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*Am J Sports Med* 2008 36: 276 originally published online October 11, 2007

DOI: 10.1177/0363546507307866

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# Injuries in Young Elite Female Soccer Players

## An 8-Season Prospective Study

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**Background:** Epidemiologic data on injuries in young female soccer players at elite levels are scarce.

**Purpose:** The aim of the present study is to investigate the incidence of soccer-related injuries in young elite female French players.

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

**Methods:** Injuries sustained by players between 15 and 19 years of age, during 8 seasons, were diagnosed and documented by a sports physician according to type, location, severity, the date the injury occurred, and playing position.

**Results:** Altogether 619 injuries were documented for 110 players (92.4%). Of these injuries, 64.6% (4.6/1000 training hours; 95% confidence interval [CI], 4.2-5.0) and 35.4% (22.4/1000 match hours; 95% CI, 19.4-25.4) were sustained during training and matches, respectively. The risk of injury was greater in the youngest (under age 15) group compared with the oldest (under 19) group (relative risk 1.7; 95% CI, 1.3-2.3). Traumatic injuries amounted to 536 (86.4%) and 83 (13.4%) were overuse injuries. There were 51.9% minor injuries, 35.7% moderate injuries, and 12.4% major injuries. Most injuries were located at the lower extremities (83.4%), with the majority affecting the ankle ( $n = 157$ ). The most commonly diagnosed injury was ankle sprain (16.8%). Twelve anterior cruciate ligament ruptures were sustained, with the majority occurring during matches ( $n = 10$ ; 1.0/1000 match hours; 95% CI, 0.4-1.6). Reinjuries accounted for 4.4% of total injuries, and September was the predominant month for injury (14.2%).

**Conclusions:** The results, when compared with those of other investigations on female soccer players, revealed high rates of both traumatic injury and match injury, whereas recurrence of injury was low. Injuries, notably sprains, to the ankle were common, suggesting a need for the implementation of specific injury prevention strategies for this joint.

**Keywords:** training; trauma; overuse; women

The popularity of soccer among girls and women in France, as in many other countries worldwide, is on the increase, with nearly 50 000 players currently registered in 1200 clubs nationwide.<sup>34</sup> Consequently, in 1998 the Centre National de Formation et d'Entraînement (National Soccer Training and Development Centre for Females), or CNFE, was created by the Fédération Française de Football to host and develop elite French female soccer players from 15 to 19 years of age. Since the establishment of the CNFE, the French National

Under-19 team has won the Under-19 European Championship in 2003 and finished runner-up 4 times.

The growing popularity of soccer among female participants has led to an increase in game dynamics as well as more distinct athletic makeup of the players.<sup>13</sup> Clinicians are consequently seeing more female players sustaining trauma through playing soccer.<sup>5</sup> Epidemiologic research on female soccer players of differing ages and levels has demonstrated varying rates of injury. Incidence of training injury has been shown to range from 1.2<sup>17</sup> to 8.4<sup>26</sup> per 1000 hours of exposure. Players are at greater risk of sustaining injury in match play compared with training contexts, with reported rates varying from 9.1<sup>40</sup> to 24<sup>12</sup> per 1000 hours of exposure in competition. The overall incidence of injury in female players is generally lower than that for male players,<sup>9</sup> although there are comparable rates of injury in match play at elite levels.<sup>12,13,20,21</sup> The knee and ankle have been shown to be the most

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No potential conflict of interest declared.

common locations for injury in female players,<sup>5</sup> and of particular interest is an increased incidence of anterior cruciate ligament (ACL) injuries.<sup>6,13</sup>

However, the number of published studies about the extent of the injury problem in female soccer players is limited compared with male players,<sup>40</sup> and results from epidemiologic studies lack consistency with respect to the methodologies employed.<sup>26</sup> More specifically, prospective studies of injury data obtained from elite female soccer players are few; so far, there has been no investigation concentrating exclusively on injury in a population of elite young female players. Furthermore, most authors have collected injury data on female players only across 1 or 2 seasons or during tournaments. If suitable prevention strategies especially tailored for female players are to be developed, data on a large sample of top-level players are necessary.<sup>13</sup>

In 1998, staff of the Medical Center at the CNFE established a prospective study over 8 seasons to investigate the extent of soccer-related injuries in its young elite female players. The main objectives were to examine the general incidence, severity, nature, location, seasonal disposition, and recurrence of injury and to compare injury incidence across the different seasons and different age categories. These data would inform appraisal of current prophylactic strategies and prehabilitation regimens and define future epidemiologic research.

## MATERIALS AND METHODS

In this prospective cohort observational study, injuries were investigated in young elite French female soccer players at the Clairefontaine CNFE. Epidemiologic data were captured over a period of 8 seasons from August 1998 to June 2006. All injuries were prospectively diagnosed and recorded over the whole study period by the same CNFE physician. This procedure reduced bias through differences in injury interpretation, recall, and changes in observation methods between practitioners.<sup>31</sup> Consent forms for the study were completed by the parents of players who were under the legal age of consent. The study was approved by the ethics committee of the Fédération Française de Football.

