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original research

Injuries and Associated Risk Factors Among Adolescent Elite Orienteerers: A 26-Week Prospective Registration Study

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Context: In orienteering, the number of injury-registration studies is limited. Most researchers have used a cross-sectional design during specific events and, therefore, have mainly identified acute injuries.

Objective: To determine the prevalence of injuries by registering acute and overuse injuries in adolescent elite orienteerers over 26 weeks and to study the variation of injury prevalence over the season and the potential risk factors.

Design: Cohort study.

Setting: Two high schools in Sweden with national orienteering teams.

Patients or Other Participants: All athletes (33 adolescent girls, 31 adolescent boys; age = 17 ± 1 years) from 2 high schools with orienteering teams.

Main Outcome Measure(s): We used a weekly Web-based questionnaire to identify the incidence and prevalence of injuries and training variables. Risk factors for injury were calculated using multiple linear regression techniques.

Results: The average weekly prevalence of overuse and acute injuries was 35.7% (95% confidence interval = 34.8%, 36.6%) and 1.7% (95% confidence interval = 1.3%, 2.1%), respectively; overuse injuries (78.0%, n = 85) accounted for the majority. The incidence of acute and overuse injuries was highest for the foot/lower leg (48.6%, n = 53), and 71.6% (n = 78) of all injuries affected the foot/lower leg and knee area. Time to the first reported injury was associated with training volume (β = 0.184, P = .001), competition time (β = –0.701, P = .009), running on asphalt roads (β = –0.348, P = .008), and running on forest surfaces and trails (β = –0.331, P = .007), with a model fit of r^2 = 0.50 (intercept = 2.196, $P < .001$). During the study, we observed a weekly increase (0.3%) in the prevalence of overuse injuries in the foot/lower leg (r^2 = 0.33, P = .001); the highest prevalence (26.9%) was at the beginning of the competitive season.

Conclusions: Overuse injuries, predominately in the foot/lower leg area, were more common than acute injuries in adolescent elite orienteerers. These injuries had the highest prevalence at the beginning of the competitive season; therefore, this period can be seen as a possible risk factor for sustaining overuse injuries in the foot/lower leg.

Key Words: athletes, runners, severity score, training load

Key Points

- Overuse injuries were more common than acute injuries in adolescent elite orienteerers.
- Overuse injuries most often affected the foot/lower leg area, with the highest prevalence occurring at the beginning of the competitive season.
- Training volume, competition time, running on asphalt roads, and running on forest surfaces and trails were associated with time to the first reported injury.
- Researchers should focus on establishing injury mechanisms affecting the foot, lower leg, and knee in adolescent elite orienteerers.

In orienteering, athletes must navigate to specific control points through unknown terrain.[1] While running through tough terrain and making route choices at the same time, both physical and cognitive skills are required to complete the course as quickly as possible.[2] The competitive season usually starts in April and ends in October and includes such competitions as the World Orienteering Championship and Orienteering World Cup.[2] The aerobic fitness of elite orienteerers is similar to that of elite athletes in other endurance sports because of a large amount of aerobic training.[2,3] However, compared with long-distance running, a higher proportion of orienteering training takes place on rough ground and forest trails, which likely affects the injury profile.

Prospective injury-registration studies in orienteering are sparse and have not been presented recently in the scientific literature. Instead, most studies[2–7] have been conducted at competition events and have cross-sectional designs. In 1990, Ekstrand et al[4] registered injuries during a 5-day competition and identified an incidence rate of 7.3 injuries per 1000 competition hours. Of all injuries, 23.9% were ankle sprains. Later, Linko et al[1] reported an overall injury incidence rate of 2.5% during a 1-day competition; most injuries occurred to the lower extremities (70%), and ankle sprains represented 25% of all injuries. Folan,[5] Hintermann

and Hintermann,[6] and McLean[7] registered injuries during 2-, 6-, and 6-day events, respectively, and noted the injury incidences were 1.4 to 5.3 per 100 orienteerers. Most injuries were wounds, mild cuts, and ankle sprains. In all of these studies, the researchers identified mainly acute injuries; overuse injuries have received little attention recently. In addition, these reports have predominantly involved adult athletes. Therefore, the injury rate for adolescent elite orienteerers is unknown.

In 1 identified prospective registration study, Linde[8] followed 42 orienteerers over 1 year. A total of 73 injuries (average = 1.7 injuries per orienteerer per year) were reported; 52% of these injuries were acute, and 48% were overuse injuries. All overuse injuries were located in the lower extremities: diagnoses were medial shin pain, Achilles peritendinitis, peroneal tenosynovitis, and iliotibial band friction syndrome. Acute injuries most frequently occurred during the competitive season, whereas overuse injuries occurred most often during continuous training periods. Risk factors for injuries were not presented.

