Training in spikes and number of training hours correlate to injury incidence in youth athletics (track and field): A prospective 52-week study

Anna Ek a, Jan Kowalski b,c, Jenny Jacobsson a,b,d,⁎

a Athletics Research Center, Linköping University, Sweden
b Swedish Athletics Association, Sweden
c JK Biostatistics AB, Sweden
d Department of Health, Medicine and Caring Sciences, Linköping University, Sweden

Objectives: The aim was to describe the annual incidence and types of musculoskeletal injuries, and to examine factors associated with injury risk.

Methods: A 52-week prospective study in Swedish youth athletics aged 12–15 years. Data on exposure to training and injury were collected from parents/caregivers and youth athletes using a web-survey system.

Results: A total of 101 (86%) youth athletes participated. Fifty-four (53%) of the athletes reported one new injury. Girls were at higher risk of sustaining an injury than boys (p = 0.048). Ninety-one percent of the new injuries were non-traumatic and 85% occurred in the lower extremities. Injuries to the front thigh represented 20% of the injuries. Cox proportional hazard regression analyses showed a six-fold increased risk for a first injury for athletes reporting use of spikes and training <6 h every two weeks (hazard ratio, 6.1; 95% confidence interval, 1.2–31.3) compared to athletes training <6 h using no spikes. Athletes training 6 h or more reporting use or no use of spikes had an eight-fold increase injury risk (p < 0.01).

Conclusions: Almost half of the youth athletes experienced a new injury and girls had a higher risk compared to boys. Nine out of ten injuries were related to overuse. An interesting observation was the high incidence of injuries to the quadriceps muscle complex. The study identified a correlation with training hours and an interaction with track spikes and risk of injury that needs further attention.

© 2021 The Author(s). Published by Elsevier Ltd on behalf of Sports Medicine Australia. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

Keywords: Child Overuse Prevention Growth Talent development

1. Introduction

Athletics is a global sport where the governing body, World Athletics, has 214 member federations (https://www.worldathletics.org). Athletics encompasses a variety of events, including running, jumping and throwing, and until high school, child and youth athletes are advised not to specialize but rather practice all the track and field events (https://www.worldathletics.org). Participating in sports is considered good for health, but there are signals that young athletes get negative effects from participation.1 So far, most research addressing negative health consequences like musculoskeletal injuries in child and youth sport have been conducted in team sports and are almost lacking in individual sports.2

Studies in youth athletics have shown incidences of musculoskeletal injury ranging from 35% to 65% and a predominant proportion of the injuries (65% to 95%) were related to overuse affecting the lower extremities.3–7 The most common injury types reported in youth sports are...
athletics are hamstrings strains, stress fractures and ankle sprains. Some factors that have been associated with risk of overuse injury in youth athletics are training routines, training loads and growth. To address the problem with overuse, emphasis is placed on appropriate planning of training during adolescence, but coaches have expressed uncertainty about how the training should best be conducted to avoid injuries. For instance, the surface on which athletes train and the type of footwear used in training and its significance for the development of injuries has been discussed (personal communication 2016, Daniel Bergin youth athletics coordinator Swedish Athletics Association, https://www.friidrott.se).

Despite these observations, there is a dearth of research describing the mechanisms of injury types in child and youth athletics. The reasons for this may be linked to how the sport is organized because it differs between countries, e.g. it can be in the form of a sports academy, in a school environment or following a coaching structure. In much of Scandinavia, the sport is organized mostly in club environments, which often means small training groups with several coaches who share responsibility for groups of athletes. Training conducted under such conditions poses challenges in reaching a large number of athletes (parents/caregivers) who also want to participate in longitudinal studies, which is a requirement for investigating causal relationships. To create the conditions for reducing the incidence of injuries in youth sports, more knowledge is needed about the underlying factors associated with injuries. Epidemiological research is a prerequisite for understanding the different conditions in a sport and its specific needs.

The primary aim of this 1-year prospective study was therefore to describe the injury incidence and types of musculoskeletal injuries in Swedish youth athletics aged 12–15 years and an additional aim was to examine possible factors associated with injury risk.