### Subjects

Over the course of the study period, the CNFE cohort for each season varied from 20 to 40 players aged from 15 to 19 years of age. Every player was asked to participate voluntarily in the study and they all accepted the invitation, resulting in a total of 119 participants. All active players present in the center at the beginning of each season were included in the study, and epidemiologic data were collected for every participant throughout her time at the CNFE until she dropped out at the end of any 1 season. Players who completed at least 1 whole season at the center were included for statistical analysis. Over the 8-year period, all 119 players completed at least 1 season and no new players were recruited midseason. Those who were already injured at the beginning of the study period were included, but their preexisting injuries were not taken into account in the injury statistics.<sup>19</sup>

Before enrolling at the center and before acceptance into the elite program, each player underwent medical screening

as it is possible that some injuries are prevented by an effective screening program before the start of each season.<sup>39</sup> This screening program was employed to identify any pathophysiologic condition that may have contraindicated playing soccer. The musculoskeletal system of each player was examined to determine any joint laxity, malalignments, muscle tightness, or imbalances, and, where necessary, medical procedures were employed to prevent these being a causal factor in future injury.<sup>31</sup> These screening procedures were carried out by a single CNFE physician who specialized in sports medicine and were identical for every season throughout the 8-season period of the present study.

### Injury Definition and Injury Recording

To facilitate the comparison of results, the methodologies and definitions of injury used in the present study closely follow those employed in previous epidemiologic investigations on female soccer players or as recently recommended by International Injury Consensus Groups.<sup>15,19</sup> Injuries sustained during training were immediately assessed and documented at the Center by the CNFE physician after self-referral by the players. All injuries sustained during matches were assessed and documented back at the Center by the same CNFE physician after self-referral by the players either the same day or the morning immediately after the event. An injury was defined as any physical complaint received during soccer training or competition and which prevented the injured party from participating in normal training or competition for at least 1 day after the day of the onset.<sup>13</sup> An injury was classified as an overuse injury if it was the consequence of repetitive microtrauma and was classed as traumatic if it was caused by a single incident.<sup>13</sup>

When fit, all players trained together at the CNFE for up to 2 hours each day from Monday to Friday of every 39-week season. Fit players also participated in up to 30 matches each season, and these mainly took place at the weekends for their home clubs or when they represented the CNFE in the National Championship. To calculate the exact incidence of injury, the number of games and training sessions should be documented for each player.<sup>28</sup> It was deemed impractical to do so in the present study because of the working practices of the Center and at the individual player's home club. Therefore, exposure time was calculated per player on a best estimate of 10 hours of training and 1.5 match-hours per week when not injured. Injury incidence was calculated as the number of injuries per 1000 hours exposure in training and matches.<sup>15,19</sup> The soccer season for women in France runs from August through June. Depending on the vacation calendar, the players were absent from training and competition for 1 week in October, December, and January and 2 weeks in February and April and from mid-June until the beginning of August.

The type, location, and severity of the injury were recorded, the latter depending on the time period over which the player was absent from training or competition. If 1 incident resulted in more than 1 diagnosis, the main injury was used for statistical analysis. Injuries were classified into 3 subdivisions according to their severity: minor (absence from training/games <7 days), moderate (absence from 7 to 30 days), and major (absence >30 days).<sup>12,13,35,40</sup> Reinjuries were defined as the same type of injury to the same side and location within

2 months after the final rehabilitation day of the previous injury.<sup>26,27</sup> Injuries were also recorded according to the individual playing position (goalkeeper, defender, midfielder, or forward) designated at the beginning of each season. Finally, the precise date of each injury was recorded to examine the seasonal distribution of injury over the playing season.

The mechanism of injury (for example, a contact or non-contact event) and the time in the match when the injury was sustained were not recorded in this study. This omission was because the study practitioner was not always present and medical presence was not obligatory at the matches. It was deemed too unreliable to ask the players or coaching staff to record the data and report back to the Medical Center.

## Statistics

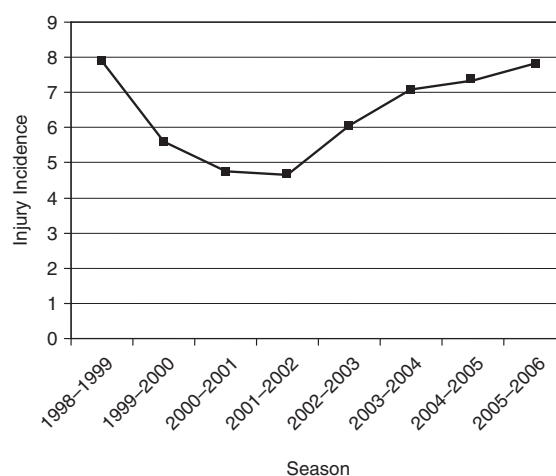
Epidemiologic data were stored onto a computer spreadsheet (Microsoft Excel, Microsoft Corp, Redmond, Wash). Data were analyzed using frequencies and cross-tabulation procedures (SPSS Science Inc, Chicago, Ill). Statistical comparisons within the dataset were investigated using the nonparametric Mann-Whitney *U* test and Kruskal-Wallis 1-way analysis of variance on ranks. Where appropriate, a post hoc Student-Newman-Keuls multicomparison test was conducted on the ranks to isolate any differences between groups and seasons.

