A prospective study of overuse injuries among mountain runners

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ABSTRACT

Background: Mountain running is an increasingly popular sport at the elite and as well as the recreational level. However, there is very little knowledge on overuse injuries exists, especially among mountain runners.

Objective: The main aim of this study is to investigate the prevalence of overuse injury problems among mountain runners throughout a season of training and competition.

Methods: This 26-week prospective cohort study included 33 international mountain runners, both elite runners and recreational, in different mountain running disciplines including vertical/uphill-course, up- and downhill-courses of different distances, and sky running. Data on overuse injuries in any anatomical location were collected every second week using the validated Oslo Sports Trauma Research Centre Overuse Injury Questionnaire. A severity score was calculated for each overuse problem reported. Additional details about the reported overuse injuries, and information about acute injury and illnesses were recorded using standard surveillance methods.

Results: The average prevalence of overuse injuries due to running was 19% (95% CI 9 - 29%). The average prevalence of substantial overuse injuries was 8% (95% CI 4 - 12). As much as 23 runners reported an overuse injury (whether substantial or not) at some point over the course of the study. 13 runners reported at some point a substantial overuse injury. The average weekly prevalence of overuse problems due to running was highest in the beginning of the study, but with a considerable reduction towards the end. The most prevalent sites of reported overuse problems throughout the cohort was the foot, followed by the knee. Acute problems were less frequent with an incidence of 6% (95% CI 2-10). There were two runners who reported illness (non-musculoskeletal) during the study.

Conclusion: Overuse injuries/problems constitute the majority of injuries among mountain runners, and are far more common than acute injuries and illnesses. The severity of the overuse problems has a wide range, and many runners continue training despite an overuse problem, which might not be captured using traditional injury surveillance methods. The most prevalent sites of injury in this study were the foot and the knee. Future injury prevention studies in mountain runners should focus on these areas.

INTRODUCTION

Mountain running is an activity that is as old as human kind. While our ancestors may have been running over hills, over mountains, through forests, across rivers as fast as they could, to collect food, escape danger, and as a messenger or in war, today such a purpose is no longer needed. Today, mountain running has become extremely popular, for recreation, healthy life and competition. Especially competitive mountain running events have grown over the past couple of decades, with increasing number of participants. The mountain running scene has

become an increasingly competitive and high-profile affair, with national and international championships. Even participation of national teams exist in such competitions.

The term mountain running incorporates many different types of courses and terrain, with large variations in distance, ascent, descent, altitudes as well as course difficulty. The race course may be uphill- or up- and downhill, in several disciplines including vertical race, short/long/ultra distance and sky running. The mountain running terrain is mainly off-road, with a minimum of 5% incline over the full course (1, 2). Sky running is a more extreme version of this, with trails above 2000 m in altitude and elevation gain higher than 30%, and if climbing is part of the course it should be accomplished without a rope (2). With elements of harsher mountain climate, technical trails and unforgiving terrain, in some cases aspects of scrambling or climbing, mountain running is a considerable physical and mental challenge, which differentiates the mountain running from other sports.

Even though this sport is growing, very little is known about the extent to which mountain runners suffer from overuse injury problems. Previous studies of injuries in mountain running have been limited by the study design, a short duration and a narrow focus on certain anatomical regions. One cross-sectional Italian study has been published, *Self-Reported Knee Symptoms Assessed by KOOS Questionnaire in Downhill Runners (Skyrunners,)* (*Roi et al.* 2015) investigating problems related to knees in downhill runners at a single point of time. Here, *Roi et al.* concluded that downhill running and participation in Skyraces could not be considered risk factors for subjective knee symptoms. Their study provided some insights of the injuries in mountain runners. However, they conclude that longitudinal studies with much more objective measures are required to better understand the impact of mountain running, and make precise estimates of overuse injuries among mountain runners.

To our knowledge, there have been no previous prospective studies of problems and overuse injuries in mountain runners. The objective of this 26-week prospective cohort study was to record the prevalence and severity of injuries among mountain runners by using a new validated methodology for overuse injuries developed by *Clarsen et al (2013)* at Oslo Sports Trauma Research Centre (OSTRC). We believe our study will be a first step towards future overuse injury prevention research in the field of mountain running.

