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Intrinsic Risk Factors of Noncontact Ankle Sprains in Soccer

A Prospective Study on 100 Professional Players

Konstantinos Fousekis,*† PhD, Elias Tsepis,‡ PhD, and George Vagenas,† PhD

Investigation performed at Biomechanics and Sports Injuries Laboratory, Department of Physiotherapy, Technological Educational Institute of Patras, Branch Department of Aigion, Greece

Background: Ankle sprain is an extremely common injury in soccer players. Despite extensive research, the intrinsic cause of this injury under noncontact conditions remains unclear.

Purpose: To identify intrinsic risk factors for noncontact ankle sprains in professional soccer players.

Study Design: Cohort study; Level of evidence, 2

Methods: One hundred professional soccer players were assessed in the preseason for potential risk factors of noncontact ankle sprains. The assessment included (A) ankle joint asymmetries (right-left) in isokinetic muscle strength, flexibility, proprioception, and stability; (B) somatometric asymmetries; (C) previous injuries; and (D) lateral dominance traits. Noncontact ankle sprains were prospectively recorded and diagnosed for a full competition period (10 months).

Results: Seventeen of the players sustained at least 1 noncontact ankle sprain. Logistic regression revealed that players with (A) eccentric isokinetic ankle flexion strength asymmetries (odds ratio [OR] = 8.88; 95% confidence interval [CI], 1.95-40.36, P = .005), (B) increased body mass index (OR = 8.16; 95% CI, 1.42-46.63, P = .018), and (C) increased body weight (OR = 5.72; 95% CI, 1.37-23.95, P = .017) each had a significantly higher risk of a noncontact ankle sprain. A trend for younger players (OR = 0.28; 95% CI, 0.061-1.24, P = .092) and for players with ankle laxity asymmetries (OR = 3.38; 95% CI, 0.82-14.00, P = .093) to be at greater risk for ankle sprain was also apparent to the limit of statistical significance ($.05 < P < .10$).

Conclusion: Functional strength asymmetries of the ankle flexors and increased body mass index and body weight raise the propensity for ankle sprains in professional soccer players. Age and asymmetries in ankle laxity are potential factors worth revisiting, as there was an indication for younger players and players with ankle instability to be at higher risk for ankle injury. Proper preseason evaluation may improve prevention strategies for this type of injury in soccer.

Keywords: soccer; ankle injuries; injury prevention

Soccer involves various unilateral skills that cause musculoskeletal asymmetries[22,23] and injuries[9,10] to the players. The incidence rate of soccer injuries varies from 7.4 to 47.5 injuries per 1000 hours of play,[13,16,44] with this variation being due to methodological differences (defining injury, training level, age and gender of subjects, research design).[29,51,59] The majority of soccer injuries (68%-88%) occur at the lower extremities[15,31] and affect mostly the ankle and the thigh.[18,28] The ankle joint in particular incurs 14% to 17% of all soccer injuries,[20] as it absorbs the mechanical loads produced through the constant interaction of the player with the ground and the opponents.[16] This makes the joint susceptible to injuries, such as sprains, which affect the lateral ligaments and vary in severity and disability with the degree of damage.[27,58] The incidence of recurrent ankle sprain is high and leads to further damage and to mechanical instability of the joint.[30,54]

Several studies propose potential extrinsic and intrinsic factors of ankle sprain susceptibility.[§] Direct contact with an opponent,[1,58] inadequate warm-up,[38] shoes,[38] and playing on artificial turf are the primary extrinsic risk factors of this injury,[41] whereas intrinsic risk factors include anatomic characteristics (eg, increased foot width),[3,5] functional deficits in isokinetic strength,[||] flexibility,[¶] joint position

*Address correspondence to Konstantinos Fousekis, PhD, 6 Psaron Street, Aigion 25100, Greece (konfousekis@gmail.com).

†Department of Physical Education and Sports Science, Quantitative Analysis and Kinesiology, Research, University of Athens, Athens, Greece.

‡Department of Physiotherapy, Biomechanics and Sports Injuries Laboratory, Technological Educational Institute (TEI) of Patras, Branch Department of Aigion, Aigion, Greece.