2. Methods

This was a prospective 52-week study (November 2016 to November 2017), including boys and girls aged 12–15 years. Informed written consent was collected from the parents/caregivers and the youth athletes. Ethical approval was obtained from the Ethical Committee in Linköping in October 2016 (dnr.2016/175/31) and the study is registered in ClinicalTrials.gov (NCT02882867). The study is reported according to the STROBE-SIIS guidelines.

Athletes were eligible for the study if they were members of a club affiliated to the Swedish Athletics Association and participated regularly at least once weekly in organized athletics training. In order to reach and obtain contact information for parents/caregivers, it was considered necessary that the clubs’ main activity was within youth athletics rather than adult athletics. A total of 17 clubs with a geographical spread across Sweden were identified to meet these criteria and were contacted by the primary researcher (JJ) by telephone and asked if interested in participating in the one-year prospective study. In addition, written information was sent to these clubs and to those clubs that could not be reached by telephone. Ten clubs expressed interest in participating and provided e-mail addresses for parents/caregivers who were subsequently invited, together with their youth, to participate in the one-year injury surveillance study. As all the youth athletes were minor consent was collected from both the youth athlete and the parent/caregiver.

Data on injury and exposure to athletics training and competition were collected every two weeks for 52-weeks, in total 26 surveys, using a web-survey system (Briteback AB, Linköping, Sweden) with one reminder after four days to those who did not respond to the first e-mail. All e-mail correspondence in the study was via the parents/caregivers. Information about training and injuries was self-reported by the athlete, with assistance from the parents/caregivers. During the first 2 weeks of the study, a baseline questionnaire was administrated asking for participant characteristics on athlete socio-demographics, sports-specific data like number of practising sports, training volume previous year, any previous musculoskeletal injuries. Training surface and footwear was also collected because it can potential contribute to the risk of injury; these variables were included in the training report. Every two weeks training reports thus included questions about the hours of training and competition in athletics and other sports, footwear used and training surfaces in the previous 2 weeks. If a new injury occurred information was collected in a separate survey including questions

Fig. 1. Flowchart of the recruitment of study participants. m, number of clubs; n, number of participants.
regarding date of injury, in what context the injury had occurred (sport, leisure etc.), injury onset (gradual/sudden), symptoms, affected body area and type of injury. The health problem targeted in this study was musculoskeletal injuries and a reportable injury was therefore defined as any new physical complaint, including pain and soreness, resulting in reduced training volume, difficulties participating in normal training or competition, or reduced performance in sports.14–16

The injuries were classified by two sports physiotherapist (AE, JJ) as traumatic (defined as a condition caused by an identifiable single external transfer of energy) and non-traumatic (referring to a condition with no identifiable cause), divided into gradual and sudden onset.14 Injury were thereafter classified by body region, type of injury according to the International Classification of Diseases, Tenth Revision, Clinical Modification [ICD-10-SE]. Injury severity was determined as the number of weeks of absence from full participation in athletics. Injury duration was calculated based on every two weeks reports, in intervals of 2 weeks, using the following discrete counts 0, 2, 4, 6, ..., 52 weeks. A severe injury was defined as absence from normal training of 4 weeks to 6 months. A long-term injury was defined as absence from normal training for >6 months.

### 3. Statistical analysis

All injuries were collected and summarized descriptively in terms of number by order of injury. Analyses of the time to the first injury was based on data for the athletes over 52 weeks. Athletes with an ongoing injury at the start of the study (n = 3) were censored until they reported being back in normal training. All data were evaluated using descriptive statistics, i.e. frequency and percentage for categorical variables and number of individuals, mean, standard deviation, median, and minimum-maximum for continuous data.

Survival analysis was used to evaluate time to first injury and derived as the first day observed in normal training until the day on which an injury was reported. Athletes with no injury observed during the study was censored at the last day on which they were reporting every two weeks training data. The primary outcome variable was time to first athletic injury measured as the number of weeks until the first injury.

