AJSM PreView, published on January 30, 2008 as doi:10.1177/0363546507311598

Self-Reported Injury History and Lower Limb Function as Risk Factors for Injuries in Female Youth Soccer

Kathrin Steffen,* MSc, Grethe Myklebust, PT, PhD, Thor Einar Andersen, MD, PhD, Ingar Holme, PhD, and Roald Bahr, MD, PhD
From the Oslo Sports Trauma Research Center, Department of Sports Medicine, Norwegian School of Sport Sciences, Oslo, Norway

Background: Identifying and understanding injury risk factors are necessary to develop and target measures to prevent injuries. Because youth teams rarely have health care professionals working directly with the team, identifying players at increased risk through elaborate clinical tests is not feasible. Questionnaires may be a possible alternative as screening instruments.

Purpose: To examine whether injury history and lower limb function assessed by a self-administered questionnaire represent risk factors for injury.

Study Design: Cohort study; Level of evidence, 2.

Methods: At baseline, female soccer players (aged 14-16 years) were asked to complete a detailed questionnaire covering sports participation; history of previous injuries to the ankle, knee, hamstring, or groin; as well as present function of these 4 specific regions. A total of 1430 (71% of the entire cohort) were followed up to record injuries during the subsequent 8 months.

Results: A history of a previous injury to the ankle (rate ratio, 1.2 [1.1-1.3]; $P < .001$), knee (rate ratio, 1.4 [1.2-1.6]; $P < .001$), or groin (rate ratio, 1.6 [1.2-2.1]; $P = .004$) increased the risk of new injuries to the same region. Reporting a reduced function (defined as <80% of the maximum score) for the ankle (rate ratio, 1.7 [1.1-2.7]; $P = .021$) or knee (rate ratio, 3.2 [1.8-5.7]; $P < .001$) was also a significant risk factor. However, the sensitivity of previous injuries and lower limb function in predicting new injuries was low.

Conclusion: A history of previous injury and reduced function at baseline were significant risk factors for new injuries to the same region during the following season.

Keywords: youth; soccer; risk factor; lower limb; injury; screening

Female soccer has grown exponentially worldwide and in Scandinavia in particular. Of all organized soccer players in the United States in 2006, 30% were female players.[19] More than 36 000 female players aged between 13 and 19 years were registered in Norway, a country with 4.6 million inhabitants, representing an annual growth of 10% to 13% during the last 5 years.[41] Because sports is one of the leading causes of injuries in adolescents,[15,34] the increasing popularity of youth soccer has also led to a surge in research related to the injury pattern seen in this athlete population. The injury incidence ranges from 9 injuries per 1000 match hours among adolescent female players[15,48,50] to 10 to 23 injuries among adult female players, depending on their skill level.[22,30,44,49] Injuries to the lower limb are dominant, with the ankle, knee, and thigh as the most common injury locations among adolescent[15,48,50] as well as adult elite players.[16,17,22,30]

However, analyses of risk factors for such injuries among adolescents are surprisingly scarce considering the long-term health consequences after major knee and ankle sprains.[2,36,40] Thus, identifying and understanding risk factors are necessary to develop preventive measures.[5,10] Previous injury has been identified as a risk factor for injury for both genders and at different skill levels,[5,15,26] although not in all studies.[18] Emery et al[15] reported a 74% increase in injury risk among young and adolescent female players with a history of at least 1 previous injury. Other risk factors that have been discussed in the literature are age (older players at higher risk),[5,44] longer career duration,[44] joint laxity,[44,49] mechanical or functional instability,[44,49] lower extremity strength,[7,31,49] muscular imbalances,[31] decreased range of motion,[5] and inadequate rehabilitation.[5,26,51,52]

*Address correspondence to Kathrin Steffen, Oslo Sports Trauma Research Center, Department of Sports Medicine, Norwegian School of Sport Sciences, PO Box 4014 Ullevål Stadion, 0806 Oslo, Norway (e-mail: kathrin.steffen@nih.no).

No potential conflict of interest declared.

The American Journal of Sports Medicine, Vol. X, No. X
DOI: 10.1177/0363546507311598

Youth teams are rarely attended by trained health professionals, and identifying players at increased risk for injury through clinical testing is therefore not practical. However, if questionnaires could be developed as screening instruments for injuries, they would be time efficient and easy to manage. In soccer, questionnaires have been used at various skill levels to obtain information about the sports and medical history of players, including history of previous injuries.[15,17,48,56] However, to our knowledge, no study has so far addressed joint- or muscle-specific function by questionnaire. The aim of this prospective 1-season cohort study on young female soccer players was therefore to examine whether injury history and lower limb function assessed by a self-administered questionnaire represent risk factors for new injury.

MATERIALS AND METHODS

Study Population

This study is based on data from a randomized trial on female adolescent soccer players examining the effect of a specific training program designed to prevent injuries. The design, the intervention program, and the results of the study have been described in detail in a separate report.[50] Because no differences were seen in injury rates between the intervention and control groups,[50] the analyses did not factor in group assignment, meaning that the intervention was not a covariate for new injuries. Hence, group assignment would not have been a confounder for the relationship and prediction of new injuries.

All teams (N = 157) in the southeast region of Norway that had registered to participate in the under-17 (U17) league system in the 2005 season were invited to take part in the study. Of these, a total of 113 teams volunteered to be included. The competitive season lasted from the end of April until mid-October, interrupted by a 7-week summer break without regular league matches but with some invitational tournaments. The teams were also followed for 2 months of the preseason period (March-April). Throughout the competitive season, the teams played 14 to 24 league matches and trained 1 to 3 times a week.

Before the start of the preseason, the players received written and oral information about the study, and it was emphasized that participation was voluntary. The study was approved by the regional committee for research ethics, and written consent was obtained. A player was entered into the study if she was registered by the team as participating in the U17 league system, which means that she had to be 16 years old or younger. However, teams competing in the U17 league could apply for exemption to use older players if they did not have enough eligible players. Players who were injured at the start of the study were included from the time they returned to play, but this preexisting injury was not included in the data analysis.