## RESULTS

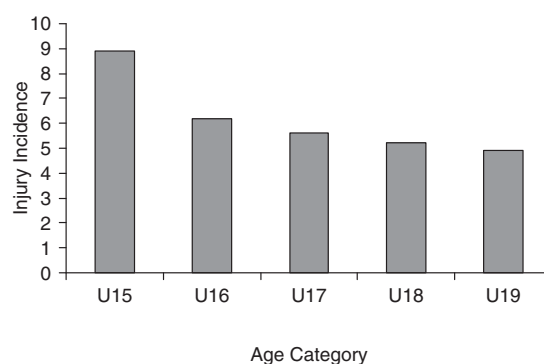
Over the 8-season period, the 119 players were subjected to 87 530 hours of training time and 9795 hours of match time, constituting a total of 97 325 hours of exposure time. The players had 8.7 hours of training per match-hour and a ratio of 6.5 training sessions per match.

### Injury Incidence and Severity

Altogether, 619 injuries for 110 players were documented (92.4% of the overall study population). There were 400 training injuries (64.6%) and 219 (35.4%) match injuries reported. The overall rate of injury acquisition per 1000 hours exposure was 6.4 (95% confidence interval [CI], 5.9-6.9), and an average of 5.2 injuries per player was sustained over the time the athlete spent at the center. The incidence of injury per season across the 8-season study period is shown in Figure 1. No significant difference was reported in the overall incidence of injury per season across the 8 seasons ( $P = .084$ ). A comparison of the incidence of injury across all age groups is presented in Figure 2. Across age groups, a significant difference in the overall incidence of injury was obtained ( $P = .034$ ). The highest incidence of injury was sustained in the youngest (under 15 years) age group and the lowest in the oldest (under 19) age group (8.7 vs 4.9; post hoc  $P < .05$ ; relative risk [RR] of 1.7 compared with under 19 group; 95% CI, 1.3-2.3). Nine players received no injury (7.6%), 11 players (9.2%) received 1 injury, 16 players had 2 injuries (13.4%), 18 had 3 injuries (15.1%), and 65 had 4 or more injuries (54.6%) during their time at the center. Injury incidences during match play and training were 22.4 (95% CI, 19.4-25.4) and 4.6 (95% CI, 4.2-5.0), respectively, per 1000 hours of exposure ( $P < .001$ , RR of



**Figure 1.** Incidence of injury per season across the 8-season study period (injuries/1000 h).



**Figure 2.** Incidence of injury according to age category (injuries/1000 h). U, under.

4.7 compared to training; 95% CI, 3.0-6.3). In total, 536 injuries were classified as traumatic (86.4%) and 83 as overuse (13.4%), corresponding to an incidence rate of 5.5 (95% CI, 5.0-6.0) and 0.9 (95% CI, 0.7-1.1) per 1000 hours of exposure. Of the total traumatic injuries, 61.9% (332) occurred during match play and 38.1% (204) during practice.

Table 1 presents the incidence of injury according to severity. Overall, 51.9% of all injuries (traumatic and overuse) were of minor severity, 35.7% were moderate, and 12.4% required a layoff time greater than 30 days. The majority of injuries incurred were classed as minor in both training and match play. Of the total number of traumatic injuries, 35.1% were classified as moderate and 12.7% as major. For the total number of overuse injuries, 39.3% were classed as moderate and 10.7% as major. Layoff for injuries exceeding 3 months accounted for 3.9% of the total injuries. A total of 1142 days were lost to injury per season, each player was injured for around 46 days per year, and the average layoff time was about 18 days per injury. Over the 8 seasons of the study, no player was forced to quit the Center because of injury.

### Location and Diagnosis of Injury

The incidence of injuries according to anatomical site is reported in Table 2. Most injuries were located in the lower

TABLE 1  
Incidence of Injury Severity in Relation to Match and Training (Injuries/1000 h)

| Severity  | Training |       |           |         | Match |       |           |           | Total |       |           |         |
|-----------|----------|-------|-----------|---------|-------|-------|-----------|-----------|-------|-------|-----------|---------|
|           | n        | %     | Incidence | 95% CI  | n     | %     | Incidence | 95% CI    | n     | %     | Incidence | 95% CI  |
| 1-7 days  | 210      | 52.5  | 2.4       | 2.1-2.7 | 111   | 50.7  | 11.3      | 9.2-13.4  | 321   | 51.9  | 3.3       | 2.9-3.7 |
| 7-30 days | 151      | 37.8  | 1.7       | 1.5-2.0 | 70    | 32.0  | 7.2       | 5.5-8.8   | 221   | 35.7  | 2.3       | 2.0-2.6 |
| >30 days  | 39       | 9.7   | 0.4       | 0.3-0.6 | 38    | 17.3  | 3.9       | 2.6-5.1   | 77    | 12.4  | 0.8       | 0.6-1.0 |
| Total     | 400      | 100.0 | 4.6       | 4.1-5.0 | 219   | 100.0 | 22.4      | 19.4-25.3 | 619   | 100.0 | 6.4       | 5.9-6.7 |

CI, confidence interval.