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§References 1-3, 5, 6, 12, 14, 17, 26, 32, 37-39, 41-49, 52, 53, 55, 56.

||References 5, 6, 10, 14, 26, 39, 46, 55, 56.

¶References 2, 5, 14, 26, 45, 46, 48, 52, 55, 56.

sense,[12,39,48,55,56] balance-postural sway[6,37,47-49,55,56] and gait mechanics,[56] limb dominance,[3] previous ankle sprains,[30,32,48] and increased weight and body mass index (BMI).[43,49]

Despite the plentiful literature dedicated to the detection of the intrinsic factors of ankle ligament injuries in various sports, very few studies have concentrated on the cause of ankle sprain in soccer players, with their results being rather conflicting. For example, from 2 studies that examined postural sway deficits in professional soccer players in connection with the risk of sustaining an acute ankle sprain, 1 concluded in favor of[47] and the other against[17] this connection. Other studies do not support the potential role of functional lower extremity deficits in soccer players, as previous injury was the only significant risk factor of ankle sprain found in their analyses.[2,14,17] Apparently, research on the intrinsic cause of ankle sprains in soccer is limited to the study of deficits in strength, flexibility, joint instability, and previous injury. Considering the effects of functional footedness in almost every soccer player, it is surprising that no study so far has focused on the potential role of lower extremity functional and anthropometric asymmetries in the propensity for ankle sprains. Therefore, this study aimed at determining the extent to which: (A) asymmetries in muscle strength, flexibility, neuromuscular coordination, and anatomic characteristics of the ankle joint; (B) physical total body characteristics; and (C) a previous history of sprains are connected with increased risk of noncontact ankle sprains in professional soccer players.

METHODS

Subjects

A cohort of 115 players was initially recruited from 4 third-division professional soccer teams. The players were screened for inclusion in the study if they sustained no injury for at least a period of 6 months before testing. This requirement allowed an injury-free period adequate to ensure that the myodynamic and functional parameters under study were unaffected; this resulted in a total of 100 players eligible for the study. All players had followed approximately the same training regimen (6-7 days of training per week, 1 game weekly). The sample size was estimated: (A) to be close to those of previous relevant studies on professional soccer players[49,57]; (B) to secure the power of detecting an odds ratio (OR) as small as 0.01[11] in order to cover ORs less than 1 in case of predictors that decrease the odds of injury; (C) to be an experimentally realistic one in order to minimize the risk of committing the very serious methodological problem of "subject loss" in cohort studies,[33] which is very high in this population of professional athletes; and (D) to permit for many complicated myodynamic and functional measurements, which is practically difficult with very large samples. The ethical acceptability of the study was approved by the postgraduate studies committee of the Physical Education and Sport Science Department at the University of Athens. Before testing, all soccer players signed informed consent.

Procedures

A preseason evaluation of the ankle joint was conducted for isokinetic muscle strength, flexibility, joint stability, neuromuscular coordination, and anthropometric characteristics. Additionally, footedness was assessed according to the questionnaire proposed by Markou and Vagenas,[35] which examines leg usage in terms of dynamic, explosive, and dexterous activities. With this assessment, 74 players were classified as right footed, 16 as left footed, and 10 as mixed footed. Figure 1 depicts an overview of the procedures, tests, and measurements made in the present study.

Before testing, each participant performed 10 to 15 minutes of pedaling on an ergometric bicycle and sufficient dynamic stretching of the lower extremity muscles, including those of the ankle joint, for warm-up. Each participant was familiarized with the testing devices and measurements before testing. Three measurements were obtained and averaged per variable, muscle group, and limb side, except isokinetic strength testing for which 5 repeated trials were performed.