Overuse injuries, defined as injuries not caused by a specific identifiable event, are common in athletes whose sports involve high training loads and repetitive work.[9] Clarsen et al[10] reported recently that previous methods for injury registration in sports have underestimated the prevalence of overuse injuries. By defining *overuse injuries* as all injuries that are not associated with a specific, identifiable injury event resulting in pain and having consequences for athletes' participation and sporting performance, Clarsen et al[10] identified 10 times as many overuse injuries as standard methods for registration. This questionnaire, the Oslo Sports Trauma Research Centre (OSTRC) Overuse Injury Questionnaire, was recently validated[10] and translated into Swedish.[11] Given that the focus in previous reports on orienteering has been on acute injuries, we hypothesized that by using the OSTRC Overuse Injury Questionnaire, a more valid description of injury data for orienteerers could be presented. Therefore, the primary purpose of our study was to determine the prevalence of injuries in adolescent elite orienteerers by registering acute and overuse injuries over 26 weeks. The secondary purpose was to study the variation in injury prevalence over the season and the potential risk factors for injuries.

METHODS

Participants

All available athletes (n = 72) at the 2 high schools in Sweden with national orienteering teams were invited to participate. Eight athletes declined to be involved, resulting in 64 participants (33 adolescent girls, 31 adolescent boys; age = 17 ± 1 years, experience in orienteering = 10.0 ± 3.8 years) from school 1 (n = 39) and school 2 (n = 25) competing at the Swedish national level for their age group. We collected e-mail addresses and background information from the athletes. The study was approved by the Regional Ethical Committee in Stockholm, Sweden (No: 2011/749-31/3). All participants provided written informed consent; the Committee waived the need for parental consent in athletes older than 15 years who understood the aim of the study and their involvement.

Instrument

Questionnaire. We used the translated version[11] of the OSTRC Overuse Injury Questionnaire[10] for self-reported injury registration. Questions concerning acute injuries, training volume, running volume, and running intensity were also included. Running intensity was rated according to the Borg Rating of Perceived Exertion scale,[12] in which *high intensity* is defined as a score of 17 to 20; *moderate intensity*, 13 to 16; and *low intensity*, 6 to 12. Operational definitions are presented in Table 1.

Development of the Questionnaire to Orienteering. We contacted 2 coaches at the 2 high schools in Sweden with national orienteering teams. These coaches chose 2 athletes (1 boy and 1 girl) at each high school and formed an expert group to discuss the content of the questionnaire. The expert groups agreed on adding a cluster of questions about the hip and 1 question about other reasons for not training. The research administrators (P.v.R., A.F.) then visited the 2 schools to introduce the revised questionnaire and to discuss its content. Based on the group discussions, questions concerning the number of days with a specific injury, recurrent injury, and running surfaces (forest surfaces and trails, asphalt roads, snowy surfaces) were included. Next, the athletes (n = 72) pretested the questionnaire 3 weeks before the start of the study. Data from these weeks were not included in the analyses.

The final version of the questionnaire contained 25 questions, including multiple-choice and open-answer questions, and provided operational definitions and examples of injury (see Supplemental Appendix, available online at http://dx.doi.org/10.4085/1062-6050-51.5.01.S1). Similar to Clarsen et al,[10] we included 4 questions about injuries to the foot/lower leg, knee, hip, and lower back and their effects on participation, training volume, pain, and performance in orienteering. The anatomical areas were chosen based on comments from the expert groups and previous injury reports in orienteering.[2,13]

If an athlete had sustained an injury or experienced pain in any anatomical area that affected participation and performance, he or she was directed to 2 additional questions per injury location (foot/lower leg, knee, hip, lower back). These questions addressed whether the injury was new or recurrent and the approximate number of days the athlete had been affected by that injury during the past week. If an athlete reported that an acute injury had occurred the previous week, the injury was diagnosed during a telephone interview and categorized according to an injury form (see Supplemental Appendix).

Data Collection

We used a Web-based self-reporting injury registration (version 9.9; Questback AS, Oslo, Norway). The questionnaire was e-mailed to the orienteerers once each week for 26 weeks. If no response was registered, a reminder was sent 4 days later. The 26 weeks were divided into 3 periods based on the recommendations of the expert groups. *Period 1* was defined as the time from the end of the season to the beginning of base training (from the end of October to the end of December, or 9 weeks); *period 2*, as base training (from the beginning of January to the beginning of March, or 9 weeks); and *period 3*, as the competitive season (from the beginning of March to the end of April, or 8 weeks).

Table 1. Operational Definitions

Overuse injury	Injury or presence of pain not induced by a sudden event, resulting in reduced training volume, experience of pain, difficulties participating, or reduced performance in orienteering.
Acute injury	Injury that refers to a sudden event, such as a sprain, fall, or tackle.
Recurrent injury	An injury reported by the athlete within the previous 3 weeks.
Substantial injury	An injury leading to moderate or severe reductions in training volume, moderate or severe reduction in performance, or complete inability to participate in orienteering.
Training volume	All performance-based training, including competitions.
Running volume	All orienteering or running training, including competitions in orienteering or running.
Illness	A health problem other than in the musculoskeletal system, such as a cold or influenza, that affected participation, performance in orienteering, or experiences of pain that reduced training volume.