Risk Factor Questionnaire

At baseline, each player was asked to complete a detailed questionnaire covering sports participation; history of previous injuries to the ankle, knee, hamstring, or groin; as well as present symptoms and function of these 4 specific regions. Ankle function and knee function were classified using the Foot and Ankle Outcome Score (FAOS)[46] and the Knee and Osteoarthritis Outcome Score (KOOS)[47] forms, respectively, and similar forms were constructed to classify hamstring and groin function by adapting questions from the FAOS and KOOS forms to these muscle groups.

The FAOS and KOOS are self-explanatory 42-item questionnaires developed to assess patient opinion about ankle- and knee-associated problems, respectively, after ligament reconstruction or other surgical treatment.[11,47] Patient-relevant outcomes are measured in 5 separate subscores: pain, other symptoms, activities of daily living, sport and recreation function, and ankle-/knee-related quality of life (QOL). Both questionnaires meet set criteria of validity and reliability.[46,47] The questionnaires developed to assess hamstring (hamstring outcome score [HaOS]) and groin function (groin outcome score [GrOS]) included 19 and 29 items, respectively. These questions formed the basis for the following 5 subscale scores: symptoms, stiffness, pain, sport and recreational function, and hamstring-/groin-related QOL. The reliability and validity of these questionnaires have not been assessed.

A 5-point Likert scale was used to answer each question, and all items were scored from 0 (no problem) to 4 (extreme problems). Each of the 5 subscale scores was calculated as a sum of the items included, composing a raw score. Raw scores were transformed to a total score, ranging from 0 to 100, with 100 representing optimal function. The criteria for classifying a leg as having an increased risk of injury were as follows: a history of an injury to the ankle, knee, hamstring, or groin or a reduced function with a mean score of less than 80% for either of the 4 body parts mentioned.

The forms used were designed to be read optically, and data were transformed into an SPSS database (SPSS for Windows 15.0, SPSS Inc, Chicago, Ill). If a mark was placed outside a Likert box, the closest box was used. If 2 boxes were marked or a mark was placed between 2 boxes, that box which indicated the more severe problem was chosen. If no mark at all was placed, a missing value for that particular item was registered in the database.

The questionnaire was introduced to the players at a team meeting by staff who were carefully instructed in how the questionnaire should be completed. They were also present to answer questions while the players completed the questionnaire. It took the players about 45 minutes to complete the full questionnaire. Completed questionnaires were missing for players who did not attend the scheduled team meetings and for teams that for unknown reasons were unable to arrange team meetings.

Injury Registration

To monitor all injuries throughout the 8-month study period, 18 physical therapists were recruited and assigned to the teams (typically 5-7 teams each) to record injuries from March 1 through October 31. All coaches were asked to keep a continuous log of all data requested. The coach of each team was contacted by telephone and/or e-mails at least once a month to record new injuries, as well as all playing activities in training and matches. Injured players were interviewed by the injury recorders to assess aspects of the injury

based on a standardized injury questionnaire. All information was registered using a Web-based recording system.

An injury was registered if it caused the player to be unable to fully take part in match or training sessions the day after the injury ("time loss" injury).[20] Acute injuries were defined as injuries with a sudden onset associated with a known trauma, whereas overuse injuries were those with a gradual onset without any known trauma. A previous injury was defined as an injury of the same type and the same site as an index injury and that occurred after a player had returned to full participation from the index injury. The location and type of injury were recorded. In almost all cases of moderate and major injuries, the players were seen in a medical center to diagnose the injury by clinical examination, imaging studies, or surgery. In cases of minor injuries, the players were generally examined by a local physical therapist, the coach, or not at all. However, the injury information was obtained from the interviews with injured players. None of the injured players were examined or treated by any of the authors or injury recorders involved in the study.

Statistics

As stated above, this cohort study represents a secondary analysis of data from a randomized controlled trial.[50]

Descriptive data, such as anthropometrics, player history, and sum scores for the 4 function scores, are presented as mean values with SDs. Groups of injured and uninjured players were compared using the Student *t* test, and group differences are presented as mean values with 95% confidence intervals (CIs). *P* values below .05 were considered significant.

As in other recent studies on lower limb risk factors,[5,8,26] each limb was used as the unit of analysis. An odds ratio (OR) with 95% CI was calculated for a group of players with previous injuries versus new injuries. The predictive values of anthropometric and player history data, previous injuries, and the 4 different function scores in relation to new injuries were analyzed using Poisson regression models based on generalized estimating equations. The number of new injuries was used as the dependent variable, whereas the number of previous injuries as well as function scores were used as independent variables. All regression models were adjusted for the effects of cluster (person and team, using geographic region as surrogate). Rate ratios (RRs) with 95% CIs associated with a 1 SD decrease in the exposure variable (function score; total and subscores) were calculated to compare the risk for new injuries between players. Similarly, we calculated RR with 95% CI for a 1-unit increase in the number of years of play and previous injuries, as well as a 1-unit change for the groups of players with low function scores. Limb as the unit of analysis was also used for the calculation of the sensitivity and specificity of previous injuries and lower limb function in predicting new injuries.

RESULTS

Baseline Data

A total of 1430 players (71% of the entire cohort)[50] completed the questionnaire on history of previous injuries and present lower limb function. The mean age of these players was 15.4 years (SD, 0.8). Their mean weight was 56 kg (SD, 7), height was 166 cm (SD, 6), and body mass index was 20 kg/cm^2 (SD, 2). Anthropometric data, player history, as well as joint- and muscle-specific function scores at baseline are described separately for previously injured and uninjured players (Table 1). There were highly significant between-group differences for all of the 4 function scores, as well as for the 5 subscores within each function score in disfavor of previously injured players, except for hamstring-related QOL ($P = .21$) (Table 2).

