Injury history as a risk factor for incident injury in youth soccer

K L Kucera, S W Marshall, D T Kirkendall, P M Marchak, W E Garrett Jr

Methods: A prospective cohort study of Classic League soccer players playing at the level under 12 through under 18. Injury history forms were mailed to all registering Classic League soccer players in the North Carolina Youth Soccer Association during 1997–2000 (n = 7000); 1483 (19%) returned the baseline questionnaire and were followed up for injuries.

Results: There were 5139 player-seasons of follow up and an estimated 171 957 athlete-exposures. More than half self reported an injury history (59.7%). Overall, the unadjusted incidence rate was 4.6 (95% confidence interval (CI) 4.3 to 4.9) incident injuries per 1000 athlete-exposures. Multivariate generalised Poisson regression modelling indicated that players with one previous injury had a twofold greater risk of incident injury (IRR = 2.6; 95% CI 2.0 to 3.3), and those with two or more previous injuries had a threefold greater risk of incident injury (IRR = 3.0; 95% CI 2.3 to 3.8) compared with athletes with no previous injuries.

Conclusions: Injury history was associated with an increased injury rate. This suggests that, even in these youth soccer players, those with an injury history may be at higher risk.

Soccer is the most popular sport worldwide for adults and youth, with over 200 national associations representing about 200 million active players, of whom 40 million are women. The Soccer Industry Council of America estimates that 18.2 million Americans, 13.8% of who were under 18 years of age, played organized soccer in 2000.

Previous injury and inadequate rehabilitation have been shown to be the most important intrinsic predictors for subsequent injury. Van Mechelen et al reported that previous injury, with an odds ratio of 9.41 (95% confidence interval 2.80 to 31.58), was one of the strongest independent predictors for sports injury. Powell et al, in a population based study, reported that in high school soccer 8.4% (148/1765) of injuries to boys and 10.4% (184/1771) of injuries to girls were reinjuries. Ekstrand and Tropp, in a one year prospective cohort study of male adults, found 2.3 times greater risk of injury for soccer players with a history of ankle problems. A recent study by Arnason et al found that adult male soccer players with a history of ankle or knee sprain were at an increased risk of subsequent sprain injury to the ankle (odds ratio (OR) = 5.3; 95% CI 1.5 to 19.4) or knee (OR = 4.6 95%; 95% CI 1.6 to 13.4).

Youth sports injuries in non-school sport settings are rarely attended by trained health professionals, and the reinjury risk may be increased in this population because of inadequate treatment and rehabilitation. The primary purpose of this study was to examine self reported injury history as a risk factor for incident injury in a group of young soccer players participating in the North Carolina Youth Soccer Association (NCYSA) Classic Soccer League. A secondary purpose was to determine if previous lower limb, ankle, and knee injury influence reinjury rate at these body locations. Lower limb, specifically the ankle and knee, are the body parts most often injured in youth soccer. No previous soccer studies have used multivariate regression techniques to describe the association between predictor variables and the rate of soccer injury.

METHODS

The NCYSA Classic Soccer League is one of the highest levels of team soccer competition in the state of North Carolina, second only to the Olympic Development Program. Classic League soccer comprises about 5000 boys and 2000 girls divided into seven levels of competition: under 12 (U12), under 13 (U13), under 14 (U14), under 15 (U15), under 16 (U16), under 17 (U17), and under 18 (U18). Divisions are based on birth year at the beginning of the season, but players sometimes play in higher levels at the league’s discretion. Girls and boys teams compete separately: level U12 to U14 boys and girls play fall (autumn) and spring seasons, level U15 to U18 boys play only the spring season, and level U15 to U18 girls play in the fall season. At the coaches’ discretion, teams generally play 14 games (two per weekend) and hold 20 (two a week) practices in a season. In game situations, coaches are required to play every player listed on the game roster, thus guaranteeing each player some game time.

A prospective cohort study was conducted to describe the association between self reported injury history and prospective incident injury. Fact sheets, consent forms, and injury history forms were included with NCYSA registration forms sent out to every player during 1997–2000. Players and their parents read about the study, signed the consent forms, and completed previous injury history information at the beginning of the season. In addition, detailed project descriptions were sent out to coaches and managers. Players who returned the consent forms were followed prospectively for incident injury from fall 1997 to spring 2000. This study was approved by the institutional review board of the Duke University Medical Center.

