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Epidemiology of Lower Limb Injuries and Dysfunctions in Athletes of Mountain Sports

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Abstract

Background: Lower limbs have been reported as the most common site of acute injury in mountain sports, however, the long-term effect of participating in sports that are practiced in steep terrain is not clear. This study aimed to investigate specifically the frequency of lower limb injuries and functional disorders of athletes in different disciplines of mountain sports including mountaineering, skiing, and sky running.

Methods: In this cross-sectional study, 114 athletes registered in the Mountaineering and Skiing Federations of Iran, completed an online survey. The link sent to volunteers included a checklist for demographic profile, history of acute injury, and the Persian version of the Lower Extremity Functional Scale (LEFS).

Results: The overall prevalence of lower limb injury was 27.4%, and the median score of LEFS was 78, which was in the normal range. However, 44.2% of the athletes had an LEFS score that indicated a lower-than-normal lower extremity function. No correlation was found between a history of acute injury and reduced LEFS score.

Conclusion: The high prevalence of lower limb dysfunction in mountain athletes and the lack of correlation between the history of acute injury and lower limb dysfunction in this study indicates the possible role of other risk factors in the development of overuse injuries.

Keywords: Cumulative trauma disorders, Lower extremity, Mountaineering, Musculoskeletal diseases, Skiing

Introduction

Injuries are an inseparable part of professional sports; however, they could be prevented by identifying risk factors and ultimately developing specific injury-prevention strategies for athletes. Many studies have investigated the frequency of injuries and factors affecting their occurrence in popular sports like soccer, but the number of such studies in the field of mountain sports is very limited (1,2). In published studies, the most common site of acute injury in climbers has been reported to be the lower limbs (3,4). Based on previous studies, it seems that the risk factors of acute lower limb injury in mountain sports include the history of previous injury, years of training in professional sports, training volume, use of inappropriate shoes or other sports equipment, and carrying a heavy backpack (4-6). Mountaineering includes a wide range of activities, from hiking to climbing peaks above 8,000 *m*. All these activities present different physiological demands and risks depending on the climbing style, altitude, environmental conditions, climbing experience, *etc.* (7,8). Due to the geographical features and easy access to the heights in Iran, there has been a significant increase in the number of climbers in recent years. On the other hand, the increase in the variety of mountain sports and the number of athletes participating in the training and competitions of these fields, including skiing and sky running, can also be regarded (9-11). Skiing, as a sport, carries the risk of injury to the upper and lower limbs; in recent years, with the advancement of technology used in manufacturing the skiing equipment, injuries related to this sport have generally decreased, but the injury pattern has changed. For example, leg injuries have decreased, and simultaneously, knee and upper limb injuries have increased.

On the other hand, the pattern of injury and its incidence in subcategories of snow sports such as snowboarding and alpine seem to be different (12-14). Sky running is another sport practiced in the mountains, and the lower limb injuries of its athletes were investigated. The sport comprises running events in the mountains above 2000 *m* above sea level, or below 2000 *m* if the inclination of the whole course is over 6% (10,15). Due to the fact that this field of sports has recently attracted the attention of athletes and the research on the injuries of athletes in this field is very limited, the need to investigate the acute injuries of these athletes and the functional disorders that follow, is felt more than ever.

In general, muscle strength and joint health of the lower limbs, as well as athletes' balance, are important components of mountain sports, and the lack or disruption of any of them increases the risk of injury to the athlete (16,17). Most of the published studies so far, have investigated the acute injuries of mountain sports, and limited studies have been published regarding the long-term effects of mountain sports and their injuries on the performance of athletes. Therefore, it was decided to measure the frequency of lower limb injuries and functional disorders of mountain sports athletes in different disciplines including mountaineering, skiing, and sky running, to take a step toward a better understanding of these injuries and to recommend preventive measures to reduce them.

Materials and Methods

This cross-sectional study was conducted with the cooperation of 114 athletes in the age range of 18 to 65 years, whose information was registered in the I.R. Iran Mountaineering & Sport Climbing Federation and Skiing Federation in 2022 and 2023.

This study was approved by the Iran University of Medical Sciences ethics committee, Code: IR.IUMS.FMD.REC.1401.175. Contact information of the athletes registered in the National Mountaineering Federation (which included both mountaineering and sky running athletes) and the National Ski Federation was obtained. All the athletes (221 individuals) were contacted by phone and those whose information was incorrect or did not respond to the phone call, were excluded from the study. A checklist for demographic profiles and a questionnaire for evaluating the function of the lower limbs were prepared in the form of a Google form, and the link was sent to those who volunteered to partake in the research (117 people). After reviewing the questionnaires, 3 cases were excluded from the study; two cases were due to not climbing in the last year and, one case was due to incomplete completion of the questionnaire.