TABLE 2  
Incidence of Injury Location in Relation to Match and Training (Injuries/1000 h)

| Location  | Training |       |           | Match |       |           | Total |       |           |
|-----------|----------|-------|-----------|-------|-------|-----------|-------|-------|-----------|
|           | n        | %     | Incidence | n     | %     | Incidence | n     | %     | Incidence |
| Ankle     | 98       | 24.6  | 1.12      | 59    | 26.9  | 6.02      | 157   | 25.4  | 1.61      |
| Thigh     | 89       | 22.3  | 1.02      | 39    | 17.8  | 3.98      | 128   | 20.7  | 1.32      |
| Knee      | 58       | 14.5  | 0.66      | 46    | 21.0  | 4.69      | 104   | 16.8  | 1.07      |
| Groin     | 42       | 10.5  | 0.48      | 16    | 7.3   | 1.63      | 58    | 9.4   | 0.59      |
| Back      | 39       | 9.8   | 0.45      | 8     | 3.6   | 0.81      | 47    | 7.6   | 0.48      |
| Foot      | 19       | 4.8   | 0.22      | 19    | 8.7   | 1.94      | 38    | 6.1   | 0.39      |
| Lower leg | 22       | 5.5   | 0.25      | 9     | 4.1   | 0.92      | 31    | 5.0   | 0.32      |
| Hand      | 14       | 3.5   | 0.16      | 5     | 2.3   | 0.51      | 19    | 3.1   | 0.19      |
| Pelvis    | 7        | 1.7   | 0.08      | 5     | 2.3   | 0.51      | 12    | 1.9   | 0.12      |
| Shoulder  | 5        | 1.2   | 0.06      | 2     | 0.9   | 0.20      | 7     | 1.1   | 0.07      |
| Arm       | 3        | 0.7   | 0.03      | 6     | 2.7   | 0.61      | 9     | 1.4   | 0.09      |
| Trunk     | 2        | 0.5   | 0.02      | 2     | 0.9   | 0.20      | 4     | 0.6   | 0.04      |
| Hip       | 1        | 0.2   | 0.01      | 1     | 0.4   | 0.10      | 2     | 0.3   | 0.02      |
| Head      | 1        | 0.2   | 0.01      | 1     | 0.4   | 0.10      | 2     | 0.3   | 0.02      |
| Neck      | 0        | 0.0   | 0.00      | 1     | 0.4   | 0.10      | 1     | 0.1   | 0.01      |
| Total     | 400      | 100.0 | 4.56      | 219   | 100.0 | 22.36     | 619   | 100.0 | 6.36      |

TABLE 3  
Incidence of Injury Diagnosis in Relation to Match and Training (Injuries/1000 h)<sup>a</sup>

| Diagnosis                    | Training |       |           | Match |       |           | Total |       |           |
|------------------------------|----------|-------|-----------|-------|-------|-----------|-------|-------|-----------|
|                              | n        | %     | Incidence | n     | %     | Incidence | n     | %     | Incidence |
| Sprain                       | 95       | 23.5  | 1.08      | 74    | 33.2  | 7.56      | 169   | 26.9  | 1.74      |
| Strain                       | 119      | 29.4  | 1.36      | 39    | 17.5  | 3.98      | 158   | 25.2  | 1.62      |
| Contusion                    | 35       | 8.6   | 0.39      | 66    | 29.6  | 6.74      | 101   | 16.1  | 1.04      |
| Tendinopathy <sup>b</sup>    | 28       | 6.9   | 0.32      | 7     | 3.1   | 0.70      | 35    | 5.6   | 0.36      |
| Back injury                  | 33       | 8.1   | 0.38      | 4     | 1.8   | 0.41      | 37    | 5.9   | 0.38      |
| Meniscal                     | 22       | 5.4   | 0.25      | 5     | 2.2   | 0.51      | 27    | 4.3   | 0.28      |
| Fracture                     | 10       | 2.5   | 0.11      | 10    | 4.5   | 1.02      | 20    | 3.2   | 0.20      |
| Osteochondroses <sup>b</sup> | 5        | 1.2   | 0.05      | 1     | 0.4   | 0.10      | 6     | 0.9   | 0.06      |
| Chondral                     | 3        | 0.7   | 0.03      | 3     | 1.3   | 0.31      | 6     | 0.9   | 0.06      |
| Dislocation                  | 1        | 0.2   | 0.01      | 1     | 0.4   | 0.10      | 2     | 0.3   | 0.02      |
| Other overuse <sup>b</sup>   | 39       | 9.6   | 0.46      | 9     | 4.0   | 0.92      | 48    | 7.6   | 0.49      |
| Others                       | 15       | 3.7   | 0.17      | 4     | 1.8   | 0.41      | 19    | 3.0   | 0.19      |
| Total                        | 405      | 100.0 | 4.62      | 223   | 100.0 | 22.77     | 628   | 100.0 | 6.45      |

<sup>a</sup>Because some injuries were multiple injuries with more than 1 injury type, the total number of diagnoses exceeded the total number of injuries (N = 619).

<sup>b</sup>Classed as overuse injuries.

extremities (n = 516, 83.4%), with the majority affecting the ankle (157), followed by the thigh (128) and knee (104). Sixty-one percent of injuries to the lower extremities were to the dominant member, 38% were to the nondominant member, and around 1% of injuries were bilateral. Of the upper body injuries (n = 103), the majority occurred in the back region

(n = 47, 44.7%). Two head injuries were reported, accounting for 0.3% of total injuries. The knee was the most common region for serious injury in both competition and training.