TABLE 1
Baseline Data (Mean ± SD) for Previously Injured and Uninjured Players Regarding Player Characteristics and Training History

	Previously Injured (n = 1003)	Previously Not Injured (n = 422)
Age, y	15.4 ± 0.8	15.3 ± 0.8
Weight, kg	55.9 ± 7.2	55.1 ± 7.5
Height, cm	166.3 ± 5.6	165.9 ± 6.0
Body mass index, kg/cm^2	20.2 ± 2.2	20.0 ± 2.3
No. of years in organized soccer	5.5 ± 2.2	5.1 ± 2.1
Hours of training per week	7.6 ± 3.2	7.0 ± 3.0
Hours of soccer training per week	4.4 ± 2.5	4.1 ± 2.0

Overall Injury Characteristics

A total of 296 of the 1430 players (20.7%) sustained at least 1 injury. Of these players, 49 (3.4%), 16 (1.1%), and 1 (0.07%) incurred 2, 3, and 4 injuries, respectively, leading to a total of 380 injuries. There were 330 acute injuries and 50 overuse injuries. The most common types of overuse injury were anterior lower leg pain (35% of all overuse injuries) and knee pain (21%), whereas an ankle sprain was the most common acute injury type (111 injuries, 34%). Of the 330 acute injuries, 70 (21%) were reinjuries. The type and location of acute injuries are described in Table 3.

Risk Factors for New Injuries

As many as 1003 players (70.1%) reported to have had at least 1 previous injury to 1 of the 4 body regions covered by the questionnaire: ankle, knee, hamstring, or groin. Of these, 179 players (17.8%) sustained at least 1 new injury during the 2005 season to the same region, compared with 38 players (9.0%) among players with no injury history. Thus, the risk of injury was almost twice as high for players with an injury history to the same region on the same site during the study period than for players without previous injuries (OR, 1.9; 95% CI, 1.4-2.5; $P < .001$). The risk of sustaining a new injury increased with the number of previous injuries (RR, 1.08 [1.04-1.12] for each additional previous injury reported; $P < .001$). None of the anthropometric variables (age, height, weight, body mass index) or weekly sports participation were significant risk factors for new injuries. However, years of organized soccer play

TABLE 2
Baseline Ankle, Knee, Hamstring, and Groin Scores for Previously Injured and Uninjured Legs[a]

Subscore	Previously Injured	Previously Not Injured	Δ (95% CI)
Ankle (FAOS)	n = 936	n = 1485	
Pain	92.0 ± 11.3	97.3 ± 6.0	–5.3 (–6.0 to –4.5)
Symptoms	62.8 ± 11.1	68.2 ± 9.7	–5.4 (–6.3 to –4.5)
Activities of daily living	96.3 ± 7.5	98.7 ± 4.2	–2.3 (–2.9 to –1.8)
Sport	89.0 ± 16.2	96.3 ± 8.4	–7.3 (–8.4 to –6.2)
Quality of life	71.3 ± 12.4	76.3 ± 10.0	–5.0 (–5.9 to –4.0)
Total	411.5 ± 46.8	436.7 ± 26.8	–25.2 (–28.5 to –21.9)
Knee (KOOS)	n = 649	n = 1869	
Pain	87.6 ± 15.4	96.8 ± 8.2	–9.2 (–10.1 to –8.2)
Symptoms	58.6 ± 12.9	67.1 ± 10.1	–8.5 (–9.5 to –7.4)
Activities of daily living	93.4 ± 11.0	98.3 ± 5.7	–4.9 (–5.8 to –4.0)
Sport	80.5 ± 22.3	94.8 ± 12.4	–14.2 (–16.1 to –12.4)
Quality of life	65.9 ± 13.0	74.2 ± 10.0	–8.3 (–9.4 to –7.2)
Total	386.1 ± 64.6	431.2 ± 37.1	–45.1 (–50.4 to –39.8)
Hamstring (HaOS)	n = 451	n = 2169	
Pain	88.9 ± 12.0	95.0 ± 7.6	–6.1 (–7.2 to –4.9)
Symptoms	80.4 ± 23.1	93.3 ± 15.0	–7.9 (–9.9 to –5.9)
Stiffness	87.0 ± 13.3	91.6 ± 10.5	–4.6 (–5.9 to –3.3)
Sport	95.1 ± 11.4	98.2 ± 6.5	–3.1 (–4.2 to –2.0)
Quality of life	53.6 ± 16.3	54.8 ± 18.2	–1.2 (–3.0 to 0.7)
Total	408.4 ± 46.3	431.2 ± 37.3	–22.8 (–27.4 to –18.3)
Groin (GrOS)	n = 363	n = 2271	
Pain	92.7 ± 10.7	97.3 ± 4.9	–4.5 (–5.7 to –3.4)
Symptoms	80.4 ± 23.1	93.3 ± 15.0	–11.9 (–14.4 to –9.5)
Stiffness	92.6 ± 10.4	96.7 ± 6.7	–4.1 (–5.7 to –3.4)
Sport	96.1 ± 10.2	99.0 ± 4.0	–2.9 (–4.0 to –1.9)
Quality of life	66.7 ± 13.6	69.1 ± 12.5	–2.4 (–3.9 to –0.9)
Total	428.4 ± 48.1	454.4 ± 29.0	–25.9 (–31.0 to –20.8)

[a]Each leg has been treated as a separate case. Complete function scores were available for 88% of the Foot and Ankle Outcome Score (FAOS), 90% of the Knee and Osteoarthritis Outcome Score (KOOS), and 94% of the hamstring outcome score (HaOS) and groin outcome score (GrOS) forms, respectively. Data are mean ± SD and mean difference (Δ; 95% confidence interval [CI]).

