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# Injury risk factors in female European football. A prospective study of 123 players during one season

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**The purpose of this study was to register prospectively the injuries in female soccer and to study their correlation to potential risk factors. A total of 123 senior players from eight teams of different levels were followed during one season. Isokinetic knee muscle strength at 60 and 180°/s, one-leg-hop, vertical jump, square-hop, and continuous multistage fitness test (MFT) were tested at the end of the pre-season. In addition, Body Mass Index (BMI) and general joint laxity were measured. During the season, April–October, all injuries resulting in absence from one practice/game or more were registered. Forty-seven of the 123 players sustained altogether 65 injuries. The total injury rate was 14.3 per 1000 game hours and 3.7 per 1000 practice hours. The knee (26%) was the most commonly injured region followed by the foot (12%), ankle (11%), thigh (11%) and back (11%). The risk of sustaining moderate and major injuries increased in the later part of the game or practice. Significant risk factors for injuries were an increased general joint laxity (odds ratio (OR)=5.3, $P<0.001$), a high performance in the functional test square-hop (OR=4.3, $P=0.002$), and an age over 25 years (OR=3.7, $P=0.01$). The injury rate was not different compared to male soccer, but knee injuries were more common, which is in accordance with previous studies. None of the risk factors identified in this study is easily applicable for future intervention studies in the attempts to reduce the injury rate in female soccer.**

Soccer is a worldwide sport with a large number of participants (Janda et al. 1995). The popularity of female soccer has increased during the last decade and it now attracts a fair number of women. In 1997 a total of 203 853 soccer players were registered in Sweden, of which 20% were women. This is an increase of 7% since 1995 for female soccer players.

The general injury rate for Swedish female soccer players during practice is estimated to be 7/1000 h and during the game 24/1000 h (Engström et al. 1991), which is equal to the injury rate in a similar setting with male soccer according to Ekstrand (1983).

Although the general injury rate is about the same, the injury pattern seems to be different in female soccer compared to male soccer. Lately, there has been focus on the higher risk for major knee injuries in female soccer (Engström et al. 1991, Arendt & Dick 1995, Roos et al. 1995). Besides the higher risk of injury, it also appears that female soccer players sustain their knee injuries at an earlier age. The mean age for anterior cruciate ligament (ACL) injuries in female players has been shown to be 19 years compared to 23 years among male players (Roos et al. 1995). The risk for an ACL injury in junior soccer has been estimated to be 5.4 times higher for the girls compared to their male counterparts according to a recent Norwegian study (Björdal et al. 1997). A major knee injury will in many cases cause severe consequences such as an interrupted soccer career, but the risk for an early developing knee osteoarthrosis with permanent disability for the player must also be considered (Engström et al. 1990, Roos 1994).

Anatomic and training related factors have been discussed as explanations for the higher risk for knee injuries in female players. Conceivable anatomic factors are the wider pelvis, the more spherical shape of the femoral condyles, the narrower inter-condylar notch, and the increased general joint laxity in females compared to males (Haycock & Gilette 1976, Good et al. 1991, Fridén et al. 1993, Roos 1994, Arendt & Dick 1995, Huston & Wojtys 1996). Myklebust et al. (1998) have suggested that the menstrual cycle might influence the injury rate for ACL injuries. Training related risk factors in females that have been discussed are the possible lack of muscular control, insufficient muscular strength, a possible imbalance between strength and mobility of the lower extremities and low aerobic endurance (Haycook & Gilette 1976, Knapik et al. 1991, Jones et al. 1993, Huston & Wojtys 1996).

The earlier introduction of girls into the senior team and high level soccer may also increase the risk for the young players (Roos 1994), just as high level soccer as such constitutes an increased risk for injuries (Björdal et al. 1997). High Body Mass Index (BMI) has been documented as an injury risk factor for men, but there is no evidence that this is true for women (Heir & Eide 1996).