Concentric and eccentric isokinetic strength testing of the dorsal and plantar flexors of the ankle joint at 60 deg/sec was performed with a Biodex-System III dynamometer (Biodex Medical, Shirley, New York). The flexibility of the ankle was assessed goniometrically according to the method described by Van Roy and Borms.[50] Proprioception was assessed in terms of neuromuscular coordination errors produced during performance on a Prokin-200 kinesthetic stabilometer (Prokin-Technobody Dalmine, Bergamo, Italy).[19] For this assessment, the player had to cover a sequence of 5 traces of a circular route to the best of his ability by the movement of the ankle joint using a cursor controlled by an electronic platform. The percentage deterioration from the ideal circular route covered was calculated to reflect the degree of neuromuscular coordination of the lower extremity. The anthropometric measurements were taken with the International Society for the Advancement of Kinanthropometry method[40] by a level III–accredited anthropometrist. Lower limb length was measured as the distance from the great trochanter of the femur to the ground.[40] The stability of the ankle joint was assessed with the anterior drawer test.[8]

The first incidence of any noncontact ankle sprain that forced the player to be absent from at least 1 scheduled practice or game was recorded by each club's medical staff for a period of 10 months after the initial measurements. The side (limb) and the severity of the injury, along with all necessary details, were recorded using a questionnaire proposed by Fuller et al.[24] To ensure that the observed asymmetries and imbalances were unaffected by corrective programs during the 10-month competition period, the clubs' physiotherapists and the players were informed about their results only after the completion of the study.

Data Processing and Analysis

Before the statistical analyses, all outcome variables were recoded into dichotomies. Age, weight, height, and BMI