Data Analysis

The proportions of injuries in different anatomical areas and of injured athletes in the entire cohort were determined. The average weekly response rate; number of competitions; number of days injured; number of hours per week per individual of competition time, training volume, and running volume; and proportion (%) of running on different surfaces (forest surfaces and trails, asphalt roads, snowy surfaces) and at different intensities were calculated with 95% confidence intervals (CIs). Prevalence of injuries or illnesses was calculated by dividing the number of athletes reporting the injuries or illnesses by the number of respondents for each week. We determined the average weekly prevalence of injuries and illnesses for the 26 weeks. The incidence rate of injuries was estimated by summing all new injuries per 1000 hours of training. We analyzed the distribution of injuries for adolescent boys and girls using the χ^2 test, with the α level set at .05. For each anatomical area (foot/lower leg, knee, hip, lower back), we determined the injury incidence by dividing the number of new injuries in an anatomical area by the total number of new injuries. For all anatomical areas, a severity score (0 to 100) was calculated by allocating a numerical value from 0 to 25 to the 4 questions for each anatomical area. We summed the 4 questions and calculated an average severity score for each area, with 0 representing *no injury* and 100 representing *highest level of severity*. (Consult Clarsen et al[10] for additional information.)

We used linear regression analysis to analyze the variations in injury prevalence over time (weeks 1–26). Classic multiple linear regression techniques were performed to analyze risk factors associated with injury; the response variable was the logarithm of time to first injury, and the independent variables consisted of training volume, running volume, competition time, running intensity (high, moderate, low), and running surface (forest surfaces and trails, asphalt roads, snowy surfaces). We used a logarithmic response variable because its variance was more stable over time than the untransformed version. Variable selection was carried out by studying the squared multiple correlation coefficient. The α level was set at .05. We chose the model with the highest correlation. The clinical value of the model was studied by increasing 1 variable at a time with 1 hour of exposure.

All data were compiled and analyzed in SAS (version 9.3; SAS Institute, Cary, NC), and all tables and figures were created in Excel (version 2013; Microsoft Corporation, Redmond, WA).

RESULTS

Response Rate and Overall Data on Overuse and Acute Injuries and Illnesses

The average weekly response rate was 77.8% (95% CI = 75.5%, 80.5%). A total of 109 new and recurrent injuries were identified during the 26-week study period, constituting an injury incidence rate of 18 injuries per 1000 hours of training. The proportions of injuries in adolescent girls and boys were 56.0% and 44.0%, respectively. Most injuries were overuse injuries (78.0%, n = 85) versus acute injuries (22.0%, n = 24). The average weekly prevalences of overuse and acute injuries were 35.7% (95% CI = 34.8%, 36.6%) and 1.7% (95% CI = 1.3%, 2.1%), respectively (Table 2; Figure 1). The average weekly prevalence of substantial injuries was 18.4% (95% CI = 17.7%, 19.2%). Of the entire cohort, 76.6% (n = 49) reported overuse injuries, 54.7% (n = 35) reported substantial injuries, and 31.3% (n = 20) reported acute injuries over the 26 weeks. Illness was the second most common reason for not training

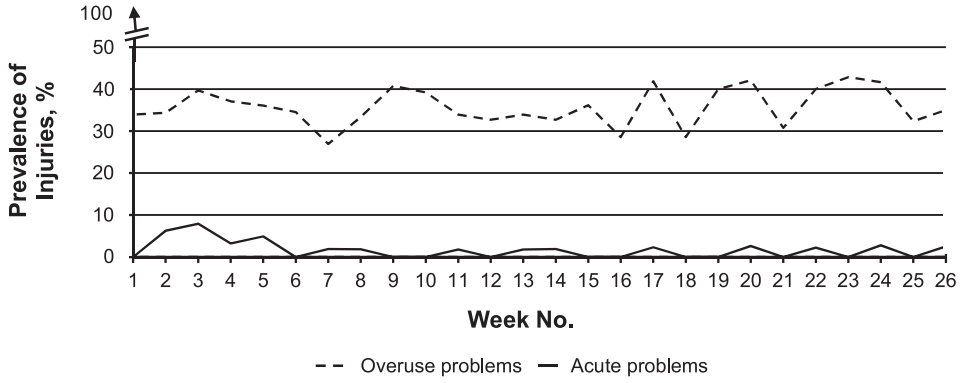

Figure 1. Weekly prevalence of acute and overuse injuries during the 26-week study.