The purposes of this investigation were to register prospectively all injuries in a group of female soccer players during one season and correlate the pre-seasonal results of isokinetic muscle strength, functional performance, aerobic capacity and physical characteristics to the distribution of injuries. The hypothesis was that a high BMI, increased general joint laxity, low $VO_{2max}$, low isokinetic muscle strength and low jumping ability were risk factors for injuries in female soccer.

## Material and methods

The study group consisted of senior players from the first team of eight soccer clubs in the south of Sweden. The clubs were evenly distributed over the five different levels available, representing a cross-section of female soccer players in Sweden. Thirty-two players were elite players (first and second national leagues) and 91 were non-elite players. Each coach was asked to select the players who were supposed to participate regularly in the first team during the season to take part in the tests, resulting in 16 (14–18) players per soccer team ($n$=123). The mean age for the total group was 20.7 years (SD=4.6, range=14–39). Subject characteristics are outlined in Table 1.

Table 1. Baseline characteristics (mean±SD) of the 123 female soccer players

| | ($n$=123) |
|---|---|
| Age (years) | 20.7 (4.6) |
| Weight (kg) | 61.5 (7.0) |
| Height (cm) | 167.2 (5.0) |
| Years of soccer playing | 12.3 (5.2) |
| Debut age (years) | 9.1 (3.1) |
| BMI ($kg \cdot m^{-2}$) | 22.0 (2.2) |

Table 2. Modified Beighton method to assess generalized joint laxity (Beighton et al. 1973)

| Score[a] | Test |
|---|---|
| 1 point (each finger) | Passive dorsiflexion of small finger metacarpophalangeal joint beyond 90° |
| 1 point (each thumb) | Passive apposition of the thumb to the flexor aspect of the forearm |
| 1 point (each elbow) | Hyperextension of elbow beyond 10° |
| 1 point (each knee) | Hyperextension of knee beyond 10° |
| 1 point | Forward flexion of the trunk with the knees fully extended and placement of the palms flat on the floor |

[a] A score of 4 or more, on a scale from 0 to 9, indicates generalized joint laxity.

Prior to the season, all players took part in the testing procedure. Before testing, all players were informed of the purpose of the study and screened for injuries by questionnaire and knee related problems were identified with the Knee injury and Osteoarthritis Outcome Score (KOOS) (Roos et al. 1998). The means in the five dimensions of KOOS, where a maximum score is 100, ranged from 87 to 97, indicating that the players had no knee complaints. Five players did not perform all the tests because of an actual injury or a previous knee injury. Two teams declined to do the continuous multistage fitness test (MFT aerobic test), since they were currently using a different type of aerobic test, and one team declined to do the isokinetic muscle strength test. One team at a time was tested. The length of the soccer career as well as the age at onset was registered for all players. No selected player declined to participate in the study.

### Injury report questionnaire

All injuries were registered during the entire 1996 soccer season. Injuries during training and games were registered separately.

An injury was registered if it resulted in an absence from scheduled activities for at least one practice or game (Ekstrand 1983). All injuries were diagnosed and reported on a special form by the physical therapist connected with the team. An orthopedic surgeon (HR) was contacted in case of a severe injury or uncertainty regarding an injury. The injuries were separated into three categories according to Ekstrand (1983): (1) minor injuries (absence from practice/game 7 days or less); (2) moderate (absence from practice/game 7 days to 1 month); (3) major (absence from practice/game more than 1 month). Injuries occurring at the end of the season were categorized as above according to the full duration of absence (Engström et al. 1991). Individual participation in practice and game sessions was registered on a separate protocol by the coach or assistant coach of the team. In mid season and at the end of the season, the injury report questionnaires were compared with the team participation sheets to ascertain that no injury was missed. In mid season, a questionnaire was sent directly to half of the players as an extra precaution. The players were asked if they had missed any practice or game during the first part of the season due to an injury. The coach or the player was contacted when there was a suspicion of an unreported injury. One of the authors (AÖ) kept in touch by telephone with all teams regularly.

### Physical characteristics

*General joint laxity* was assessed using the modified Beighton method (Beighton et al., 1973), where a score of 4 or more points indicates increased general joint laxity (Table 2).

