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PREVALENCE OF INJURY IN ULTRA TRAIL RUNNING

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ABSTRACT
Purpose. The purpose of the study was to find the rate of musculoskeletal injuries in ultra-trail runners, investigate the most sensitive anatomical areas, and discover associated predicting factors to aid in the effective prevention and rapid rehabilitation of trail running injuries. **Methods.** Forty ultra trail runners responded to an epidemiological questionnaire. **Results.** At least one running injury was reported by 90% of the sample, with a total of 135 injuries were reported (111 overuse injuries, 24 appeared during competing). Lower back pain was the most common source of injury (42.5%). Running in the mountains ($p = 0.0004$) and following a personalized training schedule ($p = 0.0995$) were found to be protective factors. Runners involved in physical labor are associated with more injuries ($p = 0.058$). Higher-level runners are associated with more injuries than lower-level cohorts ($p = 0.067$), with symptoms most commonly arising in the lower back ($p = 0.091$), hip joint ($p = 0.083$), and the plantar surface of the foot ($p = 0.054$). Experienced runners (> 6 years) are at greater risk of developing injuries ($p = 0.001$), especially in the lower back ($p = 0.012$), tibia ($p = 0.049$), and the plantar surface of the foot ($p = 0$ .028). Double training sessions could cause hip joint injury ($p = 0.060$). **Conclusions.** In order to avoid injury, it is recommended to train mostly on mountain trails and have a training program designed by professionals.

Key words: running injuries, trail running, ultra distance

Introduction

The popularity of running and ultra running is increasing. At the same time, a growing number of people are participating in a different style of road or track running known as trail running [1]. According to the International Trail Running Association, trail running takes place on various natural terrain (mountain, desert, or forest) while minimizing running on paved or asphalt surfaces (no more than 20% of the total distance in competition). It can involve uphill, downhill, and horizontal trails and is similar in duration to an ultra marathon [2], which is considered any race beyond the marathon distance of 42.195 km [3].

Many studies have focused on injuries in ultra running [4–13] and associated predicting factors [4–30]. However, the current literature shows a lack of data concerning overuse injuries developed in trail runners. Therefore, the purpose of the study was to try to determine the prevalence of lower extremity and lower back musculoskeletal injuries in ultra trail runners by considering injuries and related symptoms. Additionally, the predicting factors associated with these injuries were investigated in order to aid in the prevention and rehabilitation of trail running injuries.

Material and methods

A total of 40 ultra trail runners (36 men, 4 women) aged with a mean age of 39.4 years (22–59) were recruited and met the eligibility criteria of active participation in trail running races and competing in races longer than the marathon distance. All were from Greece, where trail running is most commonly performed on mountainous paths because of the physical geography. Mean body weight was 72 ± 10.32 kg (46.5–90), mean body height was 175.52 ± 8.14 cm (1.53–1.88), and mean BMI was 23.35 ± 1.99 kg/m^2 (18.90–27.15). All participants were informed in detail about the study. The study was approved by the Alexander Technological Educational Institute Ethics Committee (No .173/14-03-2014).

An epidemiological questionnaire was designed and administered. The questionnaire was anonymous and was completed by a physical therapist after getting every answer from the participants in order to ensure that the questions were fully understood. The questionnaire was separated into sections concerning demographic factors, training schedule and routines, and medical history. Demographics included sex, age, height, weight, alcohol use, smoking habits, marital status, and type of work. The training section collected information about running experience, running frequency (days/week or if double training sessions were performed), distance (km/week), running speed (km/h), running terrain, type of shoes, and if they follow a special training program and infor-

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mation on their recovery and stretching routine. Participation in other sports and physical activities was also considered. The medical history included information on the anatomical location of the injury associated with running, symptoms, duration of the symptoms, the severity of the injury (classified as grade 1 – symptoms that appear after running, 2 – appear hours after running, 3 – appear during running, 4 – chronic symptom), and if the symptoms were severe enough to forgo training for at least one day or causing them to quit a race. The participants also responded if their injury was diagnosed by a doctor and/or rehabilitated by a physical therapist. Ankle sprains were not considered as the participants could not recollect their occurrence due to their frequency.