Table 2. Number of Identified Injuries; Injured Orienteerers Over 26 Weeks; Prevalence of Overuse, Substantial, and Acute Injuries; Severity Score; and Days Per Week That Acute or Overuse Injuries Affected Participation in Orienteering

	Injured Area					
Variable	Foot/Lower Leg	Knee	Hip	Lower Back	Other Anatomical Areas	Total
Overuse injuries, n (boys/girls)	41 (14/27)	19 (13/6)	10 (2/8)	7 (2/5)	8 (6/2)	85 (37/48)
Acute injuries, n (boys/girls)	12 (4/8)	6 (4/2)	3 (3/0)	No data recorded	3 (0/3)	24 (11/13)
Injured orienteerers, %						
Boys	45.1	35.4	16.1	6.5	16.1	80.6
Girls	75.8[a]	27.2	15.2	15.2	12.1	75.8
	(95% Confidence Interval)					
Average weekly prevalence of overuse injuries, %	22.2 (21.4, 23.0)	10 (9.3, 10.7)	5.4 (4.9, 5.9)	1.6 (1.2, 2.0)	0.5 (0.3, 0.7)	35.7 (34.8, 36.6)
Average weekly prevalence of substantial injuries, %	10.8 (10.3, 11.3)	4.4 (4.1, 4.7)	3.3 (3.1, 3.5)	0.2 (0.0, 0.4)	No data collected	18.4 (17.7, 19.2)
Average weekly prevalence of acute injuries, %	0.9 (0.5, 1.3)	0.4 (0.0, 0.8)	0.2 (0.0, 0.4)	No data recorded	0.2 (0.0, 0.4)	1.7 (1.3, 2.1)
Average severity score	38.6 (37.3, 39.9)	39.2 (37.2, 41.2)	41.8 (39.0, 44.6)	10.2 (7.6, 12.8)	No data collected	37.4 (36.1, 38.7)
Average days per week overuse injuries affected participation in orienteering	4.0 (3.7, 4.3)	2.6 (2.3, 2.9)	4.3 (3.8, 4.8)	2.9 (2.4, 3.4)	No data collected	3.5 (3.3, 3.7)
Average days per week acute injuries affected participation in orienteering	5.2 (4.4, 6.0)	3.3 (2.8, 3.8)	1.5 (1.3, 1.7)	No data recorded	2.5 (2.3, 2.7)	4.6 (4.1, 5.1)

[a] Indicates sex difference for injured orienteerers ($\chi^2 = 6.286$, $P = .01$).

or competing. The average weekly prevalence of illness was 20.3% (95% CI = 19.0%, 21.6%).

Injury Locations

The incidences of all injuries (acute and overuse) were 48.6% (n = 53) for the foot/lower leg, 22.9% (n = 25) for the knee, 11.9% (n = 13) for the hip, and 6.4% (n = 7) for the lower back (Table 2). Other anatomical areas accounted for the remaining 10.1%: the shoulder (1.8%, n = 2), cervical spine (1.8%, n = 2), head and face (1.8%, n = 2), elbow (1.8%, n = 2), thoracic spine (0.9%, n = 1), upper limb (0.9%, n = 1), and hand (0.9%, n = 1). A higher distribution of foot/lower leg injuries was observed in adolescent girls (75.8%; 25 of 33) versus boys (45.2%; 14 of 31; $\chi^2 = 6.286$, $P = .01$; Table 2). Injuries in the foot/lower leg were more common among adolescent girls (n = 35) than boys (n = 18), whereas injuries in the knee were more common among adolescent boys (n = 17) than girls (n = 8). The average weekly prevalence of overuse injuries was highest for the foot/lower leg (22.2%; 95% CI = 21.4%, 23.0%). Detailed information about other anatomical areas is provided in Table 2.

Occurrence and Consequences of Acute Injuries

Of all acute injuries (n = 24), 50.0% (n = 12) occurred during orienteering competition or training, whereas 33.3% (n = 8) occurred due to falling or physical contact between players during alternative training, such as floor ball or field hockey. The remaining acute injuries (16.7%, n = 4) occurred during activities of daily living. Of all acute injuries, 58.3% (n = 14) resulted in an absence from orienteering participation for 3 days or less and 12.5% (n = 3), for 3 weeks or longer. The longest absence from orienteering participation due to an acute injury was 45 days.

Severity Score and Number of Days Per Week Injured

The highest average severity score was found in the hip (41.8; 95% CI = 39.0, 44.6), followed by the knee (39.2; 95% CI = 37.2, 41.2), foot/lower leg (38.6; 95% CI = 37.3, 39.9), and lower back (10.2; 95% CI = 7.6, 12.8). Among all areas, the 4 highest scores were related to the hip: 61, 76, 61, and 68 at weeks 1, 4, 8, and 14, respectively. The average number of days per week per anatomical area affecting participation in orienteering is presented in Table 2.