*Body Mass Index* was calculated using the standard formula ($kg \cdot m^{-2}$) (Whitney et al. 1987). BMI is a commonly used surrogate for percentage of body fat, and a high BMI suggests relatively more body fat compared to a low BMI.

### Isokinetic muscle strength

Quadriceps and hamstring muscle strength were assessed in an upright seated position using a Cybex Dynamometer 325 with 3.3 software, (Lumex Inc., Ronkonkoma, NY), at an angular velocity of 60°/s and 180°/s. The subject was secured to the apparatus with straps across the chest, pelvis, thigh and ankle, according to the Cybex manual (Davies 1984). The subject was sitting with the thigh supported, with 90° hip flexion and the arms folded. The center of motion of the lever arm was aligned as accurately as possible with the slightly changing flexion–extension axis of the knee joint and the resistance pad was placed as distally as possible on the tibia. The range of motion of the knee joint was set at 0–100°. The test protocol consisted of four trial repetitions at each speed. Four test repetitions at 60°/s and 180°/s were performed by the subjects. A 20-s rest was allowed between the sets. Vocal instructions for the tests were standardized. Peak torque (Nm) and total work (J) was registered for knee extensors and flexors. The left and the right side was tested on the same occasion. The mean values ((right+left leg)/2) of the best test repetition were used.

### Aerobic capacity

*Continuous multistage fitness test* was chosen because a whole squad of players can be tested simultaneously, and it is commonly used by soccer teams to estimate maximal oxygen uptake ($VO_{2max}$) (Ramsbottom et al. 1988). The test was performed by six of the eight teams leaving the study group with only 86 subjects for analysis of this test. The continuous multistage fitness test consists of repeated 20-m shuttle runs with a progressively increasing running speed. The aim of the test is to complete as many shuttles as possible. The running speed is controlled by a series of beeps, pre-recorded on an audio-cassette. The players must always reach the end of the 20-m line at the sound of a beep. Players are required to stop running when they drop below the pre-set pace. The running speed at the start of the test corresponds to a slow jog (9 km/h) but is increased every minute, i.e. the time between the beeps becomes shorter (Brewer et al. 1988). The continuous multistage fitness test values have been shown to correlate to $VO_{2max}$ and have a predicted value of 0.92 (Ramsbottom et al. 1988).

### Functional performance

*One-leg-hop for distance.* This test has been described earlier and has shown good reliability in healthy athletes (Tegner et al. 1986). Standing on one leg, hands behind the back, the subject hopped and landed on the same leg without moving the hands from the back, or losing the postural control. The distance in centimeters was measured from the toe in the starting position to the heel on the same foot, where the subject landed. The hop was performed three times on each leg, starting with the right leg, then alternating between the legs. However, if the subject increased hop length in all the three hops, additional hops were performed until no increase in hop length was measured. The best performance was recorded and the mean ((right+left leg)/2) was used.

*Vertical jump.* The vertical jump has good repeatability in healthy athletes and has been used in different tests, such as testing of female runners and female knee deficient patients, and in a normal population (Wiklander & Lysholm 1987, Forsberg & Seger 1993, Thomée et al. 1995). The subject was placed on a wooden platform. A belt was secured around the waist. A measuring tape ran vertically down from the belt through a loop in the platform. The starting position for the test was in the upright position, equal weight bearing, feet at hip width and both arms free to help during the jump. The subject was allowed to bend the knees as much as desired to initiate the jump. When the subject performed a vertical jump, the measuring tape was pulled through the loop and the height of the jump was recorded. Three maximal trials were allowed and the best result was recorded (cm). However, if the subject increased in jump height in all three jumps, additional jumps were performed until no increase in jump height was seen.

*Square-hop.* The square-hop test is developed and used in clinical practice by physiotherapists (Östenberg et al. 1998), and has been tested for reliability. The inter- and intra-test reliability was $r=0.94$ and $r=0.74$ respectively, when tested in a total of 41 subjects, 19 knee deficient patients and 22 controls (E. Roos, personal communication 1996). This test was chosen because of its multidirectional movements, which are characteristic of soccer. The subject was standing outside a 30×35 cm square marked on the floor with tape. The subject was asked to jump clockwise on the right leg, in and out of the square during 30 s. The number of times the foot touched inside the square without touching the tape was recorded. The procedure was repeated on the left leg. The square-hop was performed once on each leg and the mean ((right+left leg)/2) was used.