METHODS

Study design
This study is prospective, a follow-up of 33 mountain runners over the course of 26 weeks, using questionnaires distributed by E-mail.

Definitions
Overuse injuries, defined as an injury caused by repeated micro-trauma, without a specific, identifiable event responsible for their occurrence (5) and is often associated with long, monotonous and repetitive movements. The definition used for the term ”problem” in the OSTRC questionnaire, refers to injuries, pain, stiffness, ache, swelling, instability/giving way and other complaints related to the athletes’ training.

Inclusion and recruitment strategy
Using both the International Association of Athletics Federations (IAAF) and International Skyrunning Federation (ISF) (1, 2) definition of a “mountain runner”, we included individuals

running >85% off-road (paths, trail, moraine, rock or snow). The profile of their running course involved either considerable amounts of ascent, or ascent and descent, with a minimum average 5% incline over the total distance, and climbing difficulty not exceeding II° grade (UIAA). We included mountain runners above the age of 18 of any gender, both elite and recreational runners, with any nationality. After the first round of recruitment, two runners were excluded as they did not fully meet the criteria.

The subjects for this study were recruited using several methods. We searched for runners primarily based on starter and finisher lists in the 2016 season of official Skyraces at the national and international level. The Skyrunner World Series ranking (3) was also used as guidance. In the process of promoting our study and recruiting subjects, we made use of social media. Several mountain runners today use social media platforms such as Instagram, Facebook and Strava to promote their passion, training, travels, sponsors etc. This was therefore a valuable tool for us to get in touch with mountain runners, especially runners outside Norway. In addition, Norwegian runners were approached by SMS and E-mail.

To promote our study and recruit runners nationally, we did an interview with the Norwegian endurance sports magazine, Kondis, who kindly published our research protocol along with an invitation-letter for mountain runners to participate (11). The potential participants could sign and send to us by email or a postal address that was provided. In addition, we posted information about the study on the Facebook of several running groups.

If the subjects agreed to participate, each subject was provided a written informed consent for participating as outlined in the information material, prior to filling out the questionnaires.

Data collection procedure
Before commencing on the 26-week study, we asked the athletes to complete a comprehensive baseline questionnaire to establish an in-depth knowledge of our study subjects. This enabled us to confirm that each participant would match the stated criteria. The baseline questions included a range of different information about their social background, any previous and existing injuries of importance and running/training profile. Some of these details are summarized under participant characteristics (table 1 & 2)

Every second Sunday during of the 26-week data collection period, an online survey software, SurveyExact, was used to send each participant an email linking them to an injury questionnaire (described below). Athletes who failed to respond within the first week received a reminder email.

Questionnaire
The full questionnaire was divided in two parts; for the first part, Oslo Sports Trauma Research Centre (OSTRC) Overuse Injury Questionnaire (6, 7) was used to collect data. The OSTRC questionnaire is quite sensitive to capture a wide range of overuse problems using a severity scale. The questionnaire provided us the information of overall prevalence of overuse injury problems, and how many of these problems were classified as substantial overuse problems, defined as problems leading to moderate or severe reductions in training volume, or moderate or severe reductions in sports performance *or* complete inability to participate in sport.

The second part of the questionnaire was more descriptive, and only the athletes who responded that they had encountered an injury/symptom would go through to this part. Using

standard surveillance methods *(10)*, we asked some basic questions about their injury/symptom such as location of the injury/symptom, how long it persists, when the injury/symptom is present (only when running/ all the time/while sleeping), type of injury/symptom (fracture, pain, stiffness, instability, giving away, etc.,), earlier experience with same injury/symptom, alteration to training regime and/or everyday routines, factors aggravating or relieving the injury/symptom and if they had received any kind of treatment.

Severity score
A severity score of 0-100, with a score of 25 per question in the OSTRC questionnaire, was calculated for each athlete each time a questionnaire was completed (6, 7). This score was monitored over the duration of the study and the average score was then calculated.