Incident injuries were reported by coaches by mail to NCYSA. Each week during the season, coaches filled out an

Abbreviations: CI, confidence interval; IR, injury incidence rate; IRR, injury incidence rate ratio; OR, odds ratio
The average number of practices and games lost was estimated to be 4.67 for ankle injuries, 6.98 for knee injuries, 5.67 for lower limb injuries, and 4.47 for all other injuries. For example, the athlete-exposures for a player in one season who had one injury (an ankle injury) in the season are calculated as follows:

Total athlete-exposures = (34 practices and games) − (4.67 × 1 ankle injury that season) = 29.33 athlete-exposures

Injury incidence rates (IR = the number of incident injuries/number of athlete-exposures per season) and incidence rate ratios (IRR = exposed IR/unexposed IR) were computed along with 95% confidence intervals (95% CI) using a generalised Poisson regression model. This model uses a log-link function and an over-dispersed Poisson model for residual variation, with the rate denominator (number of player-seasons at risk calculated above) included in the model as an offset term. In this study, there were repeated observations on the same players over time (multiple injuries per person over multiple seasons), creating statistical dependence (within subject correlation). To account for this, a Generalised Estimating Equation model was used. The IRs and IRRs were stratified by the covariates of interest. On the basis of the results of stratified analysis, a multivariate model was fitted.

Effect modification was examined by comparing stratum specific estimates. Confounding was assessed using the log confounding risk ratio:

\[ \text{lnConfIR} = \ln(\text{crude IRR/adjusted IRR}) \]

There were missing values for position, years of team experience, years of Classic League experience, and body mass index (BMI) in the data. In all, 15% of player-seasons...
were missing data on at least one of the above four variables. In pre-modelling analyses, there was very little difference in the strength of association for one injury versus no injury in the whole population versus the subgroup with complete information.

RESULTS

Descriptive statistics

A total of 1483 soccer players, on 212 Classic League teams, completed the baseline questionnaire; 37.4% were female and 62.6% were male. Mean (SD) age at baseline was 13 (1.9) years. Forty two percent of the population were 9–12 years old, 32% were 13–14 years old, 22% were 15–16 years old, and 4% were 17 years and older. The proportion of Classic League players who returned the baseline questionnaire was low—about 20%. Even though prospective injury data were collected on the entire Classic League population (including those who did not return the baseline questionnaire), we included in this analysis only the injury and baseline data from the 1483 who returned the baseline questionnaire, as the latter was the only source of data on retrospective injury history.

Playing position was evenly distributed across the cohort (27.2% defenders, 29.1% forwards, and 35.6% midfielders) except for goalkeepers (8.1%). Sixty percent of respondents reported a previous injury: 30.5% had one previous injury, 20.2% (300/1483) reported a history of ankle injuries, and 16.8% (249/1483) reported a history of knee injuries. During the course of follow up, 28.9% (429/1483) of players sustained incident injuries to the lower limb, 12.7% (189/1483) had incident ankle injuries, and 8.3% (123/1483) had incident knee injuries. Injuries to other body areas represented 13.1% (194/1483) of players at baseline and 11.7% (174/1483) of players during follow up.

During 1997–2000, 66.9% (605/905) of incident injuries were to the lower leg and 10.2% (92/905) were to the upper extremity. Of the lower leg injuries, 16.5% (149/905) were to the knee and 26.4% (239/905) were to the ankle. Of the injuries that had a type listed, the three most common types of injury during follow up were sprains at 35.9% (272/756), contusions at 28.8% (218/756), and fractures at 12.3% (93/756). Ankle sprains at 20.5% (155/756), knee sprains at 9.9% (75/756), and knee contusions 5.2% (39/756) were the three most common injury site by type combinations.

Injury incidence and unadjusted rate ratios

Table 1 shows IRs and IRRs for all categories of covariates for all participants. We observed 4.6 incident injuries per 1000 athlete-exposures (95% CI 4.3 to 4.9) overall during follow up for all participants.

There was a positive association between self reported injury history and incident injury in this population. Players with an injury history were injured at a rate 2.56 (95% CI 2.17 to 3.01) times higher than those without an injury history. Players with one previous injury had a 2.37 (95% CI 1.92 to 2.94) times higher rate of injury, and those with two or more previous injuries had a rate of injury 2.79 (95% CI 2.25 to 3.46) higher than those with no previous injury.

Without adjustment for other covariates, female players were injured at a higher rate than male players, and U15 to U18 players had a higher rate of injury than U12 to U14 players (table 1). The injury rate was roughly the same for all positions. The injury rates tended to fall with increasing soccer and Classic League experience. Increasing BMI was associated with an increased injury rate. We had few players (1.9%) who were overweight (BMI greater than or equal to 25) and therefore we were unable to examine the injury risk in this subgroup.