The incidence of the different types of injury is given in Table 3. The most frequently diagnosed injuries were sprains, strains, and contusions. The most common injury



TABLE 4  
Incidence of Major Injuries According to Location  
and Diagnosis (Injuries/1000 h)

| Diagnosis and Location       | Total No. | Incidence |
|------------------------------|-----------|-----------|
| Sprain/rupture               | 26        | 0.27      |
| Anterior cruciate ligament   | 12        | 0.12      |
| Posterior cruciate ligament  | 1         | 0.01      |
| Medial collateral ligament   | 5         | 0.05      |
| Medial ankle ligament        | 8         | 0.08      |
| Meniscal lesion              | 9         | 0.09      |
| Lateral                      | 3         | 0.03      |
| Medial                       | 6         | 0.06      |
| Back pain                    | 8         | 0.08      |
| Lumbar/thoracic spine        | 6         | 0.06      |
| Spondylolisthesis            | 2         | 0.02      |
| Fracture                     | 7         | 0.07      |
| Wrist                        | 1         | 0.01      |
| Foot                         | 3         | 0.03      |
| Ankle                        | 3         | 0.03      |
| Muscle strains               | 6         | 0.06      |
| Hamstring                    | 2         | 0.02      |
| Psoas                        | 1         | 0.01      |
| Groin                        | 1         | 0.01      |
| Thigh                        | 2         | 0.02      |
| Stress fracture              | 4         | 0.04      |
| Tibia                        | 1         | 0.01      |
| Metatarsal                   | 2         | 0.02      |
| Femur                        | 1         | 0.01      |
| Tendinitis/bursitis          | 1         | 0.01      |
| Patella                      | 1         | 0.01      |
| Osteochondroses              | 2         | 0.02      |
| Iliac crest                  | 2         | 0.02      |
| Chondral lesion              | 2         | 0.02      |
| Avulsion fracture            | 2         | 0.02      |
| Ischial tuberosity           | 1         | 0.01      |
| Iliac crest                  | 1         | 0.01      |
| Ankle impingement syndrome   | 2         | 0.02      |
| Accessory navicular syndrome | 2         | 0.02      |
| Luxation                     | 1         | 0.01      |
| Acromioclavicular            | 1         | 0.01      |
| Saphenous vein reflux        | 1         | 0.01      |
| Glenoid labrum tear          | 1         | 0.01      |
| Glenohumeral instability     | 1         | 0.01      |
| Chronic venous insufficiency | 1         | 0.01      |
| Chondromalacia patellae      | 1         | 0.01      |
| Total                        | 77        | 0.79      |

sustained in match play was sprains, while strains were most frequently incurred during training. A total of 83 (13.4%) injuries were diagnosed as overuse, with the majority classed into the other overuse injury category. This category included a wide of range of entities such as ankle impingement syndrome, periostitis, spondylolisthesis, and anterior compartment syndrome. Sprains and fractures were the most frequent type of major injury in training and match play, respectively.

The highest incidence of traumatic injury concerned both the ankle and the thigh, while the ankle and the knee were the predominant locations for overuse injury. Traumatic injuries occurring during both match play and training were mainly located in the ankle. Of the total

injuries, 70.7% were sprains to the ankle and 25.7% to the knee. Muscle strains mostly involved the thigh (58.2%) and groin regions (31.1%). Two cases of concussion were reported, accounting for 0.3% of the total injuries. There were 12 ACL ruptures (7 to nondominant leg) sustained by 11 players, with 10 occurring during match play and 2 during training. These figures correspond to an incidence rate of 1.0 ACL rupture per 1000 match hours (95% CI, 0.4-1.6). The characteristics of injuries requiring a layoff period of over 1 month are reported in Table 4. Around a third of severe injuries were classed as sprains (32.1%) and around a tenth were diagnosed as meniscal lesions ( $n = 9$ , 11.6%) and back disorders ( $n = 8$ , 10.4%).

### Reinjuries

Of the total injuries reported, 27 (4.4%) were classified as reinjuries, corresponding to an incidence rate of 0.3 (95% CI, 0.22-0.38) for every 1000 hours of play. Most reinjuries were traumatic (81.5%), with sprains and strains making up 40.7% (90.9% affecting the ankle) and 22.2% (80.0% affecting the upper leg) of all reinjuries, respectively. Of the reinjuries, 29.6% resulted in a longer absence than did the initial injury.

### Injury and Player Position

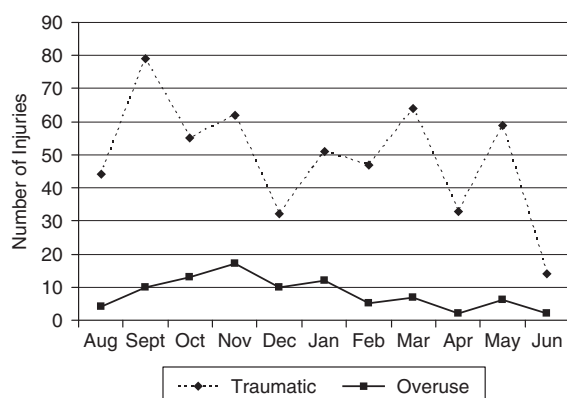
No significant differences were reported for injury incidence between playing positions ( $P = .531$ ). On average, per season, both goalkeepers and defenders sustained 1.8 injuries per player, compared with 1.5 for midfielders and 2.0 for forwards. Most goalkeeping injuries concerned the hand (21.4%) and in defenders the ankle (25.6%). Midfielders and attackers sustained the majority of their injuries to the knee (29.2% and 27.8%, respectively). Sprains were the most common injury type sustained across all positions.