The sample was also separated into level A and B groups based on the Point Calculator system. This mathematical algorithm is used in the Olympus Marathon trail race to determine race eligibility based on multiple criteria, including the sex and age of the runner, difficulty level of previous races (positive height difference, the vertical climb index, and the distance in km), and performance. Each of these factors awards a different amount of credits to the runner. The sum was then calculated for each runner; those who had more credits than the mean number of credits were classified as level A.

To determine the association between the injured anatomical area and the collected factors (treated as potential risk factors), Pearson's chi-square test was applied (or Fisher's exact test when conditions were not met using 2 × 2 contingency tables). Independent samples *t* tests compared the mean number of injuries (continuous variable) with the two categories of categorical variables (factors). For the categorical variables that have more than two categories one-way ANOVA was performed. The one sample Kolmogorov–Smirnov test was used to examine if the number of injuries followed a normal distribution. All analyses were performed by using the SPSS software package (IBM, USA). The level of significance was set at 5% for statistically significant relationships and 10% for significant relationships due to the limited number of participants.

Results

Table 1 gives the baseline demographic characteristics (age, height, weight, BMI, marital status, type of work) and lifestyle habits (alcohol use, smoking). Training factors and routines are represented in Table 2. Among the sample, 13 runners (32.5%) were classified as level A and 19 runners (47.5%) had more than 6 years of running experience. Thirty-six participants (90%) reported at least one injury, with a total of 135 injuries reported. The mean number of injuries per runner was 3.38 ± 2.57 injuries/individual (range 0–10). The majority (82.2%, 111 injuries) were overuse injuries whereas the remaining 24 injuries (17.7%) appeared during competition.

Table 1. Demographic characteristics

Demographic characteristics	Mean ± *SD*	*n* (%)
Age (years)	38.4 ± 8.73	
Height (cm)	175.52 ± 8.14	
Weight (kg)	72 ± 10.32	
BMI (kg/m^2)	23.35 ± 1.99	
Marital status		
Unmarried		18 (45)
Married		22 (55)
Type of work		
Mental labor		18 (45)
Physical labor		8 (20)
Sports/military		14 (35)
Alcohol use		
Every day/every week		20 (50)
Never		20 (50)
Smoking		
Every day		4 (10)
Never		36 (90)

The lower back was the most frequently reported injured anatomical area. Figure 1 illustrates the rates of the injured anatomical areas, in which 31.85% (43 injuries) were diagnosed by a doctor, 22% (9 injuries) were overuse bone stress injuries, and 16% (7 injuries) were due to iliotibial band syndrome (Figure 2). The achilles tendon was the anatomical area with the highest percentage of injury severity (Figure 3) whereas lower back pain was the second most severe injury. The achilles tendon was also the most common source of chronic injury followed by the lower back and hip joint (Figure 4). Table 3 shows the characteristics of the injuries, in which a high percentage of injuries were chronic (16.30% had symptoms for more than 1 week, 26.66% for more than 1 month, and 22.22% for more than 1 year).

Those whose job was physical in nature had statistically significant more injuries/runner than those involved in mental labor and those who work in the field of sports or for the military ($p = 0.058$). We found no significant relationship between the mean number of injuries/runner and BMI index, smoking, and alcohol use.

As shown in Table 4, runners classified as level A had a higher mean injury rate than those belonging to level B ($p = 0.067$). Experienced runners (> 6 years) had more injuries than novice runners (≤ 6 years) ($p = 0.001$). Participants who trained in the mountains had less injuries than those who trained on synthetic material and those who ran on asphalt ($p = 0.0004$). Runners who followed a special training schedule were associated with fewer injuries ($p = 0.0995$). We found no significant associations between the number of injuries and training characteristics (days/week, double training sessions, km/week, running speed), if recovery was performed, stretching routine, and the type of running shoes.