TABLE 3
Number and Proportion of Acute Time Loss Injuries in Relation to Injury Type and Location

								Total	
	Contusion	Sprain	Strain	Dislocation	Fracture	Pain	Other	No.	%
Head/neck	5	1					8	14	4.2
Upper body	9	5	4	1	6		2	27	8.2
Lower body	64	135	73	1	1	1	14	289	87.6
Hip	4							4	1.2
Groin			19					19	5.8
Thigh	3		46					49	14.8
Knee	19	20	2	1			11	53	16.1
Lower leg	12		4				1	17	5.2
Ankle	13	111					1	125	37.9
Foot, including toe	13	4	2		1	1	1	22	6.7
Total (%)	78 (23.6)	141 (42.7)	77 (23.3)	2 (0.6)	7 (2.1)	1 (0.3)	24 (7.3)	330 (100)	

was significantly associated with new injuries (RR, 1.12 [1.04-1.22] for each additional year reported; $P = .003$). Figure 1 presents the risk of new injuries based on having reported a history of previous injuries to 1 of the 4 regions. Players with an injury history to the ankle, knee, or groin were more likely to sustain a new ankle, knee, or groin injury than were players without previous injuries. Figure 2 presents the risk of new injuries when scoring low (defined as a score below 80%) on 1 of the 4 function scores for the same 4 regions. Having reported reduced function

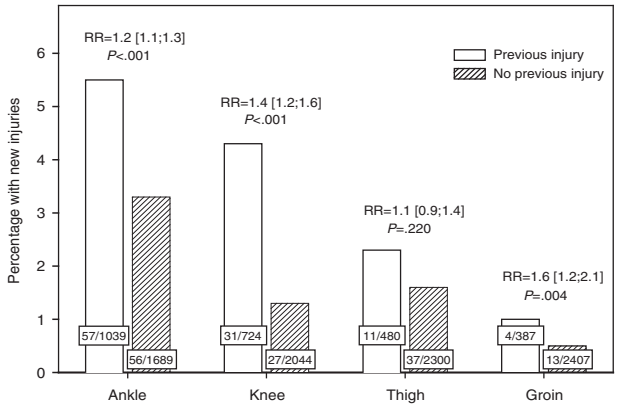

Figure 1. Risk of new injuries for players with previous injuries for each of the 4 specific regions. Each limb has been treated separately in this analysis. RR, relative risk.

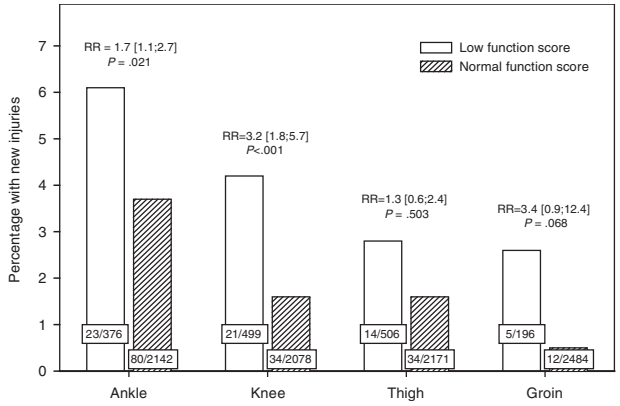

Figure 2. Risk of new injuries for players with low function scores for each of the 4 specific regions. Each limb has been treated separately in this analysis. RR, relative risk.

scores significantly increased the risk of sustaining new ankle or knee injuries.

Poisson Regression

Table 4 shows the subscores of each of the joint- and muscle-specific function scores for players who were injured and not injured during the 2005 season. Table 4 also reports the results from the Poisson regression model, for each subscore and for the total function score. All of the ankle- and knee-specific subscores were significant risk factors for new ankle and knee injuries.

Sensitivity and Specificity to Predict New Injuries

Based on a simplified model with limb as the unit of analysis and each injury treated as a separate case, the sensitivity and specificity of self-reported previous injuries and low function scores to predict new injuries were calculated (Table 5). Reporting a previous ankle or knee injury was more sensitive in predicting new ankle and knee injuries than was reporting a reduced ankle or knee function score. However, this difference in sensitivity was smaller for the prediction of new thigh or groin injuries. The specificity of injury history and joint- and muscle-specific function scores to identify new injuries was higher than for sensitivity, ranging from 62% to 93%, respectively.

DISCUSSION

The principal finding of this prospective cohort study was that young female soccer players with at least 1 previous injury or a reduced lower limb function score had a significantly increased risk of sustaining a new injury of the same kind during the 8-month follow-up period. Thus, we were able to identify athletes prone to be injured at the ankle, knee, thigh, or groin simply by having the players complete a preseason questionnaire on their history of injury and present lower limb function, albeit with low sensitivity.

Almost one fourth of all new acute injuries recorded in the present study were in fact reinjuries, which may come as a surprise in such a young player population. However, the explanation seems quite obvious; as many as 1 in every 5 players sustains an injury every season, and the injury pattern is quite consistent, with hamstring strains and ankle and knee sprains being by far the most common injuries. In addition, previous injury in itself clearly represents a risk factor for injury, possibly through physiologic or anatomical deficits resulting from the previous injury, for example, reduced strength and neuromuscular control or increased joint laxity.[5,15,26,44,49,55] That reinjury rates are high in elite male players is well known,[5,26,54] but our findings are also corroborated by previous studies on female players, reporting the proportion of reinjuries to range between 19%[17] and 41%.[48]

Ankle Injuries

Lateral ligament injuries to the ankle are typical in soccer and mainly result from tackling, running, or landing.[3,6,21] As shown in the present and previous studies on young and adolescent female players,[15,48] ankle sprains represent the dominant injury type and are proportionally more frequent than among youth male[35] or female[16,17,30,44] or male elite players.[5,25,56]

Previous injury has been reported to be a strong risk factor for soccer-related ankle injuries.[5,51,52] However, studies investigating the association between previous and new ankle sprains have produced conflicting results, even at the elite level. In contrast to the present data, showing an 18% increased risk for new ankle injuries, injury risk was increased neither in female[17] nor in male players[26] at the elite level who had reported an ankle sprain history.