Time to first injury was analysed descriptively using the Kaplan-Meier method by potential risk factors, and the estimate for the median time to injury is presented and illustrated graphically using the Kaplan-Meier curve. The corresponding log-rank test was used univariately to test for differences between groups/categories. Further, Cox proportional hazards regression was used for multivariate analysis for time to first injury including potential risk factors.

The following risk factors were explored in the survival analysis; history of at least a 3-week injury in the previous year (yes/no) retrospectively reported at baseline, training volume (where the ride as the cumulative number of hours per 2 weeks until the week of injury reported), training surface (athletic track, hard surface, soft surface, gymnastic floor) and number of training hours with various foot conditions (barefoot or shoes or track spikes), where all reported every two weeks and further calculated as the individual median number of training hours by each condition. On a group level median time was categorized into; 0 – “not at all”, 1–3, 4–6, 7–9 and >10 h. Sex and participation in multiple sports (yes/no) was also included in the modelling. Training volume was derived as the individual median training hours per 2 weeks until the first injury, or if no injury was reported, the median hours by order of injury. Analyses of the time to the first injury was based on data for the athletes over 52 weeks. Athletes with an ongoing injury at the start of the study (n = 3) were censored until they reported being back in normal training. All data were evaluated using descriptive statistics, i.e. frequency and percentage for categorical variables and number of individuals, mean, standard deviation, median, and minimum-maximum for continuous data.

Survival analysis was used to evaluate time to first injury and derived as the first day observed in normal training until the day on which an injury was reported. Athletes with no injury observed during the study was censored at the last day on which they were reporting every two weeks training data. The primary outcome variable was time to first athletic injury measured as the number of weeks until the first injury.

Time to first injury was analysed descriptively using the Kaplan-Meier method by potential risk factors, and the estimate for the median time to injury is presented and illustrated graphically using the Kaplan-Meier curve. The corresponding log-rank test was used univariately to test for differences between groups/categories. Further, Cox proportional hazards regression was used for multivariate analysis for time to first injury including potential risk factors.

The following risk factors were explored in the survival analysis; history of at least a 3-week injury in the previous year (yes/no) retrospectively reported at baseline, training volume (where the ride as the cumulative number of hours per 2 weeks until the week of injury reported), training surface (athletic track, hard surface, soft surface, gymnastic floor) and number of training hours with various foot conditions (barefoot or shoes or track spikes), where all reported every two weeks and further calculated as the individual median number of training hours by each condition. On a group level median time was categorized into; 0 – “not at all”, 1–3, 4–6, 7–9 and >10 h. Sex and participation in multiple sports (yes/no) was also included in the modelling. Training volume was derived as the individual median training hours per 2 weeks until the first injury, or if no injury was reported, the median

### Table 1

Results of survival analysis for time (weeks) to a first reported injury.