### Statistical analysis

Means and standard deviations (SD) for continuous variables such as age, weight, height, BMI, and the continuous multistage fitness test were calculated for the subjects of this study to document, describe and compare physical characteristics and physical performance. Statistical comparisons of mean values for non-injured and injured groups were done with Student's *t*-test and Chi-square test. The Chi-square test was used when analyzing occurrence of injuries according to time into game or practice.

The influence of potential predictor test variables on the risk for any injury and knee injury respectively was analyzed by means of logistic regression (Hosmer & Lemeshow 1989). First, the influence of each potential predictor was assessed in univariate logistic regression analyses. Those predictors which implied a *P*-value less than 0.20 were considered further in a multivariate analysis. Backward stepwise elimination was then employed to obtain the statistically significant predictors. An appropriate relation between a continuous predictor and risk was assessed based on the model assumption; categorization of a continuous predictor was considered. In a logistic regression analysis, an estimate of the effect of a predictor variable on the risk is reflected by an odds ratio (odds=risk/(1−risk)).

## Results

### Injuries

No dropouts were seen during the study period. During the study period 65 injuries were reported in 47 players. Sixty percent of the injuries occurred during soccer games and the remainder during practice. Twenty (31%) were classified as minor, 33 (51%), as moderate and 12 (18%), as major injuries (Table 3). Fifty-two (80%) of the injuries involved the lower extremity, 29 on the dominant leg and 21 on the non-dominant side. Two of the injuries were bilateral shin splints. The distribution of injuries between right and left leg was equal on both. The incidence of injury during games was 14.3/1000 h, while the incidence during practice was 3.7/1000 h. The proportion of traumatic injuries, e.g. injuries with a sudden onset, was 78%, the rest outlined as overuse injuries, e.g. injuries that could not be referred to any special oc-

Table 3. Severity of injuries according to Ekstrand (1983) and time of occurrence, during one season in 123 female soccer players

| Injury | Games *n*/% | Training *n*/% | Total *n*/% |
|---|---|---|---|
| Minor (<7 days) | 12/18 | 8/12 | 20/31 |
| Moderate (7–30 days) | 19/29 | 14/22 | 33/51 |
| Major (>30 days) | 8/12 | 4/6 | 12/18 |
| Total | 39/60 | 26/40 | 65/100 |

Table 4. Type of injury and time of occurrence during one season in 123 female soccer players

| Type of injury | Games *n*/% | Training *n*/% | Total *n*/% |
|---|---|---|---|
| Fracture | 2/3.1 | 0 | 2/3.1 |
| Dislocation | 2/3.1 | 0 | 2/3.1 |
| Ligament sprain | 9/13.8 | 3/4.6 | 12/18.5 |
| Muscle strain | 12/18.5 | 9/13.8 | 21/32.3 |
| Contusion | 8/12.3 | 3/4.6 | 11/16.9 |
| Tendinitis/Bursitis | 1/1.5 | 8/12.3 | 9/13.8 |
| Other | 4/6.2 | 4/6.2 | 8/12.3 |
| Total | 39/60 | 26/40 | 65/100 |

Table 5. Localization of injuries and their severity according to Ekstrand (1983) in 123 female soccer players during one season

| Site | Total *n*/% | Minor *n*/% | Moderate *n*/% | Major *n*/% |
|---|---|---|---|---|
| Foot | 8/12.3 | 3/4.6 | 5/7.7 | 0 |
| Ankle | 7/10.8 | 3/4.6 | 3/4.6 | 1/1.5 |
| Leg | 4/6.2 | 2/3.1 | 2/3.1 | 0 |
| Knee | 17/26.2 | 3/4.6 | 9/13.8 | 5/7.7 |
| Thigh-front | 7/10.8 | 3/4.6 | 4/6.2 | 0 |
| Hamstring | 4/6.2 | 1/1.5 | 2/3.1 | 1/1.5 |
| Groin | 5/7.7 | 1/1.5 | 3/4.6 | 1/1.5 |
| Back | 7/10.8 | 2/3.1 | 4/6.2 | 1/1.5 |
| Other | 6/9.2 | 2/3.1 | 1/1.5 | 3/4.6 |
| Total | 65/100 | 20/31 | 33/51 | 12/18 |