The most likely explanation for this apparent discrepancy is that medical care is less available for youth teams than for elite players and that the quality and consistency of the rehabilitation program after injury influence the prognosis of recurrences. In youth sports, knowledge about injury rehabilitation is typically low and access to professional medical care limited. The decision to return to play after an injury is therefore usually made by the coach, the

TABLE 4
Poisson Regression Model Based on Mean Sum Scores for Subscores Within Each of the 4 Function Scores for Legs That Were Injured and Not Injured During the 2005 Season[a]

	Sum Score, Mean ± SD		Poisson Regression Prediction of New Injuries, n	
Subscore	Injured 2005	Not Injured 2005	RR (95% CI)	*P*
Ankle (FAOS)	n = 103	n = 2415		
Pain	92.8 ± 12.6	95.5 ± 8.5	1.22 (1.07-1.40)	.004
Symptoms	65.5 ± 10.9	66.3 ± 10.7	1.24 (1.03-1.50)	.032
Activities of daily living	97.3 ± 7.0	97.8 ± 5.7	1.21 (1.09-1.34)	<.001
Sport	90.0 ± 17.8	93.8 ± 12.1	1.25 (1.08-1.45)	.001
Quality of life	71.4 ± 13.6	74.7 ± 11.2	1.29 (1.07-1.54)	.010
Total	417.0 ± 50.2	428.1 ± 37.0	1.3 (1.1-1.5)	<.001
Knee (KOOS)	n = 55	n = 2522		
Pain	86.2 ± 20.3	94.6 ± 11.0	1.50 (1.29-1.75)	<.001
Symptoms	59.5 ± 9.9	65.0 ± 11.5	1.62 (1.31-1.99)	<.001
Activities of daily living	91.0 ± 14.7	97.2 ± 7.5	1.42 (1.27-1.58)	<.001
Sport	78.3 ± 29.4	91.4 ± 16.4	1.59 (1.39-1.82)	<.001
Quality of life	66.8 ± 14.3	72.2 ± 11.3	1.72 (1.31-2.27)	<.001
Total	381.8 ± 78.9	420.4 ± 48.7	1.6 (1.4-2.0)	.001
Hamstring (HaOS)	n = 48	n = 2629		
Pain	92.0 ± 10.2	94.0 ± 8.8	1.18 (0.99-1.40)	.058
Symptoms	85.9 ± 21.2	90.3 ± 17.2	1.17 (0.92-1.46)	.229
Stiffness	89.1 ± 11.8	90.8 ± 11.2	1.02 (0.78-1.33)	.889
Sport	96.9 ± 6.4	97.7 ± 7.7	1.08 (0.93-1.24)	.316
Quality of life	57.9 ± 20.7	54.5 ± 17.7	1.13 (0.86-1.50)	.414
Total	421.7 ± 44.7	427.3 ± 39.8	1.1 (0.8-1.5)	.530
Groin (GrOS)	n = 17	n = 2663		
Pain	93.5 ± 8.3	96.6 ± 6.2	1.20 (0.99-1.45)	.068
Symptoms	76.5 ± 25.7	90.7 ± 16.9	1.51 (1.01-2.26)	.045
Stiffness	93.1 ± 10.3	96.1 ± 7.4	1.01 (0.64-1.59)	.971
Sport	95.8 ± 8.2	98.6 ± 5.4	1.07 (0.79-1.44)	.657
Quality of life	66.8 ± 19.7	68.8 ± 12.7	1.12 (0.85-1.48)	.398
Total	425.7 ± 58.4	450.9 ± 33.4	1.4 (1.0-1.9)	.056

[a]CI, confidence interval; FAOS, Foot and Ankle Outcome Score; GrOS, groin outcome score; HaOS, hamstring outcome score; KOOS, Knee and Osteoarthritis Outcome Score; RR, rate ratio.

player, and/or the parents. In contrast, the medical staff of professional teams are generally well aware of the principles for optimal treatment and secondary prevention of ankle sprains.[26] Kucera et al[34] also postulated that an increased risk of ankle injuries is consistent with the nature of youth soccer, where kicking, planting, cutting, sprinting, jumping, and landing are performed on partially uneven natural grass pitches, which can be highly stressful for the foot and ankle structures.

An indication that rehabilitation after previous injuries had been inadequate is that the baseline FAOS function score was lower in players with a previous ankle injury compared with uninjured players. It is therefore not surprising that the FAOS function score, in total and all subscores, represents a risk factor for new ankle sprains, although the sensitivity was low. In most cases, pain and swelling are indicators of a poorly rehabilitated injury or signs that the joint is not functionally stable during sports activities.

Knee Injuries

Knee sprains are common in female soccer players, with injury rates several-fold higher than that of male players at the same level.[1,23] Running, turning, and landing after heading in combination with rapid brakes and changes of direction put the knee joint at risk,[28,32,33] although the reasons for the gender gap are not fully elucidated.[23] In the present study, a previous knee injury increased the risk for a new knee injury by 38%, which corresponds to data from other investigations on elite[5,26,55] and adolescent players of both genders.[34]

One fifth of all acute injuries involved the knee joint, and nearly 40% of all acute knee injuries recorded in the present study were ligament sprains. Because there is solid evidence that previous knee sprains increase the risk of early osteoarthritis in soccer players,[36,40,54] the present results suggest that special attention should be given to players with a knee injury history and knee-related symptoms. As was seen for ankle injuries, the baseline KOOS function score was reduced in players with previous knee injuries, again indicating that rehabilitation after injury was insufficient before the start of the season.