### Table 2

<table>
<thead>
<tr>
<th></th>
<th>One previous injury versus none</th>
<th>Two or more previous injuries versus none</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>IRR</strong></td>
<td><strong>95% CI; CLR</strong></td>
</tr>
<tr>
<td>Adjusted estimates stratified by playing level*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>U12–14</td>
<td>2.47</td>
<td>1.67 to 3.64; 2.18</td>
</tr>
<tr>
<td>U15–18</td>
<td>2.44</td>
<td>1.79 to 3.35; 1.87</td>
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<tr>
<td>Adjusted estimates stratified by playing level and position†</td>
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<td></td>
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<tr>
<td>Amid U12–14</td>
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<td></td>
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<tr>
<td>Defenders</td>
<td>1.28</td>
<td>0.71 to 2.28; 3.20</td>
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<tr>
<td>Goalkeepers</td>
<td>1.84</td>
<td>0.91 to 3.76; 4.15</td>
</tr>
<tr>
<td>Forwards</td>
<td>4.02</td>
<td>2.49 to 6.52; 2.62</td>
</tr>
<tr>
<td>Midfielders</td>
<td>3.04</td>
<td>1.92 to 4.81; 2.50</td>
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<tr>
<td>Amid U15–18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defenders</td>
<td>1.37</td>
<td>0.89 to 2.10; 2.36</td>
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<tr>
<td>Goalkeepers</td>
<td>1.97</td>
<td>0.97 to 4.02; 4.16</td>
</tr>
<tr>
<td>Forwards</td>
<td>4.31</td>
<td>2.62 to 7.08; 2.71</td>
</tr>
<tr>
<td>Midfielders</td>
<td>3.25</td>
<td>1.96 to 5.39; 2.75</td>
</tr>
</tbody>
</table>

IRR, Incidence rate ratio; CLR, confidence limit ratio (upper confidence limit divided by lower confidence limit*).

*Generalised Poisson regression model stratified by playing level and adjusted for sex, playing position, years of playing experience, years of Classic League soccer experience, and body mass index.

†Generalised Poisson regression model stratified by playing position and playing level adjusted for sex, years playing experience, years of Classic League soccer experience, and body mass index.
Adjusted rate ratios
There was very little modification by playing position and level (table 2). In addition, none of the covariates studied (years of team experience, years of Classic League experience, sex, BMI, playing position, and level) showed any major confounding of the previous injury-incident injury association (table 1). Multivariate analysis indicated no difference in the rate of injury between male and female players when adjustment was made for other covariates and likewise for player position and BMI.

Subgroup analyses
To explore further the reinjury effect, we conducted subgroup analyses at three anatomical sites: knee, ankle, and lower limb. Because of small cell sizes, few covariates could be included in these models. In general, the association between previous injury and incident injury was even stronger when restricted to specific anatomical sites (table 3).

Sensitivity analyses
This study relied on coach report of incident injuries, and our finding of a positive association could be due to bias if coaches tended to under-report injuries in subjects with a positive injury history. A simple deterministic sensitivity analysis performed to explore the potential for bias from under-reporting of incident injury between the exposed and unexposed. Assuming 100% outcome specificity for under-reporting of incident injury between the exposed and unexposed, and 90–60% outcome sensitivity for under-reporting of incident injury between the unexposed group—that is, 15% return versus 25% return—the corrected IRRs for one previous injury versus none and for two or more previous injuries versus none were 4.19 (95% CI 2.97 to 5.92; 1.99) and 1.96 (95% CI 1.52 to 2.49), respectively.

Injury data on players who consented to participate but did not return baseline questionnaires could not be included in our analysis, as we had no data on injury history if the baseline questionnaire was not returned. This group was a large proportion of all the players (about 80%). We conducted a second sensitivity analysis to explore the potential for selection bias due to the low number of players who filled out the form. As long as the difference in the return rates between injury incident positive and injury incident negative subjects was no more than 10% in the injury history positive group—that is, 15% return versus 25% return—the corrected rate ratio for both associations were in the region of 1.5, indicating a smaller but still elevated effect of injury history on incidence of injury.

