J. Phys. Ther. Sci.
25: 1269–1272, 2013

A Comparison of the Foot and Ankle Condition between Elite Athletes and Non-athletes

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Abstract. [Purpose] The purpose of this study was to compare the foot and ankle condition between elite athletes and non-athletes. [Subjects] The elite athletes group included 85 subjects (28 males and 57 females) and the non-athletes group included 85 subjects (38 males and 47 females). [Methods] All subjects were evaluated for pain (visual analogue scale, VAS) and foot and ankle condition (The Foot and Ankle Disability Index, FADI, and The Foot and Ankle Outcome Score, FAOS). [Results] The elite athlete group showed significant differences from the non-athletes group in VAS, FADI (FADI, FADI-Sports), and FAOS (FAOS-symptoms, FAOS-pain, FAOS-ADL, FAOS-sports, FAOS-QoL). In addition, a meaningful difference in VAS, FADI-Sports, and FAOS-symptoms was observed between gymnasts and wrestlers. [Conclusion] The results of this study suggest the necessity prevention of injury to the foot and ankle of elite athletes, and for the development of exercise for the rehabilitation of foot and ankle injuries, because there is a difference in foot and ankle condition between elite athletes and non-athletes.
Key words: Elite athletes, FAOS, Ankle

(This article was submitted Mar. 29, 2013, and was accepted May 20, 2013)

INTRODUCTION

In order to acquire consistent power and skill, elite athletes who aim at performance improvement spend a significant amount of time training. In the training and similar repeated processes, athletes are exposed to fatigue and the danger of injury, which may result in sports injury[1)]. Sports injury is defined as injury to the body occurring in relation to sports, causing disability in daily life or reducing enthusiasm for exercise, and is the major factor behind declines in athletes' performance. Most professional athletes have chronic injury, resulting in performance decline, so that early retirement occurs repeatedly[2)]. Accordingly, not only is supervision of athletes needed, but prevention of chronic sports injury in general persons, and allowing subjects to continue exercise consistently without losing interest in sports is also needed. Prevention of injury is most important, and when injury occurs, it is very important to allow a return to sports activities through rehabilitation.

The foot and ankle are the most common sites of both acute and chronic injury in athletes and other physically active individuals[3)]. Fong et al.[4)] reported that more than 80% of ankle injuries due to indoor volleyball, American football, martial arts, badminton, and netball were ankle sprains. When an injury to the foot or ankle occurs, athletes are limited in their ability to run, jump, kick, and change direction[5)]. Injury of the ankle is a frequently occurring sports injury, because the ankle joint plays an important role in supporting weight, and in the adjustment of movement of the lower body while walking or exercising. In particular, lateral ankle sprains are common acute injuries suffered by athletes[3)]. The most common mechanism for a lateral ankle sprain is excessive inversion and plantar flexion of the rearfoot on the tibia. The injured ligaments are located on the lateral aspect of the ankle and include the anterior talofibular, the posterior talofibular, and the calcaneofibularligaments[6)]. According to a previous study, lateral ankle sprain is caused mainly by malfunction, symptoms of which include pain, edema, weakened strength, and instability[7)]. Repeated re-injury causes Chronic Ankle Instability (CAI)[8)]; in severe cases, it can develop into post-traumatic osteoarthritis[9)]. Coughlan et al.[10)] reported CAI due to reoccurring sprain in 55–72% of cases after ankle injury, which was reported to cause residual symptoms lasting for 6–18 months.

There are various methods for analyzing of the state of the foot and ankle. The Visual Analog Scale (VAS) is used to assess subjects' foot and ankle pain and for measurement of the range of pain. The Foot and Ankle Disability Index (FADI) was designed to assess of functional limitations related to foot and ankle conditions[11)]. The Foot and Ankle Outcome Score (FAOS) is another region-specific questionnaire that has been widely reported in the foot and ankle literature[12)]. VAS, FADI, and FAOS most closely describe foot and ankle pain and condition within the past week[11, 12)].

This study was conducted in order to compare elite athletes with non-arthletes regarding foot and ankle pain and injuries using VAS, FADI, and FAOS, and to provide basic data through analysis of foot and ankle conditions of elite athletes' according to sports type, for the prevention of foot

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and ankle injury, and to emphasize the necessity of the implementation of exercise program for rehabilitation of foot and ankle injuries.