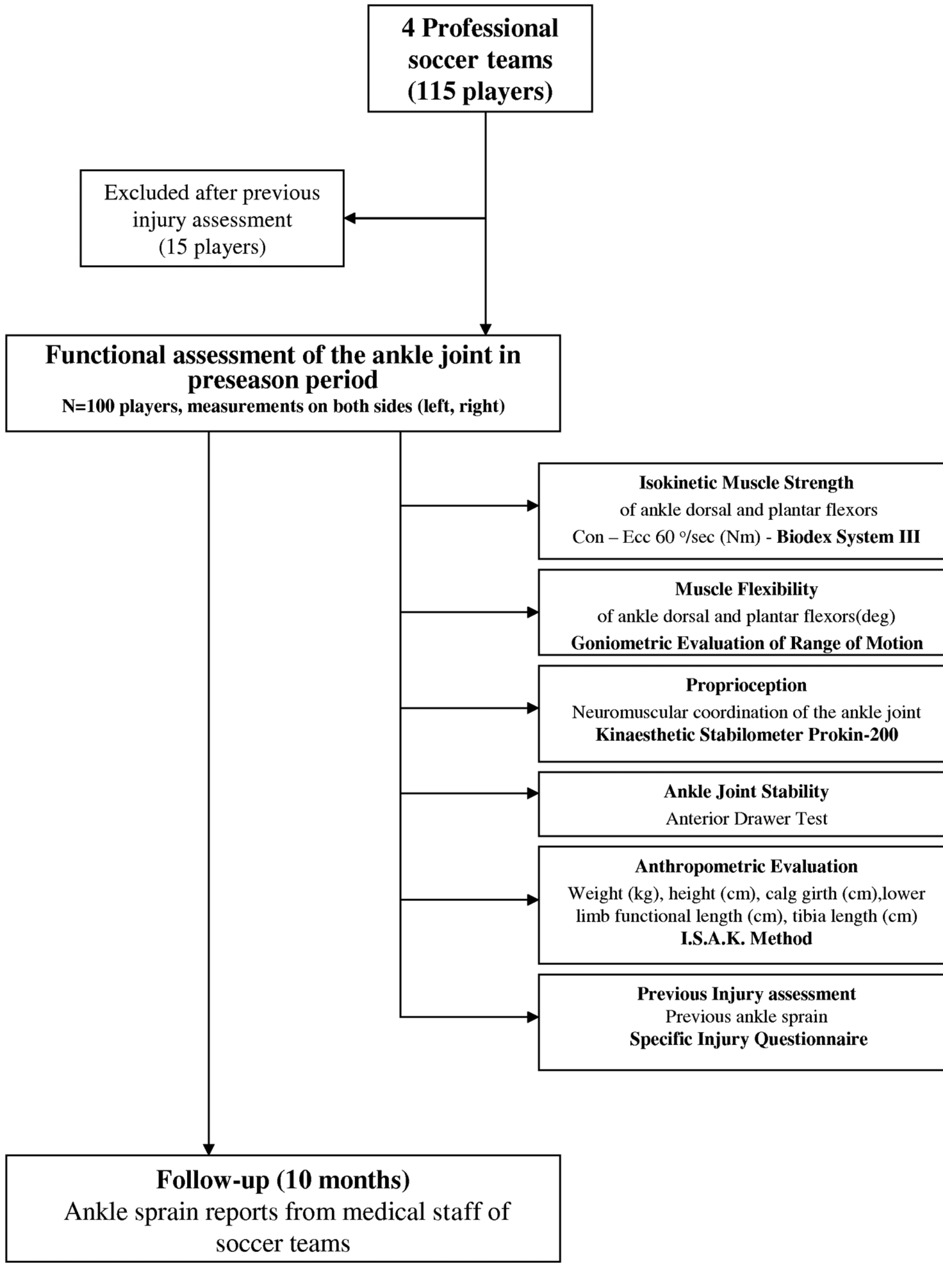

Figure 1. Flowchart of the procedures, tests, and measurements of the study.

were recoded as above or below the median value. Strength and proprioception data were recoded to express asymmetry if right-left (R-L) $\geq$15% or no asymmetry if R-L <15%.[9] Flexibility data were recoded to express asymmetry if R-L $\geq$6° or no asymmetry if R-L <6°.[46] Players were classified as anatomically asymmetric if they were at least 1 standard deviation above or below the average sample value on their total lower limbs. Joint stability was recoded as deficient in the case of a positive anterior drawer test on at least 1 ankle. Criteria for the positive anterior drawer test included laxity and poor endpoint on forward translation of the talus relative to the ankle. Although dichotomous variables are less informative than continuous variables, converting continuous variables into binaries is a common practice in relevant clinical studies[9,46] to simplify interpretation of the risk factors and the related OR values and, most importantly, to provide more clear-cut directions for practical assessment and prevention.

Means and standard deviations for all outcome variables were calculated. Backward stepwise logistic regression was applied to explore the relationship between the occurrence of ankle sprain or not (dependent variable) and the linear combination of all outcome (independent) variables (physical, anthropometric, strength, flexibility,

TABLE 1
Mean (Standard Deviation) Values for Age, Height, and Weight by Footedness in Professional Soccer Players (N = 100)

Footedness	n	Age, y	Height, m	Weight, kg
Right	74	24.4 (3.7)	1.78 (0.06)	73.75 (6.26)
Left	16	23.5 (4.4)	1.77 (0.04)	71.72 (3.47)
Mixed	10	28.5 (5.3)	1.76 (0.06)	72.90 (6.60)
Total	100	23.6 (4.2)	1.78 (0.06)	73.34 (5.94)

TABLE 2
Descriptive Data of Players Possessing Functional and Anatomic Asymmetries and Previous Sprains[a]

	Physical Characteristics and Anatomic Asymmetries (>Median) Risk Factors					
	Age >23.9 y	Weight >72.6 kg	Height >178.8 cm	BMI >23.1	Leg Length (R-L) ≥1.8 m	Anterior Drawer Test (+/–)
% f	39	43	54	59	29	23
	Functional Asymmetries and History of Previous Sprains Risk Factors					
	Myodynamic Asymmetries (R-L) ≥15%		Flexibility Asymmetries (R-L) >6°		Proprioception Asymmetries	
	Concentric	Eccentric	Dorsal Flexors	Plantar Flexors	(R-L) < 15%	Previous Sprains
% f	37	34	28	39	54	49

[a]BMI, body mass index; R-L, right-left; % f, percentage of players in the total sample (N = 100).

proprioceptive, and previous sprains) as potential intrinsic risk factors. All significances were tested at the α = .05 probability level, and the analyses were conducted using SPSS v. 17 (SPSS Inc, Chicago, Illinois).

RESULTS

The physical characteristics of the players are presented in Table 1. The frequency distributions of all functional asymmetries and previous injuries (ankle sprains) of the players, according to the predefined cutoffs, are given in Table 2. Of the 100 players tested in 4 isokinetic variables, 37 had concentric and 34 eccentric clinically important (≥15%) ankle asymmetries. Twenty-nine players had asymmetry in lower limb length, and 23 players had anterior ankle laxity in at least 1 limb. Twenty-eight players had ankle dorsiflexion flexibility asymmetry, and 39 had plantar flexion flexibility asymmetry. Regarding ankle sprains, almost half of the players (49%) reported a history of previous injury.