### Seasonal Disposition and Injury

The highest proportion of injuries was found to occur in September (14.2%) and November (12.3%). September was the month in which the highest number of training ( $n = 59$ , 14.6%) and match ( $n = 29$ , 11.4%) injuries were experienced. The lowest number in an average month for total, training, and match injuries was during June. Figure 3 shows the total number of traumatic and overuse injuries across the season. Traumatic injuries peaked in September (79, 14.6%), whereas overuse injuries (17, 19.3%) peaked in November.

### DISCUSSION

The present investigation was carried out to examine the incidence and patterns of injury in young elite French female soccer players. Major findings were the high rates of injury in the youngest age group, traumatic injury, match injury, and injuries to the ankle (notably sprains) region. In contrast, low rates of reinjury and concussion were reported. The methodologies and definitions on soccer-related injury used in the present study closely followed those employed in previous epidemiologic investigations on female soccer players<sup>12,13,35,40</sup> or as recommended by 2 recent International



**Figure 3.** Seasonal distribution of traumatic and overuse injuries. (During each season, vacations meant that players were absent from training and competition in parts of October, December, January, February, and April and from mid-June to August.)

Consensus Group Statements.<sup>15,19</sup> This allowed for an accurate portrayal and comparison of the extent of the injury problem in the present population.

In the present study, 92.4% of the study population suffered from at least 1 injury during any 1 season. This figure is greater than those reported by Engström et al (80%)<sup>12</sup> and Faude et al (70%)<sup>13</sup> for elite adult female players and demonstrates, as in elite adult participants, that the present group of players are at high risk of sustaining injury. The results from the present study are also appreciably higher than those observed by Soderman et al. (41%) for Swedish adolescent players.<sup>40</sup> This discrepancy between investigations may have been due to the shorter observation period (6 months) employed in the Scandinavian study whereas our study covered the entire playing season (beginning of August to mid-June).

The overall rate of injury acquisition in the present investigation was 6.4 per 1000 hours of exposure, a finding within ranges previously reported for female soccer. Nevertheless, this result was higher than recently observed for elite American<sup>17</sup> (1.93) and Swedish adult players<sup>27</sup> (4.6), and lower than that previously reported for other elite senior American players (12.0).<sup>12</sup> This difference between studies may be explained by inconsistencies with respect to injury definitions and methodologies employed and differences in age and playing level. In addition, due to the working practices of the Center, exposure time in the present study was calculated per player on an estimate of 10 training hours and 1.5 match-hours/week. Therefore, approximation of player participation time could have led to over- or underestimation of injury rates.<sup>31</sup> Regional differences may also influence the results of epidemiologic investigations, as a recent prospective study on female soccer players provided evidence that regional factors play a role in determining injury rates and patterns.<sup>26</sup>

The incidence of training injury in our study was higher than that observed in recent studies on elite senior female players.<sup>13,17,27</sup> The younger elite players in the present report may still lack injury-avoidance skills in comparison with elite adult players or might have been undertaking too much intensive training at an early age.<sup>31</sup> The latter

possibility is unlikely because injury incidence during training was lower than that reported in other studies on adult amateur female<sup>26</sup> and elite adult female players.<sup>12</sup> The difference between results from our investigation and those of the former study may be due to a higher training-to-match ratio in our elite players, which is shown to lead to a reduction in overall injury rates.<sup>20</sup> The disparity with the older study by Engström et al<sup>12</sup> may be due to the general evolution of the sport. For example, better preventive measures, training methods, and player and coach education could have gradually lowered the risk of injury among female players. The current players regularly undertake prophylactic training based on validated and carefully designed scientific investigations that have been shown to reduce the risk of injury.<sup>16,24,29,33</sup> These improvements may be reasons for a reduction in injury rates reported over long observational periods for female tournaments.<sup>10,32</sup> However, the comparison between seasons of overall injury incidence per season in the present study shows that elite female soccer players in France run a similar risk of incurring injury today as they did 8 seasons ago. Hence, there is a need for further investigation on methods to reduce the incidence of injuries in the present population.

The incidence of match injury observed in the present investigation is similar to the high incidence rates reported in games in a recent study on elite adult female soccer players<sup>13</sup> and is also comparable with results on male professional players.<sup>20,21</sup> It was also markedly higher than the incidence of match injury found in elite youth male players<sup>30</sup> and in 2 further studies on elite female soccer.<sup>17,27</sup> This finding suggests that young elite female players are at high risk of injury during competition. It may be that this result is due to a wide variation in the ages of the present players competing together within the same cohort (ages range from 15 to 19 years of age). Playing regularly against older, more mature, and heavier opponents may lead to a higher incidence of injury in younger players.<sup>40</sup> This suggestion is supported by the significantly higher overall injury incidence observed in the under 15 age group compared with players belonging to the under 19 group. Similar results were obtained on a cohort of amateur female players in which injury rates were higher in the younger categories.<sup>11</sup> Injuries in the less experienced, younger players may be due to weaknesses in technical and tactical ability as well as in muscle strength, endurance, and coordination.<sup>36</sup>