The lower limb function of the athletes was evaluated using the Persian version of the Lower Extremity

Functional Scale (LEFS). Binkley *et al* designed the scale as a patient-rated instrument to assess functional status in a group of patients with various musculoskeletal conditions. The LEFS consists of 20 items with scores ranging from 0 (extreme difficulty or unable to perform activity) to 4 (no difficulty). The total score is obtained by summing the scores of each item; and the maximum score that could be obtained in this questionnaire is 80, which means perfect performance. According to the studies, a score of 77 to 80 is considered normal lower limb function, and a score of 76 or less is regarded abnormal and impaired lower limb function (18-20). The reliability, validity, and responsiveness of the LEFS has been assessed in a wide range of people, including athletes (21,22). The Persian version of the questionnaire has also been reported as a reliable and valid instrument (23). The checklist questions included demographic information of the athletes, including age, sex, years of training their sport, number of climbs above 3000 *m* in a recent year, any musculoskeletal injury preventing climbing and the location of the injury, any musculoskeletal injury leading to surgery and the location of the injury, performing regular resistance exercises and participating in sports outside of altitude. Since the aim was to obtain the prevalence of lower limb injuries among all the musculoskeletal injuries, the location of injuries was divided into three options of lower limb, upper limb and spine.

Descriptive statistics for the frequencies, as number and percent of injury for body area -lower limb, upper limb or spine- was used. Median and interquartile range was used to describe the quantitative non-normal data. The Kolmogorov–Smirnov normality test was utilized to test if the continuous variables were normally distributed and prompted the use of the non-parametric Mann Whitney U test for comparison between the groups. Correlations between the quantitative variables were investigated by the Pearson correlation coefficient and Spearman rank correlation. Data was analyzed by Statistical Package for Social Sciences, version 25.0 (IBM Corp., Armonk, NY, USA) and significance level was set at p-value <0.05.

Results

In the analysis of questionnaires, 114 mountain sport athletes were investigated with median and interquartile range (IQR) of age of 30 (24-41) years, training experience of 5 (3-11) years and climbing 5 (2-15) times in the last year. Out of a total of 114 athletes, 71 (62.3%) had experience between 1 and 5 years and 43 (37.7%) had more than 5 years of participation in mountain sports. 78% of the participants (89 people) were male. 51.3% of the athletes also participated in sports outside of altitude and 70.8% had regular resistance training sessions. The distribution of athletes in different disciplines was 77 (67.5%) climbers, 11 (9.7%) skiers, 20 (17.5%) sky runners and 6 (5.3%) athletes that practiced a combination of mountain sports.

In response to the question “Have you ever had an injury while climbing that prevented you from continuing?”, 78 (68.4%) athletes had no history of injury, 31 (27.2%) athletes had a history of lower limb injury and 5 (4.4%) athletes had a history of upper limb or spine injury. In response to the question, “ Have you ever had an injury while climbing that lead to surgery?”, 12.9% of the lower limb injuries and 60% of the upper limb injuries required surgery. The frequency of injuries in mountain sports is shown separately in table 1.

In the assessment of the performance of the lower limbs of the athletes based on the LEFS questionnaire,

Table 1. The frequency of injuries in mountain sports (in percent)

Sport discipline	Injury that leads to stopping exercise			Injury that leads to surgery		
	Lower limb	Upper limb/spine	No injury	Lower limb	Upper limb/spine	No injury
Mountaineering	31.6	3.9	64.5	3.9	1.3	94.7
Skiing	27.3	18.2	54.5	9.1	0	90.9
Sky running	10	0	90	0	5	95
Combination	33.3	0	66.7	0	26.7	83.3

Table 2. Comparison of the characteristics of athletes with and without a history of acute lower limb injury

Variable median (IQR)	No injury	History of injury	p-value
Age	31.5(26-42)	28(23-40)	0.37
Years of training	5(3-12)	5(3-9)	0.94
Number of climbs in a recent year	5(3-35)	4(2-10)	0.27
LEFS score	79(74-80)	76(73-80)	0.15

Lower Extremity Functional Scale: LEFS.

the median and IQR of the scores of the athletes was 78(73.5-80), which included 64 (55.8%) athletes with a normal score and 50 (44.2%) athletes with a score that presented a reduced performance. According to sports disciplines, the median and IQR of the questionnaire scores were 76(73-80) in mountain climbers, 78(72-80) in skiers, 80(79-80) in sky running athletes, and 78(75-75-80) in the combined group.

In the comparison between the two groups with and without a history of acute injury, no significant differences were observed in the variables of age, years of training, number of climbs in the previous year, and LEFS score. As presented in table 2, the functional score of lower limbs of athletes with a history of injury is 3 less than the other group, but the difference is not statistically significant. Athletes who sustained an injury or an injury that needed surgery did not have a lower score of LEFS, r=-0.123, p= 0.19 and r=-0.081, p=0.4, respectively.