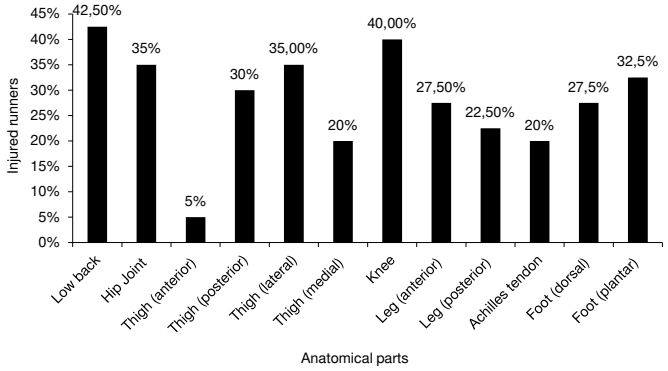

Figure 1. Injured areas

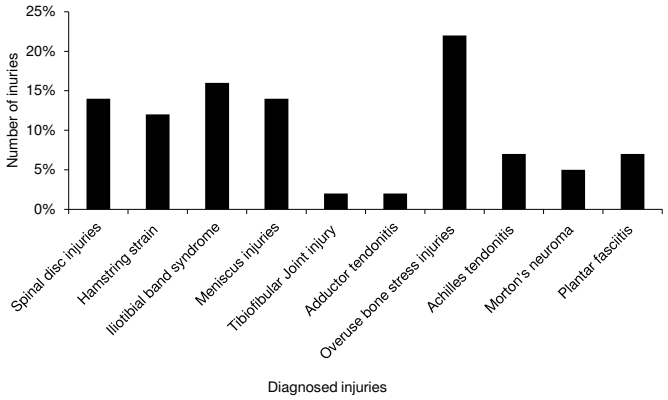

Figure 2. Diagnosed injuries (n = 43 injuries)

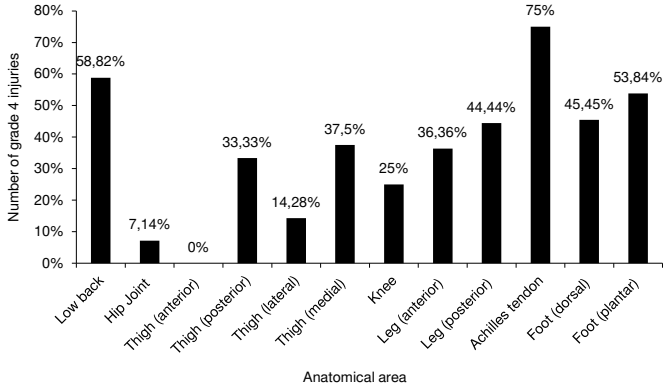

Figure 3. Grade 4 injuries

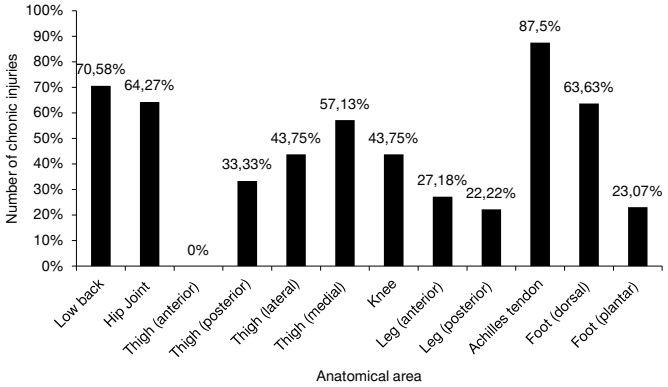

Figure 4. Injury duration of >1 month

Table 2. Training characteristics

Training characteristics	n (%)
Runner's level	
Level A	13 (32.5)
Level B	27 (67.5)
Participation in other sports	34 (85)
Indoor sports	6 (33.33)
Outdoor sports	12 (66.66)
Running experience (years)	
≤ 6	21 (52.5)
> 6	19 (47.5)
Training frequency (days/week)	
1–2	2 (0.5)
3–5	20 (50)
6–7	18 (45)
Double training	
Yes	15 (37.5)
No	25 (62.5)
Weekly distance (km)	
≤ 80	23 (57.5)
> 80	17 (42.5)
Running speed (km/h)	
≤ 10	16 (40)
> 10	24 (60)
Running terrain	
Asphalt	12 (30)
Tartan	9 (22.5)
Mountain	19 (47.5)
Special training program	
Yes	19 (47.5)
No	21 (52.5)
Stretching	
Every day/every week	21 (52.5)
Never	19 (47.5)
Recovery	
Yes	34 (85)
Never	6 (15)
Type of shoes	
Stability	18 (45)
Slip lasted	14 (35)
N/A	8 (20)