casion and had a gradual onset of symptoms. A total of 28 (55%) of the traumatic injuries occurred in contact with another player, while 23 (45%) had no contact mechanisms. Thirty-nine (60%) of the injuries occurred after 60 min or more of practice or game time. A Chi-square test revealed that the moderate and major injuries occurred later during practice/game than the minor injuries ($P=0.002$).

## Type and localization of injuries

The type and localization of injuries are shown in Tables 4 and 5. The most frequent type of injury was muscle strain 32% ($n=21$) followed by ligament sprain 18% and contusion 17%. The most frequent localization was the knee ($n=17$). Five (29%) of the knee injuries were major injuries and three (4.6%) of them were ACL injuries. The injury rate for ACL injuries was 0.31 injury/1000 player hours, or an annual injury rate of 2.4%. The ACL-injured players had a mean age of 20.7 years. The 5 major knee injuries constituted 42% of the total major injuries. A total of 13 (20%) of the injuries were recurrent injuries.

## Physical characteristics

No statistically significant difference was seen in age, height, weight, début age, or BMI between the non-injured and the injured group. The injured group had played soccer for more years than the non-injured group ($P=0.02$) (Table 6).

There was an increased general joint laxity in the injured group ($P=0.001$). In addition, when knee joint laxity was specifically studied, a difference was found between the two groups, with an increased knee hypermobility in the injured group ($P=0.05$).

## Isokinetic muscle strength

When comparing the injured and non-injured players, no difference was seen between the groups in isokinetic strength (Table 7).

## Aerobic capacity and functional performance

There was no difference between the injured and the uninjured group regarding aerobic capacity, as measured by the continuous multistage fitness test. No differences were seen between the uninjured and the injured group in the one-leg-hop, the vertical jump or in the square-hop (Table 8).

## Risk factors

From the tests and physical characteristics three factors were shown to be significant injury risk factors:

Table 6. Means (±SD) for age weight, height, years of soccer playing, debut age, and BMI for the non-injured ($n=76$) and the injured ($n=47$) female soccer players

| | Non-injured group ($n=76$) | Injured group ($n=47$) | *P*-value |
|---|---|---|---|
| Age (years) | 20.1 (4.5) | 21.7 (4.6) | 0.056 |
| Weight (kg) | 60.7 (6.6) | 62.7 (7.5) | 0.13 |
| Height (cm) | 167.5 (5.4) | 166.6 (4.3) | 0.34 |
| Years of soccer playing | 11.5 (5.0) | 13.8 (5.3) | 0.02 |
| Debut age (years) | 9.3 (3.3) | 8.9 (2.6) | 0.52 |
| BMI ($kg \cdot m^{-2}$) | 21.6 (1.8) | 22.6 (2.6) | 0.11 |

Table 7. Means (±SD) (mean=(right+left leg)/2) for knee extensors and flexors for the non-injured ($n=67$) and injured ($n=41$) group of female soccer players in isokinetic muscle strength test at the velocities of 60°/s and 180°/s

| | Non-injured group ($n=67$) | Injured group ($n=41$) | *P*-value |
|---|---|---|---|
| Peak torque (Nm) | | | |
| Ext 60°/s | 87 (14.7) | 88 (13.0) | 0.67 |
| Ext 180°/s | 60 (8.6) | 59 (10.0) | 0.76 |
| Flex 60°/s | 63 (10.4) | 62 (9.5) | 0.72 |
| Flex 180°/s | 52 (8.7) | 51 (9.2) | 0.78 |
| Total work (J) | | | |
| Ext 60°/s | 92 (16.6) | 93 (15.3) | 0.61 |
| Ext 180°/s | 60 (10.4) | 61 (11.6) | 0.79 |
| Flex 60°/s | 79 (14.7) | 79 (12.8) | 0.82 |
| Flex 180°/s | 60 (11.1) | 60 (11.4) | 0.95 |