SUBJECTS AND METHODS

The subjects of this study were 85 elite athletes (28 males and 57 females) training at the athletes' village of the Korean national team and 85 general college students (38 males and 47 females). Subjects were excluded if they reported any of the following: bilateral ankle instability a history of ankle fracture or current participation in supervised physical rehabilitation. General characteristics of the subjects are shown in Table 1. The main sports of the elite athletes are listed in Table 2. The present study was approved by Sahmyook University Institutional Review Board, and all participants were given an explanation of the objective of the study and its requirements. All those who participated in the study provided their written informed consent.

Pain level was assessed using a 10-point visual analog scale (VAS), in which 0 implied no pain and 10 implied the worst possible pain. All subjects completed the FADI and FADI-Sport for self-reported measurement of function. Separate surveys were completed in order to reflect the function of the right and left ankles. The FADI includes 26 items, and the FADI-Sports include eight items. Each item is scored from 0 (unable to do) to 4 (no difficulty at all). The four pain items of the FADI are scored from 0 (unbearable) to 4 (none). The FADI has a total possible score of 104 points, while that of the FADI-Sport is 32 points. The FADI and FADI-Sport are scored separately as percentages, with 100% indicating no dysfunction[11].

The FAOS, which is designed to evaluate the conditions of the foot and ankle[12], consists of 42 items subdivided into five categories assessing pain, symptoms, activities of daily living (ADL), sport and recreational capacity, and foot and ankle-related quality of life (QoL). Each of the 42 questions of the FAOS asks patients to rate their symptoms as none, mild, moderate, severe, or extreme. A corresponding numerical score of 0 to 4 is assigned. The scores are summed and normalized into a subscale score from 0 (worst) to 100 (best).

The SPSS statistical package, version 18.0, was used to perform all statistical analyses. The general characteristics are presented as the frequencies and percentages, and the averages and standard deviations are also provided. The dependent variables were VAS, FADI (FADI, FADI-Sport), and FAOS (FAOS-symptoms, FAOS-pain, FAOS-ADL, FAOS-sports, FAOS-QoL) test. One-way ANOVA was used for analysis of the differences in the elite athletes according to the main item of sports. The LSD test was used for post hoc analysis and the results were considered significant at values of $p<0.05$.

RESULTS

Differences in VAS, FADI (FADI, FADI-Sport), and FAOS (FAOS-symptoms, FAOS-pain, FAOS-ADL, FAOS-sports, FAOS-QoL) scores between elite athletes and non-athletes are shown in Table 3. VAS showed a statistically significant difference (p=0.000) between elite athletes (2.82 ± 2.11) and non-athletes (1.01 ± 1.78), the FADI score showed a statistically significant difference (p=0.000) between elite athletes (88.92 ± 11.97) non-athletes (99.71 ± 6.61), and the FADI-Sport score showed a statistically significant difference (p=0.000) between elite athletes (24.26 ± 4.38) and non-athletes (30.13 ± 3.16). The FAOS scores showed statistically significant differences between elite athletes and non-athletes in the following items: FAOS-symptoms (p=0.000), 7.64 ± 4.54 for elite athletes, and 2.61 ± 3.96 for non-athletes; FAOS-pain (p=0.000), 5.91 ± 4.71 for elite athletes, and 1.78 ± 3.82 for non-athletes; FAOS-ADL (p=0.001), 5.07 ± 7.24 for elite athletes, and 1.91 ± 5.17 for non-athletes; FAOS-sports (p=0.000), 4.71 ± 3.43 for elite athletes, and 1.13 ± 2.15 for non-athletes; and FAOS-QoL (p=0.000), 4.14 ± 2.80 for elite athletes, and 0.81 ± 1.72 for non-athletes.

Differences in VAS, FADI, and FAOS scores per major sports type are shown in Table 4. A significant difference was observed in VAS (p=0.036) between gymnastics (1.83 ± 1.34) and wrestling (3.53 ± 2.41). FADI-Sports showed a statistically significant difference (p=0.033) between gymnastics (26.42 ± 4.70) and wrestling (22.84 ± 4.40), FAOS-symptoms showed a statistically significant difference (p=0.011) between gymnastics (5.75 ± 4.96) and wrestling (9.95 ± 4.87), and FAOS-symptoms also showed a statistically significant difference (p=0.005) between golf (5.00 ± 3.20) and wrestling (9.95 ± 4.87).