Table 5 shows in detail the correlations between the predicting factors and injured anatomical areas. Level A participants were associated with injuries of the lower back (p = 0.091), hip joint (p = 0.083), and plantar surface of the foot (p = 0.054). Having more than 6 years of experience in running is a predicting factor for getting injured in the lower back (p = 0.012), tibia (p = 0.049), and the plantar surface of the foot (p = 0.028). Double training sessions are associated with hip joint injuries (p = 0.060).

Table 3. Descriptive data of the injuries (n = 135)

Characteristics of the injuries	n (%) of injuries
Diagnosed	
Yes	43 (31.85)
No	92 (68.15)
Duration	
Hours	6 (4.44)
Days	41(30.37)
Weeks	22 (16.30)
Months	36 (26.66)
Years	30 (22.22)
Severity	
Grade 1	68 (50.37)
Grade 2	2 (1.48)
Grade 3	14 (10.37)
Grade 4	51 (37.77)
Symptoms	
Pain	80 (59.25)
Multiple (including pain)	29 (21.48)
Burning	1 (0.74)
Numbness	5 (3.70)
Spasm	7 (5.19)
Edema	1 (0.74)
Other	12 (8.89)
Abstinence from running	
No	73 (54)
1–5 days	30 (22.22)
≤ 3 weeks	16 (11.85)
> 3 weeks	16 (11.85)
Treatment	
None	66 (48.89)
Physiotherapy	54 (40)
Medical treatment	1 (0.74)
Physiotherapy and medical treatment	14 (10.37)

Discussion

Injuries and risk factors in endurance running are well understood [4–30]. However, despite the increasing popularity of trail running, there is a lack of data on the prevalence of injuries, information on the most affected anatomical areas, and the predicting factors associated with this running modality. In the present study, a high percentage (90%) of ultra trail runners reported at least one running-related injury. Previous studies reported the prevalence of injuries varying from 26% to 92.4% [5, 6, 14, 15] although these studies sampled endurance road runners, not ultra trail runners. Ultra trail running is known to cause muscle damage and general fatigue due to the running duration, the eccentric contractions during downhill trails, and changes in slope [2, 31]. These reasons could explain the

Table 4. Statistically significant associations between the predicting factors and mean number of injury (n = 135)

Factors	Mean no. of injuries ± SD	p
Type of work		
Mental labor	3.77 ± 2.26	
Physical labor	4.62 ± 3.62	0.058*
Sports/military	2.14 ± 1.79	
Runner's level		
Level A	4.69 ± 3.32	0.067*
Level B	2.74 ± 1.87	
Running experience (years)		
≤ 6	2.14 ± 1.68	0.001**
> 6	4.73 ± 2.72	
Running terrain		
Asphalt	6.16 ± 2.32	
Tartan	2.88 ± 1.26	0.0004***
Mountain	1.84 ± 1.57	
Special training program		
Yes	1.36 ± 0.95	0.0995*
No	5.33 ± 2.05	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$

Table 5. Statistically significant associations between predicting factors and anatomical area

Factor	Injured %	p
Lower back		
Level A	61.5	0.091*
Level B	33.3	
Experienced	63.2	0.012*
Non-experienced	23.8	
Hip joint		
Level A	53.8	0.083*
Level B	25.9	
Double training (yes)	53.3	0.060*
Double training (no)	24.0	
Thigh (anterior)		
Experienced	42.1	0.049**
Non-experienced	14.3	
Foot (plantar)		
Level A	61.5	0.054*
Level B	29.6	
Experienced	57.9	0.028**
Non-experienced	23.8	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$

high percentage of injuries in our study group. However, it should be noted that not all researchers accept the same definition of running injury [5–7, 9, 14, 15].