Ligament injuries sustained by the 100 players during the 10-month period after the initial measurements accounted for 29.6% of the total number of injuries. Twenty-four players sustained 1 or more ankle sprains, both contact and noncontact, while 4 players had knee ligament injuries. Seventeen (70.8%) of the ligament injuries in the ankle joint were noncontact lateral sprains, and the incidence rate for this type of trauma was 0.47 sprains per 1000 hours of play (per player). These noncontact ankle sprains were associated with incorrect foot positioning at landing in 13 (76.5%) cases and at cutting movements in 4 (23.5%) cases. From a total of 17 noncontact ankle sprains recorded, 9 (52.9%) injuries occurred in the nondominant extremity, 3 (17.6%) in the dominant extremity, while 5 (29.5%) occurred in either extremity (mixed footedness). The functional and somatometric characteristics of the injured and noninjured players are displayed in Table 3.

The logistic regression analysis revealed 3 significant predictors of noncontact ankle sprains (Table 4): (A) eccentric isokinetic strength asymmetries of ankle dorsal and plantar flexors (OR = 8.88; 95% CI, 1.95-40.36; P = .005), (B) increased BMI (OR = 8.16; 95% CI, 1.42-46.63; P = .018), and (C) increased body weight (OR = 5.72; 95% CI, 1.37-23.95; P = .017). Specifically, soccer players with preseasonal eccentric strength asymmetries (≥15%) in the ankle joint had 8.8 times the odds to sustain a noncontact ankle sprain than did players with no eccentric strength asymmetry in the same joint at the same period. In addition, players with increased (above the sample median) weight (>72.6 kg) and BMI (>23.1) presented an almost 6-fold (5.72) and 8-fold (8.16), respectively, greater odds of sustaining an ankle sprain compared with those with less weight and lower BMI. None of the other intrinsic factors imposed a significant relative risk for ankle trauma ($P > .05$), although a trend at the limit of statistical significance ($.05 < P < .10$) was evident

TABLE 3
Descriptive Statistics Profile of Functional and Somatometric Characteristics for Players With Injured and Uninjured Ankles (N = 100)[a]

	Injured Players (n = 17)		Uninjured Players (n = 83)	
Physical characteristics				
Age, y	24.23 (5.76)		25.41 (2.45)	
Weight, kg	73.82 (5.81)		70.98 (6.17)	
Height, cm	177.07 (5.93)		177.78 (5.60)	
BMI	23.44 (1.42)		22.60 (0.94)	
	Right Ankle	Left Ankle	Right Ankle	Left Ankle
Isokinetic strength, N·m				
DFlex con 60 deg/sec	21.55 (4.23)	22.91 (5.00)	23.84 (5.55)	23.23 (5.04)
DFlex ecc 60 deg/sec	47.46 (7.64)	48.51 (10.21)	49.72 (8.09)	49.86 (9.02)
PFlex con 60 deg/sec	115.39 (23.70)	114.59 (21.30)	118.05 (23.13)	115.60 (22.23)
PFlex ecc 60 deg/sec	224.04 (53.67)	212.48 (40.68)	213.19 (39.27)	207.63 (36.07)
Muscle flexibility, deg				
DFlex flexibility	20.35 (5.36)	21.52 (6.16)	21.30 (5.80)	23.24 (6.52)
PFlex flexibility	45.05 (6.59)	45.47 (9.20)	47.93 (7.88)	48.20 (8.96)
Proprioception, % deterioration				
Kinesthesis	28.57 (5.76)	30.36 (11.15)	31.84 (13.67)	32.81 (17.89)
Anthropometric data,[b] cm				
Lower limb length	91.85 (5.28)	92.02 (5.72)	90.69(4.39)	90.90 (4.42)

[a]Values are expressed as mean (standard deviation). BMI, body mass index; DFlex, dorsal flexors; PFlex, plantar flexors; con, concentric; ecc, eccentric.
[b]Intratester reliability (body sides): technical error of measurements <1%; intraclass correlation coefficient >0.98.

