ankle injury.

## **Ankle ligament injury mechanisms**

Of the 55 ankle sprain injuries, most ankle sprain injuries occurred during match play (64.8%). Of the injured players during match play 44.1% were defenders, 26.5% midfielders, 20.6% attackers, and 8.8% goalkeepers.

Player contact was responsible for 63.6% of the ankle sprain injuries. In 81.8% there was no ball contact and 36.4% of the injuries occurred during incorrect foot placing. Two third of the ankle ligament injuries were injuries to the dominant leg (66.0%).

## **Logistic regression**

Age and years of experience were significantly correlated to each other (Pearson Correlation Coefficient of 0.801,  $p=0.000$ ). Because age was used previously in the literature, only age was included in the logistic regression.

In a backward logistic regression enter-method with age, length, weight, total exposure, ratio training-match, position, intervention 'The FIFA11', and history of ankle injury, significant risk factors were age (odds ratio (OR) 0.909, 95% CI 0.840-0.983,  $p=.017$ ), and history of ankle injury (OR 1.762, 95% CI 0.937-3.315,  $p=0.079$ ).

The significant risk factors and the  $p$ -values did not change if length and weight were replaced for BMI ( $\text{kg/m}^2$ ) and if total exposure during training and match play was replaced for exposure during training and exposure during match play. Pearson Correlation Coefficients are significant related for length and BMI ( $-0.177$ ,  $p=0.000$ ), weight and BMI ( $0.682$ ,  $p=0.000$ ), total exposure and exposure during training ( $0.963$ ,  $p=0.000$ ), and total exposure and exposure during match play ( $0.848$ ,  $p=0.000$ ).

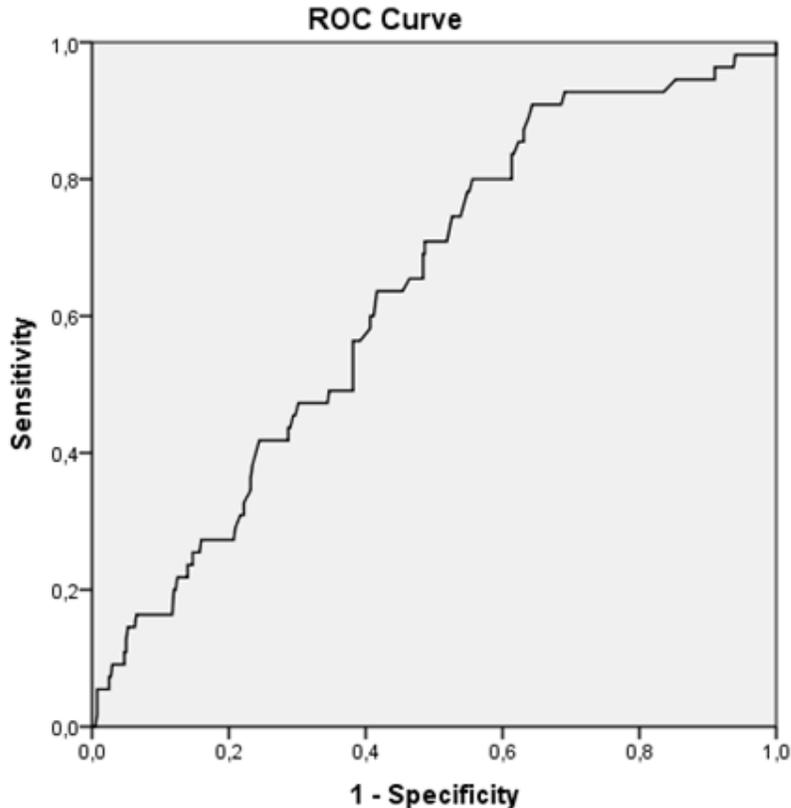
The  $\chi^2$ -test to compare observed and predicted ankle sprain injuries was 10,304 ( $p=0.006$ ). The sensitivity was 63.6%, the specificity 55.1% and the overall percentage 56.1% (table 2).

The area under the ROC-curve (c-index) was 0.636 (figure 1).