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>n</th>
<th>E (%)</th>
<th>Median (95% CI)</th>
<th>Log-rank p value</th>
<th>Cox proportional hazard regression (Multivariate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All participants</td>
<td>101</td>
<td>54</td>
<td>30 (16–43)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>54</td>
<td>32 (59.3)</td>
<td>16 (7.8–24.2)</td>
<td>0.048</td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>24</td>
<td>10 (41.7)</td>
<td>42 (red)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participation in two or more sports</td>
<td>69</td>
<td>40</td>
<td>0.598</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>39</td>
<td>23</td>
<td>20 (0–48.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>30</td>
<td>17</td>
<td>22 (1.6–42.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 week injury in the previous year</td>
<td>79</td>
<td>43</td>
<td>0.753</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>13</td>
<td>8</td>
<td>20 (2.4–37.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>66</td>
<td>35</td>
<td>30 (13.1–46.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hours training/2 weeks</td>
<td>82</td>
<td>42 (51.2)</td>
<td>36 (24.4–47.6)</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>&lt;6 h</td>
<td>25</td>
<td>7 (28)</td>
<td>Not reached</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥6 h</td>
<td>57</td>
<td>35 (61.4)</td>
<td>28 (15.5–40.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Footwear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Track spikes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not at all</td>
<td>37</td>
<td>39 (6.9)</td>
<td>Not reached</td>
<td>0.031</td>
<td>Interaction effect: training hours × track spikes</td>
</tr>
<tr>
<td>≥0.5 h/2 weeks</td>
<td>62</td>
<td>50.4</td>
<td>26 (16.5–35.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barefoot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not at all</td>
<td>46</td>
<td>20 (56.5)</td>
<td>50.0 (red)</td>
<td>0.083</td>
<td></td>
</tr>
<tr>
<td>≥0.5 h/2 weeks</td>
<td>53</td>
<td>32 (39.6)</td>
<td>26.0 (5.1–16.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Track</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–6 h</td>
<td>64</td>
<td>32 (50.0)</td>
<td>30.0 (17.2–42.6)</td>
<td>0.932</td>
<td></td>
</tr>
<tr>
<td>≥7 h</td>
<td>36</td>
<td>20 (44.4)</td>
<td>34.0 (15.4–52.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not at all</td>
<td>29</td>
<td>13 (55.2)</td>
<td>42.0 (6.1–77.9)</td>
<td>0.552</td>
<td></td>
</tr>
<tr>
<td>≥0.5 h/2 weeks</td>
<td>71</td>
<td>39 (45.1)</td>
<td>28.0 (16.3–39.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not at all</td>
<td>63</td>
<td>33 (47.6)</td>
<td>30.0 (9.6–50.4)</td>
<td>0.927</td>
<td></td>
</tr>
<tr>
<td>≥0.5 h/2 weeks</td>
<td>35</td>
<td>17 (51.4)</td>
<td>34.0 (15.4–52.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gym floor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–6 h</td>
<td>48</td>
<td>22 (54.2)</td>
<td>32.0 (14.9–49.1)</td>
<td>0.365</td>
<td></td>
</tr>
<tr>
<td>≥7 h</td>
<td>53</td>
<td>30 (43.4)</td>
<td>28.0 (11.3–44.7)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n, number of athletes; E, number of events (injuries); p values based on log-rank test; CI, confidence interval; HR, hazard ratio; red, could not be estimated because of redundancy.

Data missing for 23 subject.
for all weeks reported, and further categorized into intervals of 0–3, 4–6, 7–9, 10–12 and >12 h per 2 weeks. Training volume was categorized as athletics, other sport activities, and total training volume. Median training hours per 2 weeks were derived using the number of training hours reported until the time point for the first injury, or if no injury, for all weeks for which training was reported.

Due to the limited number of athletes in this study, the Cox proportional hazards regression was limited to multivariate modelling of a maximum two factors at the same time. Missing data was not imputed, for the statistical analysis we have only used observed data. All statistical tests were two-sided, and \( p < 0.05 \) was considered statistically significant. Median time to injury was calculated using the Kaplan-Meier estimates and presented together with 95% confidence intervals (CIs). SPSS version 26 was used for all calculations. As this is an exploratory study, there was no adjustment for multiplicity and \( p \) values should be interpreted as nominal.

4. Results

In total, 118 youth athletes, (girls, 13.2 ± 1.0 years; boys, 13.9 ± 0.9 years) with corresponding parents/caregivers, provided consent to the study and responded to the baseline questionnaire (Table 1). One-hundred and one (86%) athletes reported participation in an additional sport. The median aggregated number of hours of training in athletics and other sports is presented in Fig. 2. Twelve athletes discontinued with athletics during the year and were right censored in the survival analysis.

The injury incidence was 4.11 injuries/1000 h of exposure to all sports. In total 109 injuries which had occurred in athletics were reported (Supplement file 2). Fifty-four (53%) youth athletes reported one new injury, 29 athletes (28%) reported two injuries and 15 athletes (15%) reported three or more injuries (Fig. 3). The overall median time to the first injury was 30 weeks (95% CI, 16–43) (Fig. 4a). Boys had a statistically significant longer median time to first injury than girls. Fifty-five percent of the youth athletes who experienced a first injury, recovered and returned to full athletics training within 2 weeks (Fig. 4b), 70% returned to full training within 4 weeks and 85% returned to full training within 6 weeks.