Acute injury registration
At the end of each questionnaire (part two), we investigated the nature of onset of each complaint and those which could be linked to a specific injury event (eg., fall, collision etc) were classified as acute injuries. If an acute injury had been sustained during this 26-week period, data corresponding to these injuries that were obtained through the overuse injury questionnaires, were separated in the analysis**.**

Illness registration
Runners were asked if they had suffered from illness, defined as any health problems that were not related to the musculoskeletal system, for example influenza, respiratory tract infections or gastrointestinal tract infections, during the previous 2-week period. In the database, this illness-data was also separated from the recorded musculoskeletal problems.

Data analysis
All data was exported and compiled in a database created with Microsoft Excel software (Microsoft Excel software 2010, Microsoft Corporation, Washington, USA). Each week the prevalence of overuse problems calculated from dividing the number of athletes who have reported any type of problem by the number of questionnaire respondents. A similar calculation was made for the number of athletes who reported substantial problems, defined as problems leading to moderate or severe reductions in training volume, *or* moderate or severe reductions in sports performance *or* complete inability to participate in sport. After the data collection, the weekly average of different categories was calculated: the prevalence of all problems, the prevalence of substantial problems, prevalence in different anatomic regions and the average severity score. A 95% confidence interval was calculated for each of these measures.

Our analysis included the average prevalence of all overuse problems, the average prevalence of substantial overuse problems (defined as those leading to moderate or severe reductions in training volume, *or* moderate or severe reduction in sports performance, *or* complete inability to participate in sport) and the severity score.

Ethics
The Northern Norwegian Regional Committee for research Ethics approved the study.

RESULTS

Response rate

Of the 141 runners invited to participate in the study, 33 accepted the invitation. The average response rate to the electronic questionnaire distributed every second week throughout the course of the study was 77%, whereas 21 (64%) completed all 13 questionnaires.

Participant characteristics

Participant characteristics are summarized in table 1 and 2, where table 2 shows the particpants' running background and competition interest.

Table 1: Participant characteristics

Gender	Mean age (range)	Average weight (range)	Average height (range)
Female (n=15)	33 (20 – 50)	55 kg (49 – 65)	165 cm (157 – 174)
Male (n=16)	32 (21 – 48)	70 kg (58 – 76)	180 cm (173 – 195)
Total responders (n=31)	32,5 (20 – 50)	63 kg (49 – 76)	173 cm (157 – 195)

Table 2: Participant characteristics, running specific

Responders	Average years of running (range)	Mean years of specializing in mountain running (range).	Full time athletes(%)	Part-time(%)	Planning to participate in one or more competitions (%)
31	13,8 (4 – 31)	5,5 (0 – 17)	2 (6,5)	29 (93,5)	27 (87)

Full-time athletes include full-time runners who do not work or study. Part-time athletes include runners who also work or study full-time or part-time.

Training habits

The weekly training habits of the participants are summarized in table 3 in terms of average number of sessions, training hours, distance and elevation gain.

Table 3: Training habits, average measures per week

Training habits	Running sessions (range)	Hours training /hrs (range)	Distance/km (range)	Elevation gain/m (range)
Responders (n=31)	9,9 (3 – 14)	13,5 (4 – 25)	88,3 (20 – 150)	3548 (500 – 10000)

Information about their preferred running surfaces was also collected. Forest trails and mountains (rock, single-track, snow) were the terrains/surfaces on which the participants mostly (75%) or always run on (71%). On the other hand, road and treadmills were only used a few times (93%) or never (93%) among the participants.

Moreover, the most popular mountain running disciplines among the participants were ultra-mountain running course (over 50 km in distance) and mountain running courses with a range

between 20-50 km. Besides these two disciplines, vertical/uphill-race and skyrunning were also popular.

Earlier sustained overuse problems
At some point in their life, 20 participants (65%) had sustained a problem due to running/sports. Among these earlier problems, feet and knees were the most prevalent reported sites of the problems, more specifically achilles tendinitis/rupture and runners knee.