TABLE 2: Classification Table

		PREDICTED		PERCENTAGE CORRECT
		ANKLE SPRAIN INJURY		
OBSERVED		NO	YES	
ANKLE SPRAIN INJURY	NO	221	180	55.1%
	YES	20	35	63.6%
OVERALL PERCENTAGE				56.1%

FIGURE 1: ROC-Curve



## DISCUSSION

The objective of the current study was to identify risk factors for ankle sprain injury in 456 Dutch male amateur soccer players. In a backward logistic regression enter-method significant risk factors were age (OR 0.909,  $p=0.017$ ), and history of ankle injury (OR 1.762,  $p=0.079$ ).

### Risk factors for ankle sprain injury

In multivariate logistic regression age was a significant risk factor for sustaining an ankle sprain injury. The OR of 0.909 means that younger age is a significant risk factor. Two-third (37/55) of the ankle sprain injuries occurred in younger players ( $\leq 24.7$  yrs) and one-third (18/55) in older players ( $>24.7$  yrs). This finding is in contrast with other studies. Arnason et al. (2004) reported that older players were at higher risk of football injuries in general (OR = 1.1 per year  $p=0.05$ )(16). Pefanis et al. (2009) reported that older age was a significant risk factor to an ankle sprain injury in athletes(25,26). It is unclear why younger players were at higher risk. Possible explanations are that younger players are not so careful, because they were never or not so often injured or that younger players are less experienced. However, 23% of the younger players had a history of ankle injury and 17% of the older players. Engebretsen et al. (2010) and Kofotolis et al. (2007) found that age was not a significant risk factor for ankle sprain injury in male amateur soccer players(1,3). In these studies, age was not a significant risk factor maybe due to the narrow age range of the soccer players (24.5,  $\pm 4.4$ ). The average age and standard deviation in current study is comparable (24.7  $\pm$  4.2).

In multivariate logistic regression history of ankle injury was also a significant risk factor for sustaining an ankle sprain injury. This result is consistent with previous literature(1,3,11,16). It was found that previous ankle sprain was a significant risk factor for a new ankle sprain. Players with a previous sprain are more likely to sustain an ankle sprain injury than players without a previous sprain(11,16). Arnason et al. 2004(16) reported an OR of 5.31 (95% CI 1.5-19.4,  $p=0.009$ ) and Kofotolis et al. 2007(1) an OR of 1.826 (95% CI 1.458-2.289,  $p<0.05$ ). In the current study, the OR is 1.762, the 95% CI is 0.937-3.315 and the significance 0.079. This effect is

less reliable and uncertain due to the wide confidence interval, the interval passes 1 and the significance is not  $< 0.05$ . Furthermore, there is no explanation found why and younger age and history of ankle injury were significant risk factors in the multivariate analysis. Arnason et al. (2004) reported that previous injury is associated with increased age(16). However, in the current study the average age of players with a previous injury is 23.7 ( $\pm 3.5$ ) and, as above mentioned, 23% of the younger players had a history of ankle injury and 17% of the older players.

The multivariate logistic model is not good at discriminating who will get an ankle sprain injury from who will not get an ankle sprain injury. The  $X^2$ -test was significant, which means that there is a difference in the number of predicted injuries by the model and the number of observed injuries. The model has a poor goodness of fit and is not able to correctly predict ankle sprain injuries. The sensitivity (true positives) was 63.6%, the specificity (true negatives) was 55,1% and the overall percentage 56.1%(27). The area under the ROC-curve was 0.636. This is the percentage players that the model will predict correctly(28). The above mentioned risk factors younger age and history of ankle injury should be interpreted carefully, because of the poor discriminative model.

### **Methodological considerations**

The first limitation of the current study is the registration method. Previous injuries were registered by self-report of the players. Although it's over one year, there is a chance of recall bias, because over time it can be difficult to remember the exact injury site and type of injury(16,29). Therefore, history of ankle injury might be another injury to the ankle than an ankle sprain injury. However, ankle sprain injuries accounts for more than 80% of all ankle injuries(1,2,9-13). Injuries sustained during the study period were registered by a member of the medical staff. There is a chance of misclassification of ankle sprain injuries as a faulty diagnosis. Such errors were tried to minimize by using the BIS-system to record injuries with questions in the form of a flowchart(3,8,29).