Thigh Injuries

Hamstring strains are common in soccer players, presumably resulting from eccentric muscle activity during kicking

TABLE 5
Sensitivity and Specificity for Reported Previous Injury and Low Function Scores (<80%) to the Ankle (FAOS), Knee (KOOS), Hamstring (HaOS), and Groin (GrOS) to Predict New Injuries in the Same Location[a]

	Previous Injury, %		Low Function Score, %	
New Injuries	Sensitivity	Specificity	Sensitivity	Specificity
Ankle	50	62	22	85
Knee	53	74	38	81
Thigh	23	83	29	81
Groin	24	86	29	93

[a]FAOS, Foot and Ankle Outcome Score; GrOS, groin outcome score; HaOS, hamstring outcome score; KOOS, Knee and Osteoarthritis Outcome Score.

activities and short sprints.[4,9,26] Among female adolescent soccer players, thigh strain injuries represent 8% to 25% of all acute injuries[15,48] compared with 11% among elite female[17] and 13% to 16% among elite male players.[4,56]

In the present study, a history of a previous hamstring injury was not a risk factor for new thigh injuries, which is in contrast to reports from male soccer.[5,26] Although there was a highly significant reduction in the hamstring function score (HaOS) in players with an injury history at baseline, the functional score did not predict new thigh injuries in this group of players. This may simply be a type II error based on the low frequency of thigh injuries, previous and new, in this player population. But the results may also indicate that the questions forming the HaOS were not sensitive in identifying players with functional limitations. However, it should be noted that the set of questions composing hamstring and groin function questionnaires has not been validated. Also, the fact that we asked the players about previous hamstring injuries but recorded thigh injuries as a group (without distinguishing between, eg, hamstring and quadriceps strains) may have influenced the results.

However, prevention programs for hamstring injuries are recommended and can easily be introduced in soccer training. Eccentric strength training of the hamstring muscles increases hamstring muscle torque[7,39] and reduces the incidence of hamstring strains in elite male soccer players.[4,7,39] Because a low quadriceps to hamstring strength ratio is hypothesized to represent a risk factor for knee injuries,[9] eccentric hamstring training using the Nordic hamstring exercise now has been included in injury prevention programs targeting young athletes as well.[4,38,43,50]

Groin Injuries

As shown in the present study, in which groin strain injuries constituted 6% of all acute injuries, groin strains appear to be less common in female[15,17,48] than in male soccer players.[5,24,36,56] Nevertheless, groin injuries can result in extensive rehabilitation time, and longstanding pain may develop into problems in athletes engaged in sports such as soccer that involve kicking, rapid changes of direction, accelerations, and decelerations.[37]

We found a history of previous groin injury to be predictive in identifying players at risk for new groin injuries. In contrast, function limitations in the groin region (GrOS function score) were not a significant risk factor for new groin strains. However, questions related to pain and symptoms tended to be significant predictors for groin injuries. Reduced flexibility of the abductor muscles is believed to be a risk factor for groin strain injuries,[5,14,53] and there may be a relationship with pain and stiffness reported by the athlete in the function score.

Methodological Issues

A limitation of the study was the response rate. Of the 2020 players included in the intervention trial,[50] only 1430 (71%) completed the questionnaire. This may constitute a selection bias, if players with symptoms were more likely to respond. However, we have compared injury proportions between responders and nonresponders and could not detect any difference in the proportion of injuries to the ankle, knee, thigh, or groin (data not shown).

A weakness of this and most other studies assessing the relationship between previous and new injuries is that injury history relies on player recall. It is well known that recall bias is a concern when relying on retrospective self-reporting of injuries.[13,15,26] The only study to date to avoid this was by Hägglund et al,[26] who conducted a study over 2 consecutive seasons and included prospectively collected injury information to study the relationship to reinjuries.

Prospective injury registration on a monthly basis, which was practiced here, also raises questions on recall bias.[15,26] However, research injury recorders were in close contact with the coaches to avoid missing any injury among the players during the study period. It seems reasonable to expect that although minor injuries were missed, most major injuries would have been recorded with this procedure. Also, we were unable to record individual exposure data, as done by Östenberg and Roos,[44] and therefore could not correct for exposure in the risk factor analyses. The same registration method as in the present study was successfully used by Olsen et al.[43] The reliability and validity of the exposure and injury registration have been examined in detail previously[42] and found to be adequate.

Functional testing of all athletes at baseline could have provided additional and perhaps more objective information about possible risk factors. However, this was neither possible nor the intention of the present study.

Practical Implications

Soccer is a contact sport and requires a variety of skills at different intensities. Running is the predominant activity, and explosive efforts during sprints, duels, jumps, and kicks are important performance factors[12,29,45,57] as well as injury risk situations.[3,6,21]

The strong association observed between previous injuries, reduced function, and new injuries in this young

cohort suggests that secondary prevention of reinjuries should be emphasized. More effective strategies are needed to support players and coaches in the treatment and rehabilitation of the original injury, to prevent further injuries. As is true for all injuries, appropriate rehabilitation programs and time to allow the player to become symptom free before returning to play are necessary.[5,25] Also, several studies have now shown that including preventive exercises in training sessions can reduce injury risk significantly.[27,38,43]

Although the specificity of the questionnaire is reasonably high, the sensitivity in predicting new injuries through injury history and reduced function scores is low. This limits the usefulness of the questionnaire because it is highly questionable whether it is worth the effort to have every player on a team complete the form. Only every fourth to every second player who became injured had a positive screening result. Thus, it is not possible to use the questionnaire to target injury prevention programs to athletes at risk. If effective injury prevention methods are established for this player population, it is recommended that these are given to all athletes on the team. Whether it is possible to develop a more sensitive and practical questionnaire to screen for injury is not known. However, based on the results of this study, questions covering pain and joint- and muscle-specific symptoms seem to be essential—at least when a player had reported an injury history. Pain seemed to be a useful indicator for limited function for all 4 specific regions studied in the present study. Therefore, a player who is not able to train without pain or other symptoms from a particular region should be advised to undergo rehabilitation and restrict participation in games, as this probably will increase the risk for a new injury.