Table 8. Means (±SD) for continuous multistage fitness test (MFT), one-leg-hop, vertical jump and square-hop for the non-injured ($n$=76) and injured ($n$=47) group of female soccer players

| Test | Non-injured group ($n$=76) | Injured group ($n$=47) | $P$-value |
|---|---|---|---|
| MTF ($maxVO_2$) ($ml \cdot kg^{-1} \cdot min^{-1}$)* | 39.9 (5.2) | 40.6 (5.0) | 0.52 |
| One-leg-hop (cm) | 134.6 (12.8) | 130.1 (15.5) | 0.15 |
| Vertical jump (cm) | 39.1 (9.6) | 39.9 (9.0) | 0.63 |
| Square-hop (number) | 21.4 (4.9) | 23.3 (6.1) | 0.07 |

*$n$=52 (non-injured), $n$=35 (injured).

Table 9. Impact of significant predictor variables on the risk for any injury: Result from the logistic regression analysis ($n$=123)

| Predictor variable | OR[a] | (95% CI)[b] | $P$[c] |
|---|---|---|---|
| Age (years) (≥25 vs. <25) | 3.7 | (1.4–10.0) | 0.01 |
| General joint laxity (yes vs. no) | 5.3 | (2.0–13.5) | <0.001 |
| Square-hop (number) ≥25 vs. <25) | 4.3 | (1.7–10.5) | 0.002 |

[a] Estimated odds ratio (odds=risk (injury)/(1−risk (injury)) between the two categories of the predictor variable issue. Estimates were obtained when the three predictor variables were included in the logistic model.
[b] Confidence interval for odds ratio.
[c] $P$-value for test of odds ratio=1 (Wald's test).

(1) players who were older than 25 years (OR=3.7, CI 95% 1.4–10.0); (2) players who scored 4 or more points in the modified Beighton test and thus were considered generally joint lax (OR=5.3, CI 95% 2.0–13.5); (3) players who performed more than 25 square jumps (OR=4.3, CI 95% 1.7–10.5) (Table 9).

In addition, general joint laxity was seen as a significant predictor of knee injury (OR=5.0, CI 95% 1.3–18.9). Time elapsed during the game or practice was seen to be a risk factor since the moderate and major injuries occurred later during game or practice ($P$=0.002).

## Discussion

We have prospectively registered the injuries in 123 female soccer players during one season according to a standard definition of injury (Ekstrand 1983). The percentage of injuries (39%) was lower compared to a recent study where 80% of elite female players were injured during one season (Engström et al. 1991). This difference may depend on the fact that the present study involved not only top level players. High level soccer has earlier been shown to generate more injuries than lower levels (Björdal et al. 1997). The overrepresentation of injuries during games, the distribution of injuries, and the different types of injuries are in accordance with earlier studies (Engström et al. 1991, Lindenfeld et al. 1994, Árnarson et al. 1996).

The higher injury rate in the later part of games/practice, as seen in this study, is in accordance with a previous study (Árnarson et al. 1996). It could be explained by a lack of concentration on the game or by muscular fatigue because of depression of muscle glycogen and aerobic exhaustion (Bangsbo 1994). In a previous study it was shown that female army trainees with lower levels of fitness, as measured by mile run times, had a higher risk for exercise-related injuries (Jones et al. 1993). In this study aerobic fitness, measured as continuous multistage fitness test, was, however, not shown to be an injury risk factor. The discrepancy could be explained by the fact that the continuous multistage fitness test has some obvious limitations, of which one is that it is influenced by the motivation of the player.