Second, a main limitation of a prospective cohort study is the number of cases and events(16). Although risk factors were determined in multivariate analysis, with 55 injuries the statistical power is limited for multivariate tests(3,19).

Bahr and Holme (2003) explained that for analyzing risk factors in a multivariate analysis 200 injured subjects are preferred(19). Not only a larger sample size may increase the number of causes, also a longer observation period for predicting an ankle sprain injury over time.

The third limitation is that no physical tests were performed. Ankle sprain injuries have shown to be more frequent in players with mechanical instability(16). Increased eversion to inversion strength, inferior single leg balance, and faster reaction time of the tibialis anterior and gastrocnemius muscle are significant risk factors for ankle sprain injuries(11,15). Although these physical parameters are modifiable, Engebretsen et al. (2010) reported that leg balance tests are not significant risk factors(3). Beynnon et al. (2002) reported in a review that there is no consensus about muscle strength and muscle reaction time(17).

### **Practical implications and future directions**

Injuries during match play and contact-injuries, especially a tackle from the side or as a result from foul play, were found to be associated with more than half of the ankle sprain injuries(11-13,16,30). Contact-injuries result in more time loss than non-contact injuries. The rate of a contact injury resulting in time loss is 21.0 to 25.5 times that of a noncontact injury(1). Match injuries are predominantly caused by contact with another player and in defenders (80.6%)(1,31). In the current study, player position, e.g. defenders, was not a significant risk factor. Important aspects in the prevention of soccer injuries in general are related to warm-up and cool down, technique, protective equipment, hydration and nutrition, safe environment, the laws of the game, their observance, and especially the spirit of fair play(31,32). Coaches and players need education regarding injury prevention strategies and should include these strategies as part of their regular training(31,32).

A possible modifiable risk factor for ankle sprain injury is history of ankle injury. Functional ankle instability and neuromuscular deficits following ankle sprain injury are hypothesized to predispose players to recurrent ankle sprain injury. The deficits can be impaired balance, reduced joint position sense, and slower firing of the peroneal muscles to inversion(15,16,33,34). In previously sprained ankles there is a significant increased frequency of lateral instability and positive anterior drawer

compared with ankles without previous ankle sprain injury(16). These deficits might result in a failure to correct excessive ankle positions, due to impairment of timing and neuromuscular coordination, leading to the high risk of recurrent injuries(13,29,35). Also fatigue may influence the mechanoreceptors in the muscles around the ankle joint(36). Inadequate management and early return to play after ankle sprain injury may lead to problems like functional instability, osteoarthritis, and recurrent injuries(1,11,16). The risk for recurrent injuries increased with the number of previous ankle sprains (OR 1.23 per previous injury)(3) and the high-risk period is the first six months after a previous injury(3). Proprioception and strength training and braces may effectively break the vicious cycle of recurrent sprains, cumulative loss of proprioception and muscle atrophy, and avoids the development of ankle instability and osteoarthritis(10,13,16,17,29,32-35,37-39).

However, it is not always clear if any of these deficits were present before the injury(10,15). For example, mechanical instability is common after previous ankle sprains and ankle sprains have shown to be more frequent in players with mechanical instability(16). Therefore, it's even more important to prevent the first ankle sprain injury and determine modifiable risk factors for the first ankle sprain injury(40). In subjects without history of ankle injury, decreased balance, lower eccentric eversion strength, and lower inversion joint position sense are associated with an increased risk of ankle injury(40). Proprioceptive training using an ankle disc improves the efficacy of the peroneus longus in controlling eversion and can help to protect against ankle sprains in healthy subjects(35,39). Further studies are needed to determine risk factors and which preventive strategies are effective in soccer players with no history of ankle sprain injuries(35).

## **CONCLUSION**

Significant risk factors for ankle sprain injuries in first-class male soccer players were younger age and history of ankle injury. These risk factors should be interpreted carefully because of the poor discriminative model. Before preventive measures can be developed, further research is needed to determine modifiable and physical risk factors for a first and recurrent ankle sprain injury over a longer time in a larger population of male soccer players.

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