Overuse problems

Average prevalence of overuse problems
Table 4 shows the average prevalence of all overuse problems and of substantial problems.

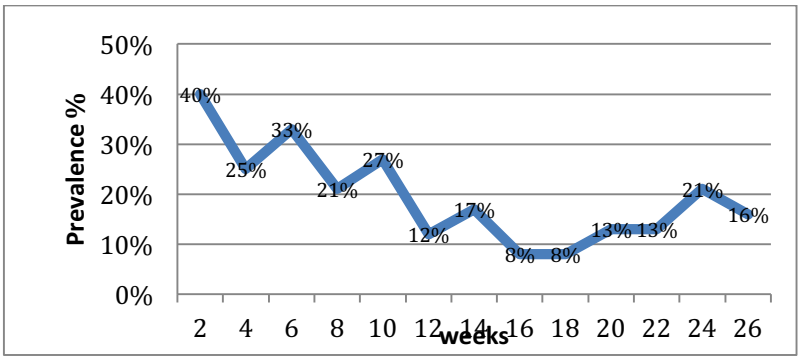
Table 4: Average prevalence of all overuse problems and of substantial problems, % (95% CI)

All overuse problems	19 (9-29)
Substantial overuse problems	8 (4-12)

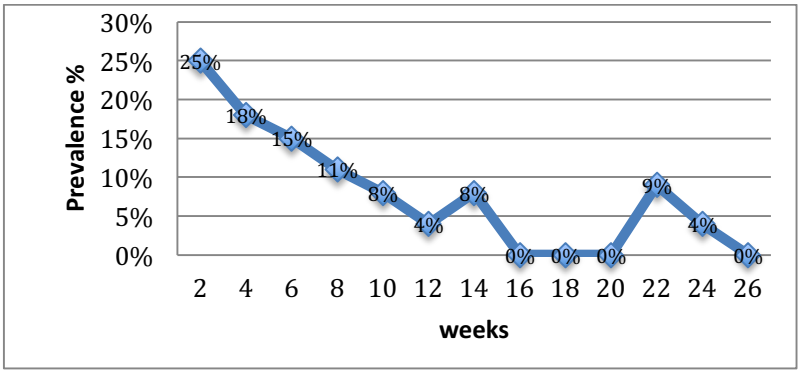
Substantial overuse problems: causing moderate/severe reductions in training volume or sports performance, or complete inability to participate in training or competition

23 runners reported some sort of overuse problem due to running at some point at the course of the study, but only 13 of these runners had one or several problems qualifying as substantial problems.

Weekly prevalence of overuse problems
Figure 1 and 2 show the weekly prevalence of overuse problems and substantial overuse problems, respectively. As illustrated, the prevalence of both overuse problems and substantial overuse problems tended to be highest at the beginning of the study, with a minor peak at week 22 (substantial overuse) and 24 (overuse).



Figur 1: Weekly prevalence of overuse problems



Figur 2: Weekly prevalence of substantial overuse problems

Impact of the overuse problems based on the severity score (Clarsen et al., 2013)
The severity score was highly variable with 14 as the lowest and the 80 as the highest (Table 5).

Table 5: The average severity score of all overuse problems

	Average severity score	Lowest severity score	Highest severity score
All overuse problems	41	14	80

Figure 3 shows the average impact of the overuse problems and the substantial overuse problems with the calculated average severity score.

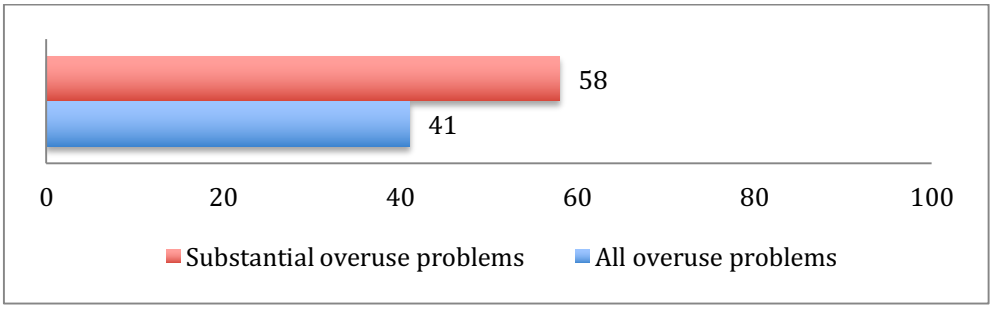


Figure 3: The average severity score of all overuse problems and substantial problems