In the comparison between men and women, there were no significant differences in age, number of climbs in one year, injury rate, and LEFS score, but the median of training years in men 5 (IQR3-12) was significantly higher than women with a median value of 3 (IQR 2-6) years, (p=0.042).

Discussion

In this study, 27.4% of the mountain athletes had a history of at least one acute lower limb injury with moderate to severe severity. In the assessment of function of the lower limb of the athletes, 44.2% of them reported reduced function based on the LEFS score, which may have occurred following acute or overuse injuries. In the data analysis, no significant correlation was observed between the history of acute injury and lower limb function loss in mountain athletes.

A wide range of prevalence of lower limb injuries has been reported in studies conducted in different mountain sports disciplines; however, in most of the studies that have been published before, the most common anatomical region of acute injury in the training and competitions of mountaineering, skiing, and sky running has been the lower limbs (24-26). In a review study by Rotlan *et al*, which examined injuries in elite female athletes of skiing, most injuries were reported in knees, ankles, and feet, and the history of previous injury in the knees has been stated as a risk factor for the occurrence of re-injury (27).

In a study conducted in Iran in 2015-2016, skeletal injuries during mountaineering and rock climbing mostly involved the lower limbs (46.7%), followed by the upper limbs and spine, and the mean age of athletes with a history of trauma was 37.95 years old. Considering the difference in sports disciplines between the two studies and considering minor injuries that were included in Abbasi *et al*'s study, the difference between their results, and the present study seems reasonable. In both studies, there was no significant difference in terms of age or gender between the two groups with and without a history of injury, and there was no correlation between age, gender, and musculoskeletal injuries (4).

Although in some studies, the age of climbers was higher (4,28), in other studies, that elite athletes have been investigated, it was reported in the range of 26 to 28 years (3,25,29). The age of the participants in the current study was very close to these studies (30 years old); and in the present study, no significant correlation was observed between age and lower limb function, which is in line with the findings of the

study of Cobos *et al* (5).

Some studies reported a higher prevalence of injury in males. In the systematic review published by Rauch *et al* about climbing injuries, the incidence of injuries was higher in young men, but in their study, minor injuries were also considered (3).

In Krieger *et al*'s study, 76% of the emergency room visitors after an outdoor climbing trauma were men, with an average age of 35.8 years. In this study, most of the injuries affected multiple body regions, followed by only the lower limb injuries; the possible reason for this difference in the results is the difference in their statistical population, which included climbers with severe injuries requiring an emergency visit (28). Another reason for these differences in findings could be the greater participation of men (78%) compared to women in the present study.

Regarding the effect of gender on the prevalence of injury, different studies that have investigated different branches of mountain sports, have reached different results. It seems that more injuries, especially severe injuries, are reported in men in sport climbing, but most studies in other mountain disciplines have not reported a statistical correlation between the prevalence of injuries and the gender of athletes (3,4,28,30,31). In this study, there was no significant correlation between gender of mountaineering athletes and the prevalence of acute injury or lower limb dysfunction.

With the increase in the number of athletes and the diversification of mountain sports, the risk of lower limb dysfunction, that may occur as a result of overuse injuries, in these athletes is increasing (24). It seems that in addition to the possible impact of acute injuries on lower limb dysfunction, overuse injuries play an important role in the occurrence of these issues. In the research that have been done in other mountain sports, lack of attention to flexibility and core stability has been mentioned as risk factors (32). The other proposed factors are those which prevented effective rehabilitation after an acute injury, like mismanagement of an acute injury and early return to mountain (33). Due to the change of forces on the joints of athletes who exercise on sloping surfaces, they are at a different risk of injury than flat surface athletes. Comparison of kinetics and kinematics of walking and running on level and sloping surfaces has shown that as the slope of the track increases, the vertical ground reaction force, muscle activation pattern, and stride length of the athlete decrease. Sloping surfaces also increase the kinetic demands of the knee joint, including knee joint moment (34-36). Various factors have been investigated as risk factors for overuse injury in mountain athletes, which include muscle fatigue, lack of adequate rest days, and return to exercise despite being symptomatic (30,32,37). It seems that the causes of functional disorders of lower extremity in mountain athletes are different from the risk factors of acute injuries, and they need to be investigated more specifically in the future.

Conclusion

The high prevalence of lower limb dysfunction in mountain athletes and the lack of statistical correlation between the age, sex, or history of acute injury and lower limb dysfunction in this study indicates that other factors may play a role in the occurrence of overuse injuries in these athletes.

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Conflict of Interest

Authors declare no conflict of interest.

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