Reported Injuries in Periods 1 to 3 and Associated Risk Factors

A weekly increase (0.3%) in the prevalence of foot/lower leg overuse injuries was observed during the 26 weeks ($r^2 = 0.33$, $P = .001$). No increase in overuse injuries over periods 1 to 3 was registered for the knee, hip, or lower back (Figure 2). During periods 1 to 3, the prevalences of foot/lower leg injuries were 20.7%, 19.6%, and 26.9%, respectively. Time to the first reported injury (12 ± 10 weeks) was associated with training volume ($\beta = 0.184$, $P = .001$), competition time ($\beta = -0.701$, $P = .009$), running on an asphalt road ($\beta = -0.348$, $P = .008$), and running on forest surfaces and trails ($\beta = -0.331$, $P = .007$), with a model fit of $r^2 = 0.50$ (intercept = 2.196, $P < .001$). For any given values of competition time, running on an asphalt road, and running on forest surfaces and trails, an increase of 1 hour of training volume delayed the time to first reported injury by 20.0%. Reductions in time to first injury of 50.4%, 29.4%, and 28.2% corresponded with an increase

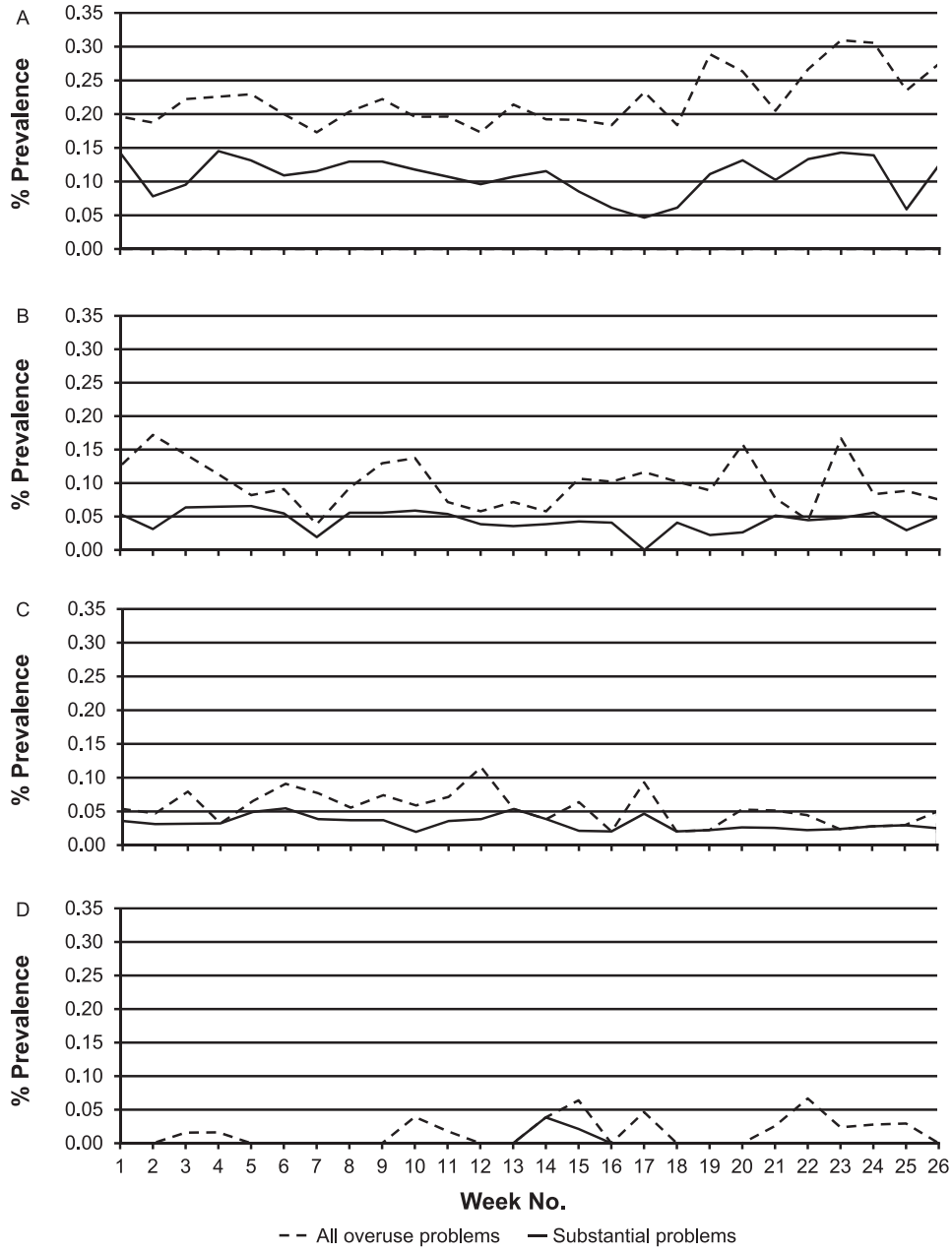

Figure 2. Weekly prevalence of all overuse and substantial injuries in the A, Foot/lower leg, B, Knee, C, Hip, and, D, Lower back over 26 weeks.

of 1 hour of competition time, running on asphalt roads, and running on forest surfaces and trails, respectively. Data about training volume, participation in competitions, running surfaces, and training intensity in periods 1 to 3 are presented in Table 3.