The cumulative severity score of all overuse problems was calculated, and divided by the number of all overuse problems reported. This gives an average severity score of 41. If only considering the problems qualified as substantial overuse problems, the average severity score is higher, 58.

Overuse problems in different anatomical locations
All overuse problems were located in the lower body. 38% of the reported problems were located in the foot, followed by 18% concerning the knee. The hip, thigh and the leg were anatomical locations that were less frequently reported.

Complete absence from running or competition
Only 3 participants reported complete absence from training due to overuse problems at some point during the study. These were overuse problems concerning the knee and the foot.

Acute injuries

Figure 4 shows the average prevalence of acute problems compared to the average prevalence of overuse problems.

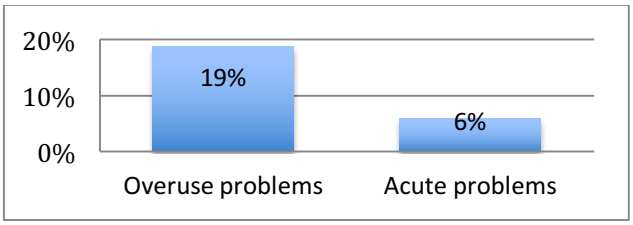


Figure 4: Prevalence of overuse problems and acute problems

Acute problems affected a total number of 7 runners during the course of the study. The most common types of acute injuries were broken ribs, followed by ankle (fracture and rolled ankle).

Illness

There were only two participants that reported illness (viral etiology) during the study period.

DISCUSSION

As far as we know, this is the first prospective study investigating the prevalence and severity of overuse problems in mountain runners. The main findings were that the average prevalence of overuse injuries due to mountain running was 19%, and the average prevalence of substantial overuse injuries was 8%. The average weekly prevalence of overuse problems due to running was highest in the beginning of the study, but with a considerable reduction towards the end of the study. At any given time during the course of study, over half of the participants, 23 runners, reported an overuse problem, and 13 of the runners reported at some point a substantial injury. Moreover, the average severity score of all overuse problems were 41, with a range of 14 – 80. These results suggest that the magnitude of overuse injuries are high in this group, and only a minority is completely free of problems. Also, the range of severity shows the importance of grading the overuse problems in order to also capture the less severe overuse problems.

While we discovered overuse symptoms in most anatomical locations, the lower extremity, especially foot and knee, were the areas with highest prevalence of overuse injury. It may be interesting to do more detailed investigation of these areas in future prevention studies on mountain runners. Furthermore, there is a need to establish more concrete information about duration of a single problem.

Our study has both strengths and limitations. First, the group we have studied was relatively small with 33 out of 141 invited runners who accepted the invitation to participate. We utilized social media to a large extent to reach out to the participants. Therefore, we may have recruited a younger group of runners in our study, because the younger generation tend to use social media more to promote their running.

In the invitation to participate we provided information about the objective of the study, described as overuse problem registration among mountain runners. By giving this information initially, we may have attracted runners who have sustained problems or injuries earlier. This may result in a selection bias, and possibly a higher prevalence of overuse

problem in our study group. In future studies, this type of selection bias may be avoided by not mentioning overuse problems in the invitation.

Moreover, only 36% categorized themselves as “elite”, of which only two were full-time mountain runners. Thus, full-time athletes and elites were under-represented in our study. Therefore, we could not state whether elites and non- elites have the same injury prevalence and patterns. However, the proportion of elite athletes compared to non-elites apparently is low both in the target population (mountain runners) and in our sample. The strength of this study is that all our subjects matched the criteria for mountain running, which was confirmed through the baseline questionnaire. We also have a good diversity of gender, age and nationalities represented in the group. Based on this, we believe that our small group of subjects are representative for our target population.