CONCLUSION

In this study of youth female soccer, about 70% of the players reported to have had at least 1 previous injury to the ankle, knee, hamstring, or groin on at least 1 side during their sports careers, and these groups reported reduced function related to the injured region at baseline. A history of previous injury and reduced function at baseline were significant risk factors for new injuries to the same region and limb during the season.

ACKNOWLEDGMENT

This study was supported by a grant from FIFA. In addition, financial support came from the Oslo Sports Trauma Research Center, which has been established at the Norwegian School of Sport Sciences through grants from the Eastern Norway Regional Health Authority, the Royal Norwegian Ministry of Culture and Church Affaires, the Norwegian Olympic Committee and Confederation of Sports, and Norsk Tipping AS. We thank our staff for administrating the questionnaires, the physical therapists involved in the injury registration, and all the coaches and players for their cooperation.

REFERENCES

1. Agel J, Arendt EA, Bershadsky B. Anterior cruciate ligament injury in National Collegiate Athletic Association basketball and soccer: a 13-year review. *Am J Sports Med.* 2005;33:524-530.
2. Anandacoomarasamy A, Barnsley L. Long term outcomes of inversion ankle injuries. *Br J Sports Med.* 2005;39:e14.
3. Andersen TE, Floerenes TW, Árnason A, Bahr R. Video analysis of the mechanisms for ankle injuries in football. *Am J Sports Med*. 2004; 32:S69-S79.
4. Árnason A, Andersen TE, Holme I, Engebretsen L, Bahr R. Prevention of hamstring strains in elite soccer: an intervention study. *Scand J Med Sci Sports*. Epub March 12, 2007.
5. Árnason A, Sigurdsson SB, Gudmundsson A, Holme I, Engebretsen L, Bahr R. Risk factors for injuries in football. *Am J Sports Med.* 2004;32:S5-S16.
6. Árnason A, Tenga A, Engebretsen L, Bahr R. A prospective video-based analysis of injury situations in elite male football: football incident analysis. *Am J Sports Med.* 2004;32:1459-1465.
7. Askling C, Karlsson J, Thorstensson A. Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload. *Scand J Med Sci Sports*. 2003;13:244-250.
8. Bahr R, Bahr IA. Incidence of acute volleyball injuries: a prospective cohort study of injury mechanisms and risk factors. *Scand J Med Sci Sports*. 1997;7:166-171.
9. Bahr R, Holme I. Risk factors for sports injuries: a methodological approach. *Br J Sports Med*. 2003;37:384-392.
10. Bahr R, Krosshaug T. Understanding injury mechanisms: a key component of preventing injuries in sport. *Br J Sports Med*. 2005;39:324-329.
11. Bremander AB, Dahl LL, Roos EM. Validity and reliability of functional performance tests in meniscectomized patients with or without knee osteoarthritis. *Scand J Med Sci Sports.* 2007;17:120-127.
12. Cometti G, Maffiuletti NA, Pousson M, Chatard JC, Maffulli N. Isokinetic strength and anaerobic power of elite, subelite and amateur French soccer players. *Int J Sports Med.* 2001;22:45-51.
13. Dvorak J, Junge A. Football injuries and physical symptoms: a review of the literature. *Am J Sports Med*. 2000;28:S3-S9.
14. Ekstrand J, Gillquist J. Soccer injuries and their mechanisms: a prospective study. *Med Sci Sports Exerc.* 1983;15:267-270.
15. Emery CA, Meeuwisse WH, Hartmann SE. Evaluation of risk factors for injury in adolescent soccer: implementation and validation of an injury surveillance system. *Am J Sports Med.* 2005;33:1882-1891.
16. Engström B, Johansson C, Tornkvist H. Soccer injuries among elite female players. *Am J Sports Med.* 1991;19:372-375.
17. Faude O, Junge A, Kindermann W, Dvorak J. Injuries in female soccer players: a prospective study in the German National League. *Am J Sports Med.* 2005;33:1694-1700.
18. Faude O, Junge A, Kindermann W, Dvorak J. Risk factors for injuries in elite female soccer players. *Br J Sports Med*. 2006;40:785-790.
19. FIFA. *Big Count 2006*. Available at: http://www.fifa.com/mm/document/fifafacts/bcoffsurv/bigcount.statspackage_7024.pdf. Accessed December 8, 2007.
20. Fuller CW, Ekstrand J, Junge A, et al. Consensus statement on injury definitions and data collection procedures in studies of football (soccer) injuries. *Br J Sports Med.* 2006;40:193-201.
21. Giza E, Fuller C, Junge A, Dvorak J. Mechanisms of foot and ankle injuries in soccer. *Am J Sports Med.* 2003;31:550-554.
22. Giza E, Mithöfer K, Farrell L, Zarins B, Gill T. Injuries in women's professional soccer. *Br J Sports Med.* 2005;39:212-216.
23. Griffin LY, Albohm MJ, Arendt EA, et al. Understanding and preventing noncontact anterior cruciate ligament injuries: a review of the Hunt Valley II meeting, January 2005. *Am J Sports Med*. 2006;34: 1512-1532.
24. Hägglund M, Waldén M, Ekstrand J. Injury incidence and distribution in elite football: a prospective study of the Danish and the Swedish top divisions. *Scand J Med Sci Sports.* 2005;15:21-28.
25. Hägglund M, Waldén M, Ekstrand J. Lower reinjury rate with a coach-controlled rehabilitation program in amateur male soccer: a randomized controlled trial. *Am J Sports Med.* 2007;35:1433-1442.