The high number of traumatic injuries in female soccer players reflects the characteristics of the sport<sup>27</sup> and may be due to the rapid development of the game among female players and the pronounced athleticism of the players, leading to more aggressive behavior during play, increased tackling, and foul plays.<sup>13</sup> This trend may be reflected by the high rate of traumatic injuries incurred by the present players compared with a previous study on elite female participants.<sup>27</sup> The incidence of traumatic injury in competition was also much greater than that previously observed in subelite adolescent females.<sup>40</sup> As intensity of play is linked to increased chance of injury, the higher intensity of competition at elite levels may have led to an increased risk of injury.<sup>31</sup> One omission from the present study is the

cause (contact or noncontact) of injury in training and match play, especially as preventive strategies specific to soccer rely on having detailed information on the injury mechanisms involved.<sup>2</sup> The high rate of traumatic injury reported in the present players is an example where a closer look at injury mechanisms in both training and matches could be advocated.

The effect of an injury can be considered in relation to its severity and the number of competitive matches missed.<sup>21</sup> The classification of injury severity in the present study was identical to that previously employed in studies on female soccer players.<sup>12,13,35,40</sup> The results for injury severity observed in our investigation are similar to those reported for elite senior players<sup>12,13</sup> in that the majority of injuries resulted in an absence of fewer than 7 days. A greater rate of injuries of moderate severity, especially in match play compared with the present findings, was reported in adolescent Scandinavian females.<sup>40</sup> This contradiction in findings may be due to better medical treatment and rehabilitation measures at elite levels<sup>13</sup> allowing players to return more quickly to training and competition. The difference may also be due to the demand to return to competition soon after injury being higher at the elite end of the game.<sup>40</sup> The authors of the Scandinavian report also suggested that the substantial rate of more serious injury in their study may have been due to their particular cohort having a high game-to-training ratio; that is, they spent more time playing games and had reduced time for training. It is pertinent to note that players in the present study were injured for around 46 days per season, compared with 32 days per season for elite youth male players,<sup>30</sup> whereas the average number of injuries per player was similar. This result suggests that the effect of injury on elite player development time is greater among female players.

The various periods in the season have been linked to injury rate in elite soccer.<sup>12,13,17,20-22,31</sup> In this report, injuries across the season were compared as a total number of injuries for each month rather than as an incidence as employed in other studies on female players. The present players' exact exposure time for each month could not be calculated precisely and may have varied over the course of the season because the players belonged to different clubs and had differing seasonal calendars. Caution should therefore be made when comparing the seasonal disposition of injury with that reported in previous investigations. Nevertheless, in this study, the highest proportion of injuries was sustained in September (both for training and competition), the month following preseason training, a result that is identical to that previously reported for elite French youth male players.<sup>31</sup> In contrast to a report on professional adult female soccer players,<sup>17</sup> injury rates in our investigation were at their lowest in the final month of the season. The greater frequency of injuries at the end of the competitive season in the professional game may be due to an increase in play intensity and competitiveness for playoff or tournament positions, which may not be the case in younger elite groups. Competitive matches for the present players begin in September, and it is no coincidence that match injuries across the competitive season were highest in this month. It has been suggested that these results are due to players

not yet reaching the appropriate levels of fitness and therefore not in optimal physical and physiologic states to withstand the stresses associated with competitive soccer.<sup>22</sup> A special preseason conditioning program based on individual strengths and weaknesses has had a significant influence on lowering the incidence of injury in female soccer players<sup>23</sup> and may be an appropriate solution to reduce the high rate of injuries in the early part of the season among the present players.

Reinjury rates have been found to account for a high percentage of all documented injuries in senior elite Swedish players (28%),<sup>27</sup> senior amateur Swedish players (46%),<sup>26</sup> and Swedish youth players (41%),<sup>40</sup> respectively, suggesting inadequate rehabilitation and incomplete healing.<sup>25</sup> However, this discrepancy between results of our study and those on Swedish youth players should be interpreted with caution as, unlike in the present study, no information on the definition of reinjury employed was provided by the authors. Nevertheless, in the present report, the rate of reinjury was substantially lower at 4.4%, with most injuries being strains and sprains. It has been suggested that the presence of on-site medical care and evidence-based physical testing to establish if a player is ready to return to play are necessary to reduce the problem of reinjury.<sup>27</sup> The CNFE has a full-time, on-site medical support team to help in the management of injury and provide sport-specific rehabilitation of the player, and this presence might have contributed to the lower rate of reinjury observed in this study.

The majority of injuries in our study were located in the lower extremity, with the most frequent injury locations being the ankle, thigh, and knee. These results are roughly similar to the findings from studies on adult female players.<sup>12,17,26,27</sup> However, in our players, the ankle region was the most common location for injuries, corresponding to the findings of other investigations on female youth soccer players.<sup>4,40</sup> One explanation for the increased rate of ankle injury incurred in the present study compared with findings in adult females is the greater frequency of overuse injuries incurred by our players. Tendinitis and ankle impingement syndrome were common occurrences, the latter linked to repetitive microtrauma through recurrent ball impact<sup>42</sup> and, particularly in female youth soccer play, to technical errors when kicking the ball.<sup>30</sup>