TABLE 4
Intrinsic Risk Factors of Noncontact Ankle Sprains in Professional Soccer Players: Final Logistic Regression Model (N = 100)[a]

		Frequencies, n (%)		Statistics		
Etiologic Factor	Ankle Sprain	Low Risk[b]	High Risk[b]	OR	95% CI	*P*
Eccentric ankle strength				8.88	1.95-40.36	.005
	No sprain	58 (69.9)	25 (30.1)			
	Sprain	8 (47.1)	9 (52.9)			
BMI				8.16	1.42-46.63	.018
	No sprain	39 (47)	44 (53)			
	Sprain	2 (11.8)	15 (88.2)			
Weight				5.72	1.37-23.95	.017
	No sprain	51 (61.4)	32 (38.6)			
	Sprain	7 (41.2)	10 (58.8)			
Age				0.28[c]	0.061-1.24	.092
	No sprain	48 (57.8)	35 (42.2)			
	Sprain	13 (76.5)	4 (23.5)			
Ankle laxity				3.38	0.82-14.00	.093
	No sprain	52 (62.7)	31 (37.3)			
	Sprain	10 (58.8)	7 (41.2)			

[a]OR, odds ratio; CI, confidence interval; BMI, body mass index.
[b]Low/high risk = without/with preseason symptoms as follows: (A) strength asymmetries below/above 15%; (B) weight, age, and BMI below/above median; and (C) no ankle laxity/ankle laxity.
[c]OR <1 = decreased odds of injury.

for younger players (<23.9 years; OR = 0.28; 95% CI, 0.061-1.24; *P* = .092) and players with ankle laxity, as indicated by an abnormal anterior drawer test (OR = 3.38; 95% CI, 0.82-14.00; *P* = .093), to be at greater risk for noncontact ankle sprain than older players and those with no ankle laxity, respectively.

This final logistic regression model (Table 4) presented the following highly satisfactory collinearity statistics (tolerance and variance inflation factor): eccentric ankle asymmetry (0.911, 1.098), ankle laxity asymmetry (0.905, 1.105), weight (0.915, 1.093), BMI (0.891, 1.122), and age (0.861, 1.161). Thus, this model was almost free of interdependency among the 5 predictors, which provided grossly nonredundant information about the dependent variable (sprain vs nonsprain). Furthermore, according to the Nagelkerke R^2 (0.340, –2 log-likelihood, 68.437), 34% of the variance in the dependent variable was extracted by the final model. The Hosmer and Lemeshow statistic was not significant (χ^2 = 13.201, df = 8, P = .105), indicating the model's adequacy in fitting the data, and this was quite apparent in the good correspondence between the observed and predicted (expected) frequencies in the respective Hosmer and Lemeshow contingency table. The omnibus test of the model coefficients was highly significant (χ^2 = 22.741, df = 5, P < .001), indicating a highly significant departure of the final model from the null hypothesis model. As a result, the model was highly successful in correctly classifying cases to the 2 possible (injury, noninjury) outcomes (overall, 89% of the cases were correctly classified).

DISCUSSION

Preliminary results verified the existence of asymmetries in certain anatomic and functional characteristics of the players' ankle joints. More than half of the players (54%) had neuromuscular coordination asymmetries, and about half (49%) had a history of previous ankle sprains; 37% and 34% of the players, respectively, presented concentric and eccentric isokinetic strength asymmetries in the joint, and almost one-third (29%) of the players possessed asymmetries in lower limb length.

The majority (70.8%) of the ligamentous ankle injuries was the noncontact type, and their incidence rate (0.47 sprains/1000 hours) was similar to that reported by Beynnon et al.[6] It appears that foot supination at landing and in cutting activities during the game is a suspect mechanism for the 17 noncontact lateral ankle-injured players found in this study. This mechanism affects athletes of different sports as well,[25,36] and it explains, at least partially, why lower limb dominance was unrelated to increased risk of noncontact ankle injury in the present study. Kinesiologically, this adaptation makes sense, as most soccer players use the preferred foot for jumping and kicking skills and the opposite foot for landing and body support.[34] Especially in explosive skills such as landing and cutting, symmetrical eccentric activation and co-contraction of the ankle joint muscles are required for adequate absorption of the damaging stresses and forces.[34] Under asymmetrical functional conditions and rather heavy body weights, this mechanism is disturbed and the joint is at risk of trauma. This theoretical assumption is confirmed by the results of our logistic regression analysis, which clearly indicated a link between the combination of eccentric isokinetic strength asymmetries and body weight above the sample median and the incidence of noncontact ankle sprains. These 2 factors predispose soccer players to the risk of suffering a noncontact ankle injury more than those with no eccentric isokinetic strength asymmetries and of less (below the sample median) weight.