Table 1. Characteristics of the subjects (N=170)

Categories		Elite athletes (n=85)	Non-athletes (n=85)
Gender (%)	Male	28 (32.9)	38 (44.7)
	Female	57 (67.1)	47 (55.3)
Age (y)		19.79 (4.17)	20.75 (1.85)
Height (cm)		165.75 (9.95)	168.20 (8.18)
Weight (kg)		62.98 (15.21)	58.96 (11.47)

n (%) or mean (SD)

Table 2. Sports of the elite athletes (N=85)

	Sports	Total
	Hockey	5 (5.9)
	Gymnastic	12 (14.1)
	Judo	18 (21.2)
	Wrestling	19 (22.4)
	Ice Hockey	18 (21.2)
	Fencing	3 (3.5)
	Golf	10 (11.88)
Total	7 Sports	85

n (%)

DISCUSSION

The foot and ankle not only support weight, but also the

Table 3. Comparison of VAS, FADI and FAOS measures between elite athletes and non-athletes (N=170)

Categories		Elite athletes (n=85)	Non-athletes (n=85)
	VAS	2.89 (2.11) ***	1.01 (1.78)
FADI	FADI	88.92 (11.97) ***	99.71 (6.61)
	FADI-Sport	24.26 (4.38) ***	30.13 (3.16)
	FAOS-symptoms	7.64 (4.54) ***	2.61 (3.96)
	FAOS-pain	5.91 (4.71) ***	1.78 (3.82)
FAOS	FAOS-ADL	5.07 (7.24) **	1.91 (5.17)
	FAOS-sports	4.71 (3.43) ***	1.13 (2.15)
	FAOS-QoL	4.14 (2.80) ***	0.81 (1.72)

mean (SD), **p<0.01, ***p<0.001
VAS Visual Analog Scale; FADI Foot and Ankle Disability Index;
FAOS Foot and Ankle Outcome Score;
FAOS-ADL Foot and Ankle Outcome Score-activities of daily living;
FAOS-QoL Foot and Ankle Outcome Score- quality of life.

Table 4. VAS, FADI and FAOS according to the main sports of elite athletes (N=77)

Categories		Gymnastic (n=12)	Judo (n=18)	Wrestling (n=19)	Ice Hockey (n=18)	Golf (n=10)	
VAS		1.83 (1.34)	2.89 (2.59)	3.53 (2.41)	3.28 (1.60)	2.90 (2.33)	Gymnastic/Wrestling*
FADI	FADI	92.33 (10.66)	85.89 (16.42)	86.21 (12.39)	91.39 (8.60)	87.70 (8.76)	
	FADI-Sport	26.42 (4.70)	24.33 (5.13)	22.84 (4.40)	24.56 (4.12)	22.70 (3.37)	Gymnastic/Wrestling*
FAOS	symptoms	5.75 (4.96)	7.94 (4.37)	9.95 (4.87)	7.44 (3.87)	5.00 (3.20)	Gymnastic/Wrestling* Golf/Wrestling**
	pain	4.50 (2.65)	7.72 (6.35)	7.32 (5.52)	4.89 (3.61)	4.20 (3.12)	
	ADL	3.08 (3.63)	7.06 (11.62)	7.16 (7.71)	3.11 (3.48)	4.50 (4.77)	
	sports	3.58 (2.23)	5.00 (3.53)	5.05 (4.39)	4.39 (3.01)	6.00 (3.27)	
	QoL	3.50 (2.07)	4.11 (3.38)	4.47 (3.15)	5.22 (2.37)	2.70 (2.41)	

mean (SD), *p<0.05, **p<0.01
VAS Visual Analog Scale; FADI Foot and Ankle Disability Index; FAOS Foot and Ankle Outcome Score; FAOS-ADL Foot and Ankle Outcome Score-activities of daily living; FAOS-QoL Foot and Ankle Outcome Score- quality of life.

most important movements, which require the ability to properly adapt to the environment between the body and the ground and to react in a situational manner. In addition, the foot is the point of contact with the ground, and an essential role for physical activity is the provision of a base while standing and an axis while walking[13]. Ankle sprains are one of the most common injuries among young and active adults[11]. Hootman et al.[3] reported that more than 50% of all reported injuries were to the lower extremies in both practice and games, with knee and ankle injuries accounting for most of the injuries of the lower extremities in college athletics. In addition, injury rates for three specific conditions across sports were highlighted as ankle ligament sprain, anterior cruciate ligament (ACL) injury, and concussion. Thus, the present study was conducted to compare foot and ankle conditions between elite athletes and non-athletes.