The rate of major injuries was 18 (12 injuries/65×100), and was, as expected, lower than in a study of top level players, as earlier discussed. The incidence of ACL injury was 0.31 per 1000 player hours or an annual incidence of 2.4%, which is similar to other studies of female athletes (Arendt & Dick 1995, Björdal et al. 1997, Levy et al. 1997, Myklebust et al. 1998). In this study, a statistical analysis of the ACL injuries and their specific risk factors could not be performed due to the limited number of this injury.

The present study showed increased general joint laxity and a higher age to be the main risk factors for injury in female soccer. Increased joint laxity has earlier been discussed as an injury risk factor in female soccer (Haycook & Gilette 1976, Arendt & Dick 1995, Roos et al. 1995, Huston & Wojtys 1996), but has not, according to our knowledge, earlier been shown to be such a factor in a prospective study. To prevent injuries it might be of value for players with an increased joint laxity to have optimal coordination and postural control to compensate for the hypermobility of the joints. Caraffa et al. (1996) showed that a training period of proprioceptive training on a so-called BAPS board significantly reduced the ACL injuries in male football players. Hewett et al. (1996) showed that after a period of plyometric training using different kind of jumps, female volleyball players showed a decrease in peak torque landing force, which might be important for the movement of the knee joint.

It has been shown that young female players have an increased risk for knee injuries (Lindenfeld et al. 1994, Roos et al. 1995, Björdal et al. 1997). However, in this study older age proved to be an injury risk factor. This is not necessarily a contradictory result since the present study concerns the general injury rate and not the specific knee injury rate. Another contributing factor to this finding could be that the elite players were older than the non-elite players in this study. Although not shown, it is known from another study that high level soccer constitutes a higher risk for injuries (Björdal et al. 1997).

Low isokinetic strength was not a risk factor for injuries in any of the velocities used. However, isokinetic strength has low or little correlation to muscular function (Andersson et al. 1991, Lephart et al. 1992, Östenberg et al. 1998) and may thus not be of importance as a risk factor for injuries. In addition to testing of the concentric muscle strength, it might have been an advantage also to test the eccentric strength since plyometric training, which involves eccentric muscle contractions, decreases the landing force, as discussed above (Hewett et al. 1996). Low performance in the functional tests was not a risk factor for injuries, but surprisingly a better performance in the square-hop test turned out to be a risk factor. However, this might be explained by the fact that elite players performed better in this test. The elite players were as a group older than the non-elite players, and higher age was associated with a higher rate of injuries.

Usually the injury registration is a limiting factor in this type of study. In the present study we have tried to reduce this weakness. In mid season, a questionnaire was sent directly to half of the players making double-checking of injury registration possible. Additionally, the close contact with the players, their coaches and the physical therapists may also have contributed to reduce this problem.

The selection of the participating teams might be a weakness since all teams came from the same area. The fact that the distributions of elite and non-elite players were skew makes it impossible to draw any conclusions regarding injury risk and soccer level.

## Conclusions

This is a prospective study of risk factors and injuries in female soccer. The injury pattern in this group is similar to other studies. General joint laxity and a higher age were seen to be risk factors for injury in this study.

We also found a high performance in one of the functional tests to be correlated to injuries. The interpretation of this finding was that it had no true relation to injuries but instead mirrored the skewed distribution of elite versus non-elite players.

Isokinetic muscle strength, functional performance tests, except the square-hop, and aerobic capacity were not shown to be injury risk factors in this study.

## Perspective

Before clinical trials in prevention of soccer injuries are initiated, knowledge of the mechanism of injuries is needed. The most important factor in the attempts to reduce the risk for premature osteoarthrosis in female soccer players is certainly to prevent major knee injuries. The first step in this attempt is to define the general risk factors for injuries in female soccer, followed by a specific analysis of risk factors for knee injuries. This study could thus be seen as a screening for risk factors in female soccer. However, none of the risk factors identified could easily be applicable for future intervention studies.

A significantly larger study group is necessary if risk factors specific for ACL injuries are to be studied. It would certainly be of importance to correlate other factors such as postural control and endurance to injuries and also to use more specific soccer-related tests. Such tests are to our knowledge not yet available.

**Key words:** female; soccer; injury; risk factors.

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