The most common types of injuries sustained by the present players were sprains, strains, contusions, and overuse. Once again, these findings on injury diagnosis are in general accordance with the epidemiologic literature, suggesting a common feature of female soccer play. A greater frequency of contusions was observed in the present players compared with a group of lower-level Swedish youth female players.<sup>40</sup> This disparity may be linked to a greater intensity of play at elite levels leading to more contact between players. However, the overall rate of injuries linked to overuse was generally less than that reported for elite adult female players.<sup>12,27</sup> Reduced rates of overuse injury may be due in part to regular recovery periods within the annual calendar.<sup>13</sup> The current players have short breaks from soccer periodically, thereby providing recovery time and helping to reduce injury rates across the season.<sup>31</sup>



The most frequent injury diagnosis was sprains to the ankle, highlighting a need for the implementation and evaluation of preventative measures. External supports such as ankle braces or taping,<sup>41</sup> and balance<sup>33</sup> and coordination<sup>43</sup> training have been shown to be prophylactic strategies beneficial in reducing the risk of ankle sprains. Ligament laxity and mechanical and functional instability may predispose athletes to ankle sprains.<sup>3,25</sup> Inadequate rehabilitation has also been shown to be the cause of more than half of all ankle sprains being classed as reinjuries in a study on adolescent Swedish female players.<sup>40</sup> Our results disagree with this Swedish investigation in that although the majority of reinjuries in the present study were diagnosed as sprains to the ankle, only 5% of the total number of ankle sprains were classed as reinjuries. Again, this discrepancy between results should be interpreted with caution as the authors' definition of reinjury employed was unknown.

Anterior cruciate ligament injuries are season-ending injuries and are common in female soccer players.<sup>5</sup> In the present study, the rate of ACL injury during match play was twofold less than that reported for professional adult German players.<sup>13</sup> Our results on ACL injuries may be distorted as no ACL injuries were reported in the last 3 years of the study period. This period coincided with the introduction of an additional special prophylactic conditioning program based on proprioceptive-coordinative training,<sup>29</sup> lower-extremity landing skills,<sup>38</sup> plyometrics,<sup>25</sup> and restoration of muscle balance with isokinetic strength training.<sup>16</sup> Nevertheless, the overall risk of ACL injury in the current players is still broadly comparable with that observed in elite adult American female players<sup>17</sup> and confirms the importance in sports medicine practice for preventing ACL injury in adolescents.<sup>44</sup>

There has been recent concern about neuropsychologic injuries experienced by soccer players,<sup>37</sup> and the recognition and management of sports-related head injuries have become major issues in recent years.<sup>5</sup> A high rate of head injury in elite senior female players has previously been reported<sup>27</sup> and in a recent review of traumatic injuries in female soccer, the incidence of concussion in female players was mentioned to be 2.4 times greater than for male soccer players.<sup>5</sup> However, in accordance with data previously reported on elite youth male players,<sup>31</sup> head injuries in the present cohort accounted for a very small proportion of the total injuries. Furthermore, over the 8-year span of the present study, only 2 cases of concussion were reported, relating to an incidence of concussion of 0.02 per 1000 exposure hours. This result is lower than the concussion incidence of 0.06<sup>17</sup> and 0.96<sup>7</sup> per 1000 player hours previously reported in female soccer players. Therefore, from these results, it seems that concussive injury was not a problem in the current population of elite youth female soccer players and contradicts the suggestion that young soccer players are more at risk for concussions.<sup>8</sup> However, concussion may involve a graded set of clinical symptoms that may or may not involve loss of consciousness.<sup>2</sup> Some of the head injuries sustained by the players in the present study may have led to unrecognized concussive injury and incidence may have been underreported as injuries were

diagnosed and followed up after self-referral by the players. When prospectively examining concussion rates, research figures may vastly underestimate the number and rates of concussions because the diagnosis of a concussion is dependent on a player volunteering his or her symptoms to medical personnel.<sup>18</sup> This may not occur if the athlete is unaware that his or her symptoms are secondary to a concussion, or if the athlete is afraid to mention his or her symptoms to a trainer or physician, for fear of being prevented from returning to play.<sup>1</sup>

There is limited and conflicting information on the influence of playing position on injury incidence in elite female soccer players. Previous research has shown that professional female defenders sustained the most injuries,<sup>14</sup> whereas our results are in agreement (albeit nonsignificant) with those reported by Jacobsen and Tegner<sup>26</sup> for Swedish elite senior female players, who showed that forwards were injured more often than players in other positions. When injury location was examined according to position, upper body and hand injuries were common in goalkeepers, whereas injuries to the ankle and knee were frequent in outfield players. These results reflect the differences in the physical demands of the game between goalkeepers and outfield players and strengthen the case for injury prevention training to be specific to positional role.

## CONCLUSION

Results from the present study on elite youth female soccer players revealed markedly high rates for traumatic injury and for injury during match play when compared with previous investigations on female soccer players of different levels and ages. A high rate of injury was observed in the youngest players (under 15 years of age) compared with the oldest players (under 19). These findings could be cause for concern and merit further epidemiologic research to establish the intrinsic and extrinsic factors leading to these injuries. A predominant proportion of injuries (notably sprains) were to the ankle region, accentuating the need for future prospective intervention studies to evaluate injury prevention protocols. Positively, the occurrence of head injuries and concussion did not seem to be problematic within lower age groups of elite female players, and the low rate of injury recurrence is noteworthy.

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