The most commonly reported first injuries were non-traumatic (91%), 51% with a gradual onset, 49% with a sudden onset; 9% were traumatic (Table 2). Eighty-five percent of the first injuries were reported to have occurred in the lower extremities: hip, groin, thigh (28%), knee, lower leg (31%) and Achilles tendon, ankle, foot/toe (26%). The most frequently reported first injury converted into the ICD-10 classification was “injury to quadriceps muscle and its tendon” (S76.1) (13%) and “pain, unspecific in the lower leg” (M796G) (11%). Injuries to the front thigh muscle and tendon (S76.0 and S76.1) represented 19% of the first injuries.

The log-rank test showed a statistically significant increased risk for a first injury among athletes training for >6 h per 2-week period and training with track spikes (Table 2, Fig. 4c). The results of the multivariate Cox proportional hazards regression analyses demonstrated a statistically significant interaction effect between training hours and use of track spikes (Table 2, Fig. 4d). Compared with the athletes with <6 h of training every two weeks (reference group reported with a hazard ratio = 1), there was a six-fold increased risk for a first injury for athletes reporting use of track spikes and training <6 h every two weeks. Athletes who trained for >6 h every two weeks with use or no use of track spikes had an eight-fold increased risk for a first injury, compared to the reference group (Table 2).

5. Discussion

Almost half of the youth athletes experienced a new injury during the year mainly related to overuse. An interesting result in the study, not previously reported, was the high proportion of injuries to the front thigh. In addition, this is, to our knowledge, the first study in athletics that have examined the possible effect of training surfaces and footwear on the risk of injury in youth athletes. The results displayed a correlation with training hours and an interaction with the use of track spikes and the risk of injury.

The relatively high annual incidence in this study is in accordance with the relatively few longitudinal studies published in youth athletics. Similar to other sports, girls in athletics seem to have

![Fig. 2. Boxplot for median weekly training hours/2 weeks (for weeks 1 to 52) in athletics and other sports. Boxes represent minimum and maximum.](image-url)
an increased risk of injury compared with boys, which requires specifically targeted actions.\textsuperscript{17–19} Also in line with previous research in youth athletics, our findings show that most injuries (90\%) were related to overuse and >8 out of 10 of the injuries were in a lower extremity.\textsuperscript{4–10} The most injured body part has been shown to be the thigh in several athletics studies, and similar to other studies, we identified that almost 20\% of all injuries affected the thigh.\textsuperscript{8–11} A finding for concern was that the quadriceps muscle complex accounted for almost 20\% of the first

**Fig. 3.** Cumulative distribution for time to injury during 52 weeks by injury order 1 to 5.

**Fig. 4.**

a. Kaplan-Meier curve for time to first injury over 52 weeks displayed by gender.
b. Kaplan-Meier curve for time to full return to training.
c. Survival curves for time to first injury during the study displayed by hours of training.
d. Survival curves for time to first injury during the study displayed by time training in track spikes.
reported injuries; such a high occurrence of injuries to the front thigh has not been observed previously in youth athletics. The presence of quadriceps muscle strains is reported in sports where sprints and kicks occur, for example in football.20 The triggering mechanism for quadriceps muscles injuries in youth athletics needs to be further understood because the risk of re-injury has been reported to be high.21 Furthermore, a fairly high proportion of the injuries in our study also affected the lower leg, a body part that many youth athletes claim to struggle with; commonly reported diagnosis are medial tibia stress syndrome and growing pains in the calf muscles.10,11 It was notable that about half of the athletes who experienced a first injury were back in full training within 2 weeks. This finding could indicate that several of the injuries might have been in the form of niggles that coaches and parents could handle themselves. Still, three of ten athletes reported a subsequent injury, and this could signal that there might have been a premature return to sport. A history of injuries has been identified as an indicator for obtaining a new injury in athletics among both adult and youth athletes.16 However, in the present study, we did not observe such a relationship. The relationship between previous and subsequent injuries is understood to be multifactorial,22 and the importance of evaluating and introducing sports-specific secondary injury prevention protocols is important because these create the conditions for a safe return to sport.19,23