DISCUSSION

Our main finding was that overuse injuries were more common than acute injuries (78.0% versus 22.0%) among adolescent elite orienteerers. The injury incidence was highest for the foot/lower leg (48.6%), and 71.6% of all injuries were located in the foot/lower leg together with the knee area. Training volume, competition time, running on asphalt roads, and running on forest surfaces and trails were associated with the time to the first reported injury.

Researchers[5–7,13,14] have reported that acute injuries are the most common injury type in orienteering. In the only identified prospective injury-registration study in orienteering,[8] 48% of all injuries were overuse injuries, compared with 78.0% in our study. The diverse results could be explained by different characteristics of the athletes, small sample sizes, the diversity in the definition used for *injury*, the risk of recall bias, or the study design. The change from identifying time-loss injuries to identifying injuries resulting in pain or consequences for participation and sporting performance[9] has led to a new perspective on overuse injuries, in which a more valid number of injuries is likely to be captured. This could explain the different proportions of acute or overuse injuries among previous and recent reports. Still, given the different definitions of *injury*, comparing our results with those of previous orienteering

Table 3. Number (95% Confidence Interval) of Completed Competitions, Competition Time, Training Volume, Running Volume, and Distribution of Running Intensity and Running Surfaces (%) for All Weeks (1–26), Weeks 1–9, Weeks 10–18, and Weeks 19–26

	Weeks			
Variable	1–26	1–9	10–18	19–26
Average no. of competitions per week	0.4 (0.3, 0.5)	0.2 (0.1, 0.3)	0.2 (0.18 0.22)	0.8 (0.6, 1.0)
Average competition time, h/individual/wk	0.4 (0.3, 0.5)	0.3 (0.2, 0.4)	0.2 (0.17, 0.23)	0.7 (0.5, 0.9)
Average training volume, h/individual/wk	6.8 (6.6, 7.0)	6.7 (6.2, 7.2)	7.1 (6.9, 7.3)	6.7 (6.3, 7.1)
Average running volume, h/individual/wk	3.8 (3.7, 3.9)	3.3 (3.2, 3.4)	3.8 (3.6, 4.0)	4.2 (4.0, 4.4)
High-intensity running, %	20.9 (20.1, 21.7)	20.0 (18.8, 21.2)	18.9 (18.3, 19.5)	24.3 (22.8, 25.8)
Moderate-intensity running, %	36.3 (35.6, 37.0)	37.5 (36.4, 38.6)	36.0 (35.0, 37.0)	35.3 (34.1, 36.5)
Low-intensity running, %	42.8 (41.8, 43.8)	42.5 (40.6, 44.4)	45.1 (43.9, 46.3)	40.4 (38.9, 41.9)
Forest surfaces and trails, %	40.7 (37.3, 44.1)	42.6 (35.7, 49.5)	27.0 (24.0, 30.0)	51.7 (41.7, 55.7)
Asphalt roads, %	39.5 (37.9, 41.1)	39.0 (36.4, 41.6)	43.9 (41.7, 46.1)	35.8 (33.1, 38.5)
Snowy surfaces, %	19.8 (16.7, 22.9)	18.4 (11.3, 25.5)	29.1 (26.2, 32.0)	12.4 (9.8, 15.0)

reports may be inappropriate. For example, we expected to capture a far greater number of injuries using the OSTRC Overuse Injury Questionnaire than using a time-loss–injury approach because many athletes continue to train and compete despite being injured.[9,15] However, our results are in accordance with those of Andersen et al,[16] Clarsen et al,[10,17] Jacobsson et al,[18] and Ristolainen et al,[19] demonstrating that overuse injuries are more common than acute injuries in several sports.

Based on measures such as prevalence, substantial injuries, severity score, and days per week injured, we observed that the foot/lower leg was the most commonly injured anatomical area in adolescent elite orienteerers. In contrast to injuries in other anatomical areas, the foot/lower leg injuries showed an increase in prevalence, with the highest prevalence during the competitive season. The prevalences of foot/lower leg injuries were almost the same in periods 1 (20.7%) and 2 (19.6%); therefore, the weekly increase of 0.3% during the study period was explained by the high prevalence in period 3 (26.9%). The competitive season can be seen as a risk period for foot/lower leg injuries, which is important from a prevention perspective.

In systematic reviews of long-distance runners[20] and adolescent cross-country runners,[21,22] researchers have reported that the knee, lower leg, and foot were the most common injury locations. Based on these findings, injury locations seem to be similar between adolescent elite orienteerers and runners. Sex differences in injury locations have not been observed in previous orienteering reports. Given that we did not collect information on injury mechanisms or specific diagnoses of injuries, explaining the differences between sexes is challenging. In future studies, researchers should pay attention to possible sex differences.