26. Hägglund M, Waldén M, Ekstrand J. Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. *Br J Sports Med.* 2006;40:767-772.
27. Hewett TE, Ford KR, Myer GD. Anterior cruciate ligament injuries in female athletes, part 2: a meta-analysis of neuromuscular interventions aimed at injury prevention. *Am J Sports Med*. 2006;34:490-498.
28. Hewett TE, Myer GD, Ford KR. Anterior cruciate ligament injuries in female athletes, part 1: mechanisms and risk factors. *Am J Sports Med.* 2006;34:299-311.
29. Hoff J, Helgerud J. Endurance and strength training for soccer players: physiological considerations. *Sports Med*. 2004;34:165-180.
30. Jacobson I, Tegner Y. Injuries among Swedish female elite football players: a prospective population study. *Scand J Med Sci Sports.* 2007;17:84-91.
31. Knapik JJ, Bauman CL, Jones BH, Harris JM, Vaughan L. Preseason strength and flexibility imbalances associated with athletic injuries in female collegiate athletes. *Am J Sports Med.* 1991;19:76-81.
32. Krosshaug T, Nakamae A, Boden BP, et al. Mechanisms of anterior cruciate ligament injury in basketball: video analysis of 39 cases. *Am J Sports Med.* 2007;35:359-367.
33. Krosshaug T, Slauterbeck JR, Engebretsen L, Bahr R. Biomechanical analysis of anterior cruciate ligament injury mechanisms: three-dimensional motion reconstruction from video sequences. *Scand J Med Sci Sports.* 2007;17(5):508-519.
34. Kucera KL, Marshall SW, Kirkendall DT, Marchak PM, Garrett WE Jr. Injury history as a risk factor for incident injury in youth soccer. *Br J Sports Med.* 2005;39:462-466.
35. Le Gall F, Carling C, Reilly T, Vandewalle H, Church J, Rochcongar P. Incidence of injuries in elite French youth soccer players: a 10-season study. *Am J Sports Med.* 2006;34:928-938.
36. Lohmander LS, Östenberg A, Englund M, Roos H. High prevalence of knee osteoarthritis, pain, and functional limitations in female soccer players twelve years after anterior cruciate ligament injury. *Arthritis Rheum*. 2004;50:3145-3152.
37. Macintyre J, Johson C, Schroeder EL. Groin pain in athletes. *Curr Sports Med Rep.* 2006;5:293-299.
38. Mandelbaum BR, Silvers HJ, Watanabe DS, et al. Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes: 2-year follow-up. *Am J Sports Med*. 2005;33:1003-1010.
39. Mjølsnes R, Árnason A, Østhagen T, Raastad T, Bahr R. A 10-week randomized trial comparing eccentric vs. concentric hamstrings strength training in well-trained soccer players. *Scand J Med Sci Sports.* 2004;14:1-7.
40. Myklebust G, Bahr R. Return to play guidelines after anterior cruciate ligament surgery. *Br J Sports Med.* 2005;39:127-131.
41. Norwegian Football Association. Statistikk breddefotball. Available at: http://www.fotball.no/files/%7BA0E1D4E8-7437-4276-806A-045CA2B33A3C%7D.pdf.
42. Olsen OE, Myklebust G, Engebretsen L, Bahr R. Injury pattern in youth team handball: a comparison of two prospective registration methods. *Scand J Med Sci Sports.* 2006;16:426-432.
43. Olsen OE, Myklebust G, Engebretsen L, Holme I, Bahr R. Exercises to prevent lower limb injuries in youth sports: cluster randomised controlled trial. *Br Med J.* 2005;330:449-454.
44. Östenberg A, Roos H. Injury risk factors in female European football: a prospective study of 123 players during one season. *Scand J Med Sci Sports.* 2000;10:279-285.
45. Reilly T, Gilbourne D. Science and football: a review of applied research in the football codes. *J Sports Sci.* 2003;21:693-705.
46. Roos EM, Brandsson S, Karlsson J. Validation of the Foot and Ankle Outcome Score for ankle ligament reconstruction. *Foot Ankle Int.* 2001;22:788-794.
47. Roos EM, Roos HP, Ekdahl C, Lohmander LS. Knee Injury and Osteoarthritis Outcome Score (KOOS): validation of a Swedish version. *Scand J Med Sci Sports.* 1998;8:439-448.
48. Söderman K, Adolphson J, Lorentzon R, Alfredson H. Injuries in adolescent female players in European football: a prospective study over one outdoor soccer season. *Scand J Med Sci Sports*. 2001;11:299-304.
49. Söderman K, Alfredson H, Pietila T, Werner S. Risk factors for leg injuries in female soccer players: a prospective investigation during one out-door season. *Knee Surg Sports Traumatol Arthrosc.* 2001;9:313-321.
50. Steffen K, Myklebust G, Olsen OE, Holme I, Bahr R. Preventing injuries in female youth football: a randomized controlled trial. *Scand J Med Sci Sports.* In press.
51. Surve I, Schwellnus MP, Noakes T, Lombard C. A fivefold reduction in the incidence of recurrent ankle sprains in soccer players using the Sport-Stirrup orthosis. *Am J Sports Med.* 1994;22:601-606.
52. Tropp H, Askling C, Gillquist J. Prevention of ankle sprains. *Am J Sports Med.* 1985;13:259-262.
53. Verrall GM, Hamilton IA, Slavotinek JP, et al. Hip joint range of motion reduction in sports-related chronic groin injury diagnosed as pubic bone stress injury. *J Sci Med Sport.* 2005;8:77-84.
54. Von Porat A, Roos EM, Roos H. High prevalence of osteoarthritis 14 years after an anterior cruciate ligament tear in male soccer players: a study of radiographic and patient relevant outcomes. *Ann Rheum Dis.* 2004;63:269-273.
55. Waldén M, Hägglund M, Ekstrand J. High risk of new knee injury in elite footballers with previous anterior cruciate ligament injury. *Br J Sports Med.* 2006;40:158-162.
56. Waldén M, Hägglund M, Ekstrand J. Injuries in Swedish elite football: a prospective study on injury definitions, risk for injury and injury pattern during 2001. *Scand J Med Sci Sports*. 2005;15:118-125.
57. Wisløff U, Helgerud J, Hoff J. Strength and endurance of elite soccer players. *Med Sci Sports Exerc*. 1998;30:462-467.