Early specialization, including one-sided training patterns, and athletes’ training volume have been shown to be associated with injuries in youth sports.17,24 We found a relationship with training volume; training for >6 h in 2 weeks increased the risk for a new injury by eight times. This number of hours is lower than proposed for youth athletes at this age; that is, the number of training hours should not exceed the age of the youth.25 However, the recommendations refer to the athlete’s chronological age, not his/her biological age. New research has shown that growth and maturation status are associated with injuries to the bone in athletics.10 Moreover, during puberty, ground reaction forces can change depending on the maturation status and thereby generate high loads on a growing skeleton.26 The present study displayed no association between injury and training surface, but we found that training <6 h every other week and the use of track spikes increased the risk of a first injury by about six times. The mechanisms by which training in track spikes may contribute to injury are not known, but can be related to the type of training done in track spikes. This finding needs further attention as high intensities such as jumping and running (both sprint and endurance) can be demanding for the growing athlete.10,26 A perceived high intensity in training and training load have been associated previously with injury in youth athletics,3 and Lysholm and Wiklander concluded in their report that most factors associated with injury in athletics were training “errors”, such as a sudden change in training routines or excessive running.27 It is further emphasized that the training of children and youth athletes requires a certain in-depth knowledge not only of sports-specific training but also of the processes of physical growth and biological maturity that the youth athlete undergoes and their possible contribution to injury.28 In addition, as early as 1978, Orava and Saarela emphasized that in order to prevent overuse injuries in athletics “attention must be paid to the education of coaches and trainers.”29 This proposed action to prevent injuries in youth athletics, including a socio-ecological approach in youth sports development, has continued support in recent research.3,12,29 The results of the present study point in the same direction.

A limitation in this study is the relatively small study population and that conditions for athletics may be context specific, e.g. venues for training. Therefore, the results cannot be immediately generalized to other youth athletics populations. Another limitation is the accuracy of injury assessment and classification when using self-reported data; these methods depend on the participants. In this study the youth athletes together with parents/caregivers reported all training and injury data and it is important to consider possible recall bias and the validity of, for example, the types of the injuries reported.14 The diagnosis was set by two experienced sports physiotherapists, independently, based on the information that parents and their children provided in the injury questionnaire which may mean that it may not be the exact diagnosis provided. However, we believe that parents and youth athlete can well describe in which part of the body (body area) the youth athlete experienced a new injury in and the onset of that injury. Moreover, because this was a prospective study where data was reported every two weeks, recall bias is assumed to be limited. However, there are gaps in the background data and irregularities in the training reports, and missing data are a threat for both the reliability and validity in a study.15 Furthermore, as the data were collected every two weeks, this gives less precision in the primary outcome variable but not necessary a bias in the estimate. The risk factor analysis includes athletes with a first injury to the upper extremity, but there are only 3 athletes and therefore the potential bias of these is low. These athletes were included in the analysis as we think it is better to use the same population for all risk factors. Given these limitations, the strength of the study is the prospective 52-week design that enabled examination of risk factors for injury.

6. Conclusions

Almost half of the youth athletes received a new injury and girls had a higher risk of injury compared to boys. Nine out of ten injuries were related to overuse. An interesting observation was the high occurrence of injuries to the quadriceps muscle complex. Furthermore, the results showed a correlation with training hours and an interaction with the
use of track spikes and the risk of injury that needs further attention. The results of this study point to groups of athletes with a need for specific support measures and also indicate a need for review and possible updating of coach education programs and training recommendations in youth athletics.

**Funding information**

The study received research grants and support for post-doctoral studies (JJ) from the Swedish Research Council for Sport Science (CIF) (FO2017-0010) and Swedish Athletics.

**Declaration of interest statement**

None declared.

**Confirmation of ethical compliance**

Ethical approval was obtained from the Ethical Committee in Linköping in October 2016 (dnr.2016/175/31).

**Acknowledgements**

We thank all athletes, parents and clubs who volunteered to participate in this study. We also want to acknowledge the support from the Swedish Athletics Association and Daniel Bergin, Swedish Athletics child and youth coordinator at the time.

**Appendix A. Supplementary data**

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsams.2021.09.006.

**References**