DISCUSSION
This analysis estimated an injury rate 2.6 times higher in athletes with at least one previous injury compared with athletes without any previous reported injury. The knee was at a nearly sixfold increased risk for one previous knee injury versus none, and the ankle was at a fourfold greater risk if the athlete had a previous ankle injury. Increasing years of soccer experience indicated a protective association in this study and may suggest a survival effect where uninjured players are more likely to continue playing soccer. These findings are consistent with the nature of youth soccer where kicking, planting, sprinting, jumping, and cutting are performed on undulating natural grassy terrain, which can be highly stressful for the foot and ankle structures.

Previous youth soccer studies report frequencies and incidence of injury, rather than rate ratios as we have in this study, and use a variety of injury definitions. Price et al20 in a two year prospective study of male youth academy soccer players aged 9–19 found that only 3% of reported injuries were reinjuries. However, they did not include injuries before their study and used an injury definition of more than 48 hours of lost time. Soderman et al21 followed 153 female youth soccer players for one season and found that 41% of traumatic injuries were re-injuries. Previous injuries were gathered retrospectively and injuries were recorded if they resulted in absence from one practice or game. One recent study of adult male soccer players examined risk factors in a multivariate model. Arnason et al22 reported previous injury as a risk factor for subsequent ankle and knee injury (OR = 5.3 (95% CI 1.5 to 19.4) and OR = 4.6 (95% CI 1.6 to 13.4)). Findings from this study of adult soccer players are in general agreement with the results from our study of youth players. The strong association observed between previous injury and incident injury in this young cohort suggests that more effective mechanisms for providing health services to these young athletes need to be explored, as treatment and rehabilitation of the original injury may be inadequate.

There is a potential for selection bias due to the low return rate of the baseline injury form. History forms were returned separately from the registration and consent form, and therefore players may have been less inclined to return them. There is no particular reason to think that the return rate would be differential with respect to exposure status, and sensitivity analysis indicated that our findings are reasonably robust to mild selection bias. We were unable to determine if coaches reliably reported all injuries. Previous studies recommend on-site reporting of injury information in prospective studies, as recall of details decreases over time.27 28 However, a well established result in epidemiology is that under-reporting only biases the rate ratio estimates when recall is different with respect to exposure status. In the case of differential under-reporting, it would lead to bias in our results if the under-reporting were related to the athlete’s exposure status. A simple sensitivity analysis indicated that our findings are robust to mild under-reporting bias.

The strength and uniqueness of this study is that it is a three year prospective follow up of a large number of youth soccer players. This study included the younger age groups: 9–13 years. There have been few studies that included players of this age. Finally, multivariate analysis techniques were used to determine the relation between outcome and exposure while controlling for covariates.

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Table 3  Incidence rate ratios for subgroup analyses by anatomical site for risk of incident injury in North Carolina Youth Soccer Association Classic League soccer players fall (autumn) 1997 to spring 2000 (n = 4453 athlete-seasons)

<table>
<thead>
<tr>
<th>Anatomical Site</th>
<th>One previous injury at that site versus none</th>
<th>Two or more previous injuries at that site versus none</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IRR  95% CI; CLR</td>
<td>IRR  95% CI; CLR</td>
</tr>
<tr>
<td>Ankle*</td>
<td>4.19 2.97 to 5.92; 1.99</td>
<td>8.16 4.89 to 13.61; 2.78</td>
</tr>
<tr>
<td>Knee</td>
<td>5.84 4.04 to 8.44; 2.09</td>
<td>3.96 1.96 to 7.99; 4.08</td>
</tr>
<tr>
<td>Lower limb†</td>
<td>2.79 2.18 to 3.58; 1.60</td>
<td>3.67 2.81 to 4.78; 1.70</td>
</tr>
</tbody>
</table>

| IRR, incidence rate ratio; CLR, confidence limit ratio (upper confidence limit divided by lower confidence limit†).  |
| *Generalised Poisson regression model for ankle injuries adjusted for player level. |
| †Generalised Poisson regression model for knee and lower limb injuries; no covariate adjustment. |

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Adapted from: Injury history and incident injury in youth soccer. BJSM. 2002; 36:459-466.
A history of injury has been shown to be an important risk factor for future injury in soccer. Knee and ankle are commonly injured body sites in soccer. Players competing in higher levels are injured more often than those in lower levels.

In this study of youth soccer players, almost 60% reported a previous history of injury. Previous injury status was a strong predictor of incident injury. There was limited modification by playing position and level. For specific anatomical areas such as ankle, knee, and lower limb, the effect of previous injury on incident injury was stronger overall when compared with results from all previous injuries.

ACKNOWLEDGEMENTS
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REFERENCES
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