Wikstrom et al.[14] conducted a study comparing of FADI and FADI-Sports scores between subjects with no residual symptoms (Coper) and those with chronic ankle instability (CAI). According to their results, FADI was 98.7 ± 3.5% in the Coper group, and 95.2 ± 6.1% in the CAI group and FADI-Sport was 98.4 ± 4.6% in the Coper group and 92.9 ± 9.1% in the CAI group Higher values were observed in the group with ankle pain, indicating that the FADI score increases when subjects experience pain. A study by McKeon et al.[15] also reported that FADI of a control group with CAI was 82.9 ± 7.4%, and FADI-Sport was 66.5 ± 9.8%. In our present study, FADI scores of elite athletes and non-athletes were 88.92 ± 11.97, and 99.71 ± 6.61, and the FADI-Sport scores were 24.26 ± 4.38, and 30.13 ± 3.16, respectively statistically significant differences (both, p=0.000). VAS of elite athletes, was 2.89 ± 2.11, and 1.01 ± 1.78 for non-athletes, a statistically significant difference (p=0.000). This means that subjects in the elite athletes group experienced more pain than non-athletes. This result suggests, elite athletes might have overused their feet and ankles through excessive training, and such overuse causes repeated damage which exceeds the body's recovery ability. The observed phenomenon would have been caused by fatigue over a long period of time, resulting in the FADI score of the elite athletes group being lower than that of the non-athletes group.

The FAOS is a widely used foot and ankle-specific score[16]. In the present study, the FAOS score showed statistically significant differences, 7.64 ± 4.54, and 2.61 ± 3.96

(p=0.000), for the elite athletes and non-athletes, respectively, for symptoms, 5.91 ± 4.71, and 1.78 ± 3.82 (p=0.000), respectively, for pain, 5.07 ± 7.24, 1.91 ± 5.17 (p=0.001), respectively for ADL, 4.71 ± 3.43, 1.13 ± 2.15 (p=0.000), respectively for sports, and 4.14 ± 2.80, and 0.81 ± 1.72 (p=0.000), respectively for QoL, indicating the foot and ankle conditions of the elite athletes group was worse than that of the non-athletes group.

We also analyzed differences among five sports types (gymnastics, judo, wrestling, ice hockey, and golf), which had more than 10 athletes. Wrestling showed a significant differences in VAS (p=0.036), FADI-Sports (p=0.033), and FAOS-symptoms (p=0.011), compared with gymnastics, and golf showed a significant difference in FAOS-symptoms (p=0.005), compared with wrestling. Lin et al.[17] reported that the top three sites of injury for males were the waist (11.1%), ankle joint (10.1%), and finger (9.6%), and the ankle joint (13.6%), knee (12.5%), and waist (11.3%) for females in elite wrestlers. Jarret et al.[18] reported that the major causes of sport injury in wrestling are sprain and bruise, and that a large number of injuries caused by violent physical strength due to instantaneous or excessive loads, and overuse, etc. The important basic physical fitness factors required for wrestling events are muscular endurance, physical strength, quickness, agility, and flexibility, as well as anaerobic power, all of which affect athletic performance[19]. A possible explanation for why wrestling showed significant differences in foot and ankle conditions, compared with gymnastics and golf, is that physical activities such as wrestling require a large amount of energy, or high intensity bursts of exercise, which may cause injury to the muscles and other tissues, which may increase the inflammatory response of the body and strain the ankle. We consider these factors were responsible for wrestlers' foot and ankle pain.

The present study showed that elite athletes' foot and ankle conditions were worse than those of non-athletes. In particular, the elite wrestlers showed the greatest difference. We suggest that prevention of injury to prevent chronic of elite athletes' sports injuries of the foot and ankle is necessary. In cases of injury, attention should be paid to the foot and ankle conditions for the return to the sports activity, through foot and ankle instability rehabilitation, such as foot and ankle strengthening exercises, balance and neuromuscular control exercises, and range of motion exercises, as tolerated[5].

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