Acute injuries (n = 24) occurred less often than overuse injuries (n = 85), and most acute injuries (58.3%, n = 14) resulted in an absence of 3 days or less from orienteering training or competition, indicating that these injuries were less severe. One-third (n = 8) of all acute injuries were sustained during alternative training, showing that injuries often occur outside the main sport. The question of whether adolescent elite orienteerers should avoid participating in alternative sports cannot be answered based on our results, but our findings highlight the importance of identifying the injury circumstances. In addition to injuries, the most common cause of the inability to train fully was illness, which is in accordance with the report of Clarsen et al,[17] who observed that 36% of athletes preparing for the Olympic and Paralympic Games reported illnesses.

Using a multiple linear regression model with a relatively high r^2, we identified 4 variables associated with time to first injury. The model showed that competition time, running on asphalt, and running on forest and trails were negatively correlated with time to first injury, whereas time to first injury was positively correlated with training volume (eg, a higher training volume resulted in a longer time to first injury). A higher prevalence of foot/lower leg injuries was also reported during the competitive season, strengthening the possible importance of the competitive element in orienteering as a risk factor. The results showing that time to first injury was positively correlated with training volume might seem paradoxical. However, the training volume of orienteerers includes sessions of sport-specific training to a wide range of diverse alternative training, making the effect of this variable on injury prevalence less predictable in this cohort. When interpreting the results, one must consider calendar time. For example, if injured later in the season, the athlete has the opportunity for a higher training volume during a longer observation period than if injured during the base training period. Factors such as seasonal variations in injuries and training may explain the large influence of the independent variables in the model on the time to injury. However, we believe the 4 variables associated with time to first injury are relevant from an injury perspective and should be included in future injury-registration studies in orienteering. Given that risk factors associated with injuries have been studied sparsely in orienteering, it is difficult to place our results in the context of previous reports. However, the identified factors associated with injury, except running surfaces, are not new as general risk factors in sports. Training volume and competition time have been linked to jumper's knee in volleyball players,[23] and running volume has been linked to running-related injury in marathon runners.[24] Reports including data on running surfaces are few and, therefore, inconclusive.[25] In addition, no association between running intensity and time to first reported injury was detected in the regression model, which supports previous epidemiologic results in running.[26]

The strength of using self-reported methods is that athletes do not need to depend on medical staff to record an injury. Even minor injuries are likely to be recorded, regardless of accessibility to medical staff. However, the results depend on the participants' compliance with the

method, the accuracy in validating and diagnosing the injury, and the definition of *injury*. In future studies, researchers need to develop medical teams who are accessible to the participants, can immediately confirm acute injuries and severe injuries, and can provide quick and effective treatment and rehabilitation.

Our statistical analyses for identifying risk factors had some limitations. First, given the limited number of data, we could not analyze risk factors associated with injuries in different body areas or with recurrent injuries. Second, the data might be confounded by various types of seasonal effects (eg, important competitions) because the injury registration did not last for a full year. Third, the severity of an injury was not used as an outcome variable in our model due to the limited sample. Therefore, more severe and less severe injuries were treated equally, which challenges the interpretation of the results. However, this is the first prospective cohort study on risk factors for injuries in orienteering using a repeated-measures approach. If we had studied a larger sample, the model would have been stronger, providing the opportunity to strengthen the associations and to include the severity of injuries. The results still highlight important aspects of variables to be included in future injury-registration studies and may guide development of prevention programs in orienteering.

Our sample was limited because only 2 Swedish high schools have national orienteering teams. We presented data on the sex, age, height, weight, and orienteering experience of our participants and believe this cohort did not differ substantially from other adolescent elite or younger adult orienteerers. Therefore, we consider that the results represent this group of athletes. However, to our knowledge, we are the first to use this method with adolescent elite orienteerers; hence, the results need to be confirmed and a larger sample studied. The average response rate in our investigation was lower than in recent reports in which the researchers used the same method with a different age group,[10,18] and yet, it can be satisfactory for 26 weekly reports in this age group. The response rate might have been higher if the schools had been visited more often. However, we believed that the close contact with the coaches at each school together with a weekly reminder e-mail was sufficient for motivating the athletes' participation.

Given that this was the first time this questionnaire was used in orienteering, its validity and reliability have not been determined fully. However, the OSTRC Overuse Injury Questionnaire has been validated in different sports.[10,11] To strengthen the content validity to orienteering in our study, the questionnaire was validated by expert groups of coaches and athletes. Given the high prevalence and incidence of foot/lower leg injuries, we suggest that future injury-registration studies on orienteerers should include more precise questions about the foot and lower leg to obtain a better understanding of the injury mechanism in this area.

CONCLUSIONS

We are one of the first groups to use a prospective design to register injuries in adolescent elite orienteerers. Overuse injuries occurred more often than acute injuries and were most common in the foot/lower leg area, with the highest prevalence during the beginning of the competitive season. In addition, training volume, competition time, running on asphalt roads, and running on forest surfaces and trails were associated with time to the first reported injury. One-third (n = 8) of all acute injuries occurred during alternative training. Researchers should focus on establishing the mechanisms of foot, lower leg, and knee injuries. Most injuries in adolescent elite orienteerers could be addressed with such an approach.