The value of muscle strength deficits in predicting ankle sprains in athletes was, so far, rather uncertain,[5,6,42,55,56] primarily because of methodological variation. Most relevant studies, in spite of evidence that sports injuries occur mainly during eccentric activations of the lower extremity musculature,[9,21] tested only concentric strength of the ankle, used different populations (students, college athletes, military recruits), and most importantly, ended up with inconsistent direction of effects.[3,5] For example, Beynnon and colleagues[3,5] examined concentric muscle strength as a risk factor for ankle injury in 2 separate studies on college athletes and reported an association of ankle strength asymmetries (plantar flexion strength asymmetries) and imbalances (low inversion/eversion ratios) with risk of future sprains in 1 study[3] but not in the other.[5] Willems et al[55,56] examined male and female physical education students involved in different sports and concluded in favor of the role of muscle strength in ankle stability and protection, which is at least partially in line with our results. Their results, although contradictory (dorsiflexors were stronger at the injured ankle in female students[55] and at the uninjured ankle in male students[56]), may suggest the potential role of anthropometric traits, such as height, weight, and BMI, which have been recognized as potential ankle joint injury risk factors in several soccer studies.[43,49] In this regard, our study provided evidence that in heavier players (ie, >72.6 kg) and those with increased BMI (>23.1) the forces applied on the ankle ligaments during the support phase of various strenuous skills are augmented, and this increases the risk of ankle injury. This confirms previous studies implicating body dimensions with the risk of ankle sprain[43,49] against several other studies that presented rather unclear conclusions in this respect.[3,6,39,46,55,56] Under these unclear bibliographical data, we hypothesized that anatomic and functional traits, such as inequalities in lower limb length and muscle flexibility, may alter the normal kinetic patterns of the lower extremity function and predispose the players to increased risk of noncontact ankle sprains. Our results did not confirm this hypothesis, as these variables' contribution to the logistic prediction of ankle sprain was not significant. It is possible that some specific myodynamic or functional adaptations (eg, pelvic tilt) are activated to compensate for these structural asymmetries. Muscle flexibility and structural imbalances may interact with variation in another critical property of foot support in athletes—that of ankle joint stability.

For example, joint laxity is not connected with ankle sprains in basketball,[4] whereas in soccer it becomes critical in higher ankle sprain incidence because of excessive anterior drawer.[6,7] We focused on the lateral imbalance aspect of ankle laxity under the logic that if significant ankle laxity asymmetry is present, the side with the worst laxity must be prone to more ankle sprains. However, our results, although they approximated statistical significance, provided no clear evidence that asymmetry in ankle joint stability is associated with increased risk of ankle injury.

Perhaps ankle laxity asymmetry is attenuated neurologically, as during strenuous 1-legged supporting activities an ideal neuromuscular coordination of the lower extremities is expected to prevent the ligaments of the ankle joint to exceed their functional limits.

The literature on this aspect of the problem is inconclusive, as some studies examined single leg balance[6,17,36,47,48,53] and other kinesthesis.[17,55,56] Most of them reported an association between proprioceptive deficits (increased postural sway) and risk of ankle sprain in soccer players,[37,47,48,53,55] whereas a few others did not.[6,56] We attempted to clarify the problem, but the lower extremity neuromuscular coordination deficits possessed by the 100 soccer players did not significantly contribute to the prediction of occurrence or nonoccurrence of noncontact ankle sprains. Given the importance of neuromuscular coordination in athletic performance[34] and in injury[2] in general, this factor must be further studied under similar conditions and with similar samples of players before a definite conclusion is drawn as to its exact role in the functional integrity of the ankle joint.