Most frequent injury

In our study, the most reported injury involved the lower back (42.5%), followed by the knee with an equally high prevalence (40%). The literature indicates that the most affected anatomical area in endurance runners is the knee, ranging from 7.2% to 80% in runners [3, 6–9, 14–17]. However, all of the cited researchers studied injuries in middle distance or marathon road runners, not in ultra distance trail runners [6–9, 14–16]. In our study, the lower back had a higher occurrence of injury than previously reported (3–8%) [5, 9, 14–16]. An explanation may be that during uphill running the trunk of the body leans forward, hence causing a shortening of the hamstring muscle complex [32]. Moreover, the lower back was the second most severe injury (chronic condition). Medical professionals and runners should treat this injury carefully in order to preclude minor disability.

Demographic factors related to injuries

We found that physical labor was related to higher number of injuries than mental labor. However, military or sports-related work (possibly due to previous athletic experience) was associated with the lowest number of injuries ($p = 0.058$). These findings can be considered logical for multiple reasons. Runners whose work demands involve physical effort are unable to devote enough time for training and recovery, while the participants who work in the field of physical activity or the military were found to be elite athletes in other sports. Hence, they may be more experienced in managing injuries, while runners whose work is physical in nature should be more informed on injury prevention. However, as the present study is the first to assess work, further research is necessary.

The relationship between smoking habits, alcohol use, and musculoskeletal injury is not well researched. Previous studies have found an association between these habits and injuries in runners [6, 7, 18], but no physiological explanation has been offered. Our results did not show any significant association between smoking, alcohol use, and running injuries.

No relationship was noted for BMI, most likely the result of the participants showing normal BMI. These findings are supported by two other studies [19, 20], although there is no consensus on the relationship between BMI and running injuries [9, 7, 16, 21]. We should note that although BMI is a valid measure of body composition for the general public, its validity in athlete populations need further research due to very low percentages of body fat.

Training factors related to injuries

Runners classified as level A were found with greater prevalence of injury ($p = 0.067$), especially in the lower back ($p = 0.091$), hip joint ($p = 0.083$), and plantar surface of the foot ($p = 0.054$). Previous studies have maintained the notion that elite runners contract more injuries than recreational runners, as the former run greater distances and at higher speed and have sustained previous injuries [21, 22]. As the participants in level A participate in many races, they may lack adequate recovery between events or even ignore any sustained injuries. However, Macera et al. suggested that high caliber runners avoid injury due to their experience [19]. In our study, experienced runners (> 6 years) were found with increased prevalence of developing an injury ($p = 0.001$), especially in the lower back ($p = 0.012$), tibia ($p = 0.049$) and plantar surface of the foot ($p = 0.028$). These injuries were mostly caused from overuse as a result of their training routine. These results are in line with other studies [19, 20], which suggest that more experienced runners have a greater probability of sustaining a knee injury [6]. On the other hand, some studies suggest that running experience is a protective factor [16, 21, 23, 24] while another associates tibial stress syndrome with a lack of experience [9]. Two studies found no correlation between running experience and injury [7, 15].

In order to minimize running-related injury, research has recommended limiting the amount of kilometers of run per week [5–7, 16, 18, 23, 25] and shortening training duration [15]. In addition, it has been suggested that a minimum training volume of 30 km/week before completing a marathon in order to avoid injury [26]. Our findings indicated no association between training volume (km/week, training sections/week, double training sessions) and the prevalence of injury. However, an individualized training program (schedule) designed by a professional was found to be associated with less injury compared with an empirical training schedule (based on personal experience) ($p = 0.0995$). Although training distance and frequency did not influence injury prevalence, hip joint problems were noticed more often in those who train twice per day ($p = 0.060$). To our knowledge, this is the first publication that has evaluated the influence of a specialized training program and double training sessions on running injury, so further research is required.

Considering running surface, running on mountain trails appears to cause less injury than asphalt or synthetic material ($p = 0.0004$), suggesting that ultra-trail runners avoid or limit running on the latter types of surfaces. One study indicated synthetic terrain to be related with ankle pain [15]. Tessutti et al. found that runners who control training volume and intensity and run on grass are at a lower risk of experiencing injuries [27]. Other researchers did not find any relationship between running terrains and injury [14, 19], although these

studies targeted recreational runners and not ultra runners. We believe that training on mountain trails is more protective than training on asphalt or tartan due to higher shock absorption afforded by the ground and the variation in trail grade.