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REFERENCES

1. Linko PE, Blomberg HK, Frilander HM. Orienteering competition injuries: injuries incurred in the Finnish Jukola and Venla relay competitions. *Br J Sports Med*. 1997;31(3):205–208.
2. About orienteering. International Orienteering Federation Web site. http://orienteering.org/about-the-iof/the-iof. Accessed June 24, 2015.
3. Creagh U, Reilly T. Physiological and biomechanical aspects of orienteering. *Sports Med*. 1997;24(6):409–418.
4. Ekstrand J, Roos H, Tropp H. The incidence of ankle sprain in orienteering. *Sci J Orienteer*. 1990;6(1):3–9.
5. Folan JM. Orienteering injuries. *Br J Sports Med*. 1982;16(4):236–240.
6. Hintermann B, Hintermann M. Injuries in orienteering: a study of the 1991 Swiss 6-days orienteering event. *Sci J Orienteer*. 1992;8(2):72–78.
7. McLean I. First aid for orienteering in Scotland. *Sci J Orienteer*. 1990;6(2):55–63.
8. Linde F. Injuries in orienteering. *Br J Sports Med*. 1986;20(3):125–127.
9. Bahr R. No injuries, but plenty of pain? On the methodology for recording overuse symptoms in sports. *Br J Sports Med*. 2009;43(13):966–972.
10. Clarsen B, Myklebust G, Bahr R. Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire. *Br J Sports Med*. 2013;47(8):495–502.
11. Ekman E, Frohm A, Ek P, Hagberg J, Wirén C, Heijne A. Swedish translation and validation of a web-based questionnaire for registration of overuse problems. *Scand J Med Sci Sports*. 2015;25(1):104–109.
12. Borg G. Perceived exertion as an indicator of somatic stress. *Scand J Rehabil Med*. 1970;2(2):92–98.
13. Kujala UM, Nylund T, Taimela S. Acute injuries in orienteerers. *Int J Sports Med*. 1995;16(2):122–125.
14. Korpi J, Haapanen A, Svahn T. Frequency, location, and types of orienteering injuries. *Scand J Sports Sci*. 1987;9(2):53–56.
15. Harringe ML, Lindblad S, Werner S. Do team gymnasts compete in spite of symptoms from an injury? *Br J Sports Med*. 2004;38(4):398–401.
16. Andersen C, Clarsen B, Johansen TV, Engebretsen L. High prevalence of overuse injury among iron-distance triathletes. *Br J Sports Med*. 2013;47(13):857–861.
17. Clarsen B, Rnsen O, Myklebust G, Flrenes TW, Bahr R. The Oslo Sports Trauma Research Center questionnaire on health problems: a new approach to prospective monitoring of illness and injury in elite athletes. *Br J Sports Med*. 2014;48(9):754–760.

18. Jacobsson J, Timpka T, Kowalski J, et al. Injury patterns in Swedish elite athletics: annual incidence, injury types and risk factors. *Br J Sports Med*. 2013;47(15):941–952.
19. Ristolainen L, Heinonen A, Turunen H, et al. Type of sport is related to injury profile: a study on cross country skiers, swimmers, long-distance runners and soccer players. A retrospective 12-month study. *Scand J Med Sci Sports*. 2010;20(3):384–393.
20. van Gent RN, Siem D, van Middelkoop M, van Os AG, Bierma-Zeinstra SM, Koes BW. Incidence and determinants of lower extremity running injuries in long distance runners: a systematic review. *Br J Sports Med*. 2007;41(8):469–480.
21. Rauh MJ, Margherita AJ, Rice SG, Koepsell TD, Rivara FP. High school cross country running injuries: a longitudinal study. *Clin J Sport Med*. 2000;10(2):110–116.
22. Rauh MJ, Koepsell TD, Rivara FP, Margherita AJ, Rice SG. Epidemiology of musculoskeletal injuries among high school cross-country runners. *Am J Epidemiol*. 2006;163(2):151–159.
23. Visnes H, Bahr R. Training volume and body composition as risk factors for developing jumper's knee among young elite volleyball players. *Scand J Med Sci Sports*. 2013;23(5):607–613.
24. Rasmussen CH, Nielsen RO, Juul MS, Rasmussen S. Weekly running volume and risk of running-related injuries among marathon runners. *Int J Sports Phys Ther*. 2013;8(2):111–120.
25. Wen DY. Risk factors for overuse injuries in runners. *Curr Sports Med Rep*. 2007;6(5):307–313.
26. Saragiotto BT, Yamato TP, Hespanhol LC, Rainbow MJ, Davis IS, Lopes AD. What are the main risk factors for running-related injuries? *Sports Med*. 2014;44(8):1153–1163.

SUPPLEMENTAL MATERIAL

Supplemental Appendix. Questionnaire.

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