The literature is also divided with regard to whether or not a history of previous sprain is connected with increased risk of a new ankle sprain. Our findings are in agreement with the results of 2 studies[4,5] reporting no increased risk for lateral ankle ligament injury after suffering a prior ankle injury. Contrary to this finding, other studies on college[6] and basketball athletes,[38] as well as on professional[16] and amateur soccer players,[32] reported that previous ligament injuries was the most important and well-established risk factor for sprain reinjury. In an earlier study, previous thigh muscle injury was protective rather than predisposing to reinjury,[21] with this being possibly attributed to effective rehabilitation in contemporary soccer[21] and/or "learning" to self-protect the injured joint or limb as a result of accumulated neuromuscular adaptations.

This in turn leads to age as a potential factor of ankle sprain in soccer players. Our results provided some indication that players below the median age (<23.9 years) are at higher risk of sustaining noncontact ankle sprains than are older players ($P < .10$). Willems et al[55] found no such association in students of small age range, and this was attributed to the aggressive playing in younger players[31] and to the improved or mature kinetic patterns that older soccer players adopt.[34] Nevertheless, age must be revisited in future studies before being permanently excluded from the list of intrinsic risk factors in noncontact ankle sprains in soccer.

Regarding the testing procedures, the possibility of induced errors of isokinetic, flexibility, and proprioception testing was minimized. Specifically, a true isokinetic peak torque was ensured by using low isokinetic testing speed and visually verifying that it occurred within the range of steady velocity (60 deg/sec). As for the rest of the functional and anthropometric measurements, their procedural recommendations were followed very strictly by the same experienced testers in the same laboratory with every participant.

The results of the present study should be interpreted with certain consideration to the 2 methodological limitations of dichotomizing the predictors and ending up with a rather low events-to-predictors ratio in our logistic regression analyses (1.7 and 3.4 for our initial and final 5-predictor models, respectively). However, as we explained in the Methods and the Results sections, the first limitation constitutes a common clinical practice, and the second reflects a rather realistic proportion of injuries to sample size found in relevant research.

Our logistic regression analysis resulted in a 3.4 events-to-predictors ratio, which seems low but is not too incomparable with those found in previous relevant studies (4.13 in McGuine and Keene[36]; 1.88 in Baumhauer et al[5]; 7.75, 3.25, and 2.5 in Witvrouw et al[57]; 4.8 and 3 in Tyler et al[49]; 3.7 and 2.8 in Willems et al[56]; and 2.2 in McHugh et al[37]). On the other hand, our events–to–sample size proportion was 17%, and this is well comparable with those of previous relevant studies (8.1% in McGuine and Keene,[36] 10.3% in Baumhauer et al,[5] 15.8% in Tyler et al,[49] 11.8% in McHugh et al,[37] 7.6% in Croisier et al,[9] and 6.8% in Witvrouw et al[57]). Especially with regard to noncontact ankle sprains, this proportion was 11.8% in McHugh et al[37] and 9.9% in Tyler et al,[49] and this is indicative of the difficulty of detecting this particular injury even after a 2-year prospective study. Therefore, our results are comparable with those of previous relevant studies in terms of methodological criteria, conditions, and limitations.

Furthermore, our subjects came from the same district area (same climatic environment), participated in the same tournament, and followed approximately the same training regimen (6-7 training sessions per week, with 1 strength training session every 2 weeks). Therefore, all conditions were homogeneous and maximally controlled, as far as the unbiased generation of the effects under study, with the best advantage of this design being the prospective method of data collection, which, besides other things, minimizes errors of estimate, especially in diagnosing and assessing injury.

CONCLUSION

Based on the results of this study, 3 definite conclusions can be reached. First, asymmetries in the eccentric muscle strength of the ankle joint and increased BMI and body weight can lead the soccer player to higher susceptibility to noncontact ankle sprains. Second, other "candidate" factors, such as height, muscle flexibility, and proprioceptive traits, do not seem to affect ankle sprain occurrence in our sample. Third, proper prophylactic training and rehabilitation must emphasize the reduction of eccentric muscle strength asymmetries of the ankle plantar and dorsal flexors and, if feasible, the relative reduction of body weight in certain players. Further research should focus on prospectively evaluating and cross-examining joint laxity, flexibility, and age in larger and different samples of players in order to detect an optimal mixture of all critical risk factors for noncontact ankle sprain in soccer.

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