No correlation between running speed during training and injury was found. Nielsen et al. attempted to categorize running injuries as either volume or pacing injuries by using GPS and not questionnaire-based [28]. According to their results a sudden change in training speed instigates injuries and that a high running pace is associated with achilles tendinopathy, gastrocnemius injuries, and plantar fasciitis. It can be surmised that running in mountainous terrain would be more beneficial, as maintaining a constant speed as in flat terrain is not possible due to the incline and decline.

No associations were found between participants' stretching frequency (daily, weekly, never) and recovery routines (cryotherapy, massage, switching to a different sport, quick training) with injury. One limit of the present study is that only stretching frequency was recorded but not the type of stretching exercises or duration nor more specific recovery details. Although the literature indicates that stretching has no association with a decreased prevalence of injury in running, its significance has been confirmed in other sports [16, 18, 19, 23, 29]. Nonetheless, comparing the results of stretching routines is difficult to perform as different protocols are used in their evaluation [23]. As for recovery, one review noted that running uninterrupted for a whole year, with no break for recovery, is a risk factor for injury [5]. Moreover, previous injuries are a strong risk factor for developing reinjury, although it is not clear if this occurs due to a premature return to running [6, 7, 14–16, 18, 19]. It is known that losing ankle mobility due to an ankle sprain will tend to transfer the role of joint mobility to an adjacent stable joint such as the plantar plate or knee joint. Since these joints are designed to be stable, by adopting the role of managing mobility a great deal of stress is placed on these joints and may result in joint pathology [32–36]. It is also know that ankle instability caused by a prior sprain could be an independent factor of reinjury in an athlete population [37]. Additional research is needed and should include stretching and recovery routines, evaluated via similar parameters in order to aid future comparisons.

No association between the mean number of injuries and the type of running shoes (stability shoes, slip lasted shoes) was indicated, although 20% of the participants did not respond to this item. Although trail shoes are designed to provide stability in order to protect runners from ankle sprains, we did not consider this type of injury in our study due to its frequent occurrence. Previous studies have indicated that stability shoes are associated with fewer injuries in trail events [10], although faster runners prefer more flexible shoes (slip lasted) [30]. Further investigation is necessary as the published material on foot strike patterns and shoes in trail runners is limited.

Strength and limitation of the study

While the most significant strength of the present study is that it is the first to analyze trail running injuries and associated predicting factors, it possesses several limitations. The sample consisted of only 40 runners, larger samples and more detailed injury data in future research is needed to reinforce the present results. Further research should include more intrinsic factors such as runner flexibility, muscle strength, biomechanical function. Dynamic and functional capacity could be assessed by using the Functional Movement Screen (FMS) system or a similar evaluation tool. This system could identify high-risk athletes as the FMS evaluates movement patterns essential for normal function and participation in sports [38, 39]. Future preventive strategies should also focus not only on functional movement training but also on ankle strengthening exercises as this anatomical area promotes joint and postural stability without involving excessive effort [40].

Returning to the sample, all of the participants verified that they were trail runners and competed in ultra trail events. However, 12 participants indicated that they used to train on asphalt. Differences between a trail runner and an endurance runner are difficult to identify, hence our results are theoretically comparable with endurance running data. However, this is not entirely objective as they are still two different kinds of running.

Only 31.85% of the types of injuries reported were diagnosed by a doctor. For this reason we collected data only by the anatomical area in which symptoms appeared and not the kind of the injury. Future research should consider all previous injuries with medical histories.

Conclusions

Low back is the most common injured anatomical area in ultra trail runners. Running in the mountains and following a personalized training schedule were found to be protective factors. Those whose work is physical in nature are more likely to experience injury, whereas level A runners are associated with a higher number of injuries in the lower back, hip joint, and plantar areas. More than 6 years running experience is a risk factor for developing injury especially in the lower back, tibia, and plantar areas. Double training sessions could lead to hip joint injury. Trainers and runners should take this data into account in order to achieve improved prevention and rapid rehabilitation.

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