Secondly, the response rate was high at the start, however it fell throughout the study period with the lowest response rate in questionnaire 13. Still, the average response rate was 75%. With a small group of subjects, there is an impact on the overall results even when one single runner fails to complete a questionnaire. It should be noted that the lower prevalence of overuse problems over the duration of the study (especially questionnaire 7 – 10) probably is related to the fall in response rate. This phenomenon may represent a non-response bias, maybe caused by a so-called “respondent fatigue” (Ben-Nun, 2008), or by the limitation in time or signal as we reached high season for mountain running competition and travelling for the participants, which may have affected our results.

Furthermore, we collected data on all physical complaints using the OSTRC questionnaire. This questionnaire is more comprehensive to pick up a range of overuse injury problems using a severity score, than other traditional methods of injury surveillance (e.g. medical attention definition, any physical complaint definition or time-loss definition *(6, 7)*. To exemplify, if we used the time-loss definition, we would only capture the very worst problems, or the so-called tip of the iceberg, which only concern 5 runners in our study. This number is much lower than the reality of overuse problems in this study, being 13 runners reporting at some point a substantial injury and a total of 23 runners reporting any grade of overuse injury.

Thus, the use of severity score in the OSTRC questionnaire strengthened our data collection and we were able to find some useful finding of overuse problems. With this we could determine different degrees of overuse symptoms for each athlete and monitor it over time. The severity measures of problems were based on changes in an athlete’s function, adjustments in training or sports performance limitation, rather than on the time loss in days from training. We found this method was very useful in this group as many runners often continue to train and compete, maybe just by adjusting their training slightly (e.g. reducing intensity, duration, mileage etc. or switching to more alternative training), despite the existence of overuse injuries. In other words, their threshold for ceasing sports participation may be high (7).

However, one must remember that the severity score reflects the athlete’s self-assessment of their pain and the impact that the problem has had on their participation, training volume and sports performance. This may represent a self-report bias, where some runners may have higher threshold to report a problem than others, or where same degree of overuse injury may be reported with differing severity scores. We cannot control the runners’ interpretation of

what an overuse problem (other than the provided definition) is, and this may be differing in the group, based on earlier experiences, pain threshold, psychological factors etc.

Moreover, the OSTRC questionnaire does not separate between overuse and acute injury problem. However, with a detailed "part 2" of the questionnaire which had specific questions about any reported problem, we were manually able to distinguish acute injuries from overuse problems. Also, owing to the prospective design of this study, we identified and eliminated pre-existing conditions from incidence calculations of acute injuries.

Furthermore, the data from part 2 of the questionnaire enabled us to understand better all reported the problems (e.g. location, onset, duration, relatable to an event, earlier similar experience, associated symptoms, aggravating/reliving factors, healthcare attention, treatment etc.), including the most common anatomical sites with problems. This extra information has strengthened the accuracy of our results, and may also be of value for any future research on this target group. *Clarsen et. al* (year) had similar discussions on the strengths and limitations of the OSTRC method in their article (6, 7).

Our study represents a first step in investigating overuse problems in mountain runners, and may be a guidance for further studies. We cannot draw any firm conclusions based on this single study, and there is a need for more cohort-studies with this method of injury surveillance on mountain runners, in order to make comparison to our results. For future studies, it may be ideal to follow a larger group, and see how the group size would impact the results. Furthermore it would be interesting to investigate different groups and compare these, eg. elites and non-elites, road runner and mountain runners, etc. Lastly, if possible it may be more accurate if the subjects reporting a problem are personally examined by the researchers or other medical professional.

CONCLUSION

The prevalence of overuse problems in mountain runners is high, whereas the acute injury incidence appears to be low. The findings of this study suggest that overuse problems constitute most injury cases in mountain runners, with the most prevalent sites of injury being the foot and the knee. There is also a large range in terms of the severity of the reported overuse problems. Future injury prevention studies in mountain runners should focus on the mentioned problem areas, and include a bigger group of subjects.

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