


## Article

# Analysis of Sports Injury in Lower Extremities of High School Taekwondo Athletes

Hyeri Oh <sup>1</sup>, Hyosung Lim <sup>2,\*</sup> and Minsoo Jeon <sup>3,\*</sup> <sup>1</sup> School of Sports Medicine, Cha University, Pocheon-si 11160, Korea; simbi0430@naver.com<sup>2</sup> Industry-Academy Cooperation Foundation, Sangmyung University, Seoul 03016, Korea<sup>3</sup> Department of Sports Science, Korea National Sport University, Seoul 05541, Korea

\* Correspondence: limhyosung@gmail.com (H.L.); minsu1144@nate.com (M.J.)

**Abstract:** Sports injuries frequently occur in athletes during competitive activities and practice routines, and the causes include cumulative fatigue from repetitive training, lack of warm-up exercises, and absence of motivation during competition. We aimed to determine the frequency and characteristics of lower extremity injuries in high school Taekwondo athletes. This study evaluated lower extremity sports injuries in 473 high school Taekwondo athletes. We conducted frequency and cross analyses. The questionnaire tools were developed to identify the characteristics of lower extremity injuries in Taekwondo athletes. **Results:** For injury by person, thigh injuries and re-injuries were most frequent. In non-contact injury, ankle injuries and re-injuries were most numerous. In the men's lightweight category, thighs were injured the most in injury by person and ankles suffered the most non-contact injuries. In the men's heavyweight category, the number of knee injuries was highest in injury by person, and the number of ankle injuries was highest in non-contact injury. In the women's lightweight category, thighs suffered a higher number of injuries by person, whereas ankles had the highest number of non-contact injuries. In the women's heavyweight category, thighs had the highest number of injuries by persons, whereas ankles had the highest number of non-contact injuries. The causes of ankle injury in weight classes were different in the two sexes. **Conclusion:** In this study, we confirmed that the sports damage suffered by student athletes mainly occurs as injuries in training situations without opponents. Our findings could help formulate basic guidelines for preventing sports injury in Taekwondo.

**Keywords:** Taekwondo athletes; sports injury in lower extremities; injury by person; non-contact injury; Taekwondo



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## 1. Introduction

Sports injury is a significant factor that weakens the performance levels of athletes, though various opinions exist regarding the matter. Ref. [1] argued that prevention of lower extremity injuries among Taekwondo players is essential since they are experienced by 75% of Taekwondo athletes experience lower extremities injuries. In addition, according to [2], the rate of lower extremity injuries suffered by Taekwondo players is significantly higher (60.5%) than injuries to other joints. According to a study by [3], international sports organizations such as the Federation International de Football Association (FIFA) and the International Olympic Committee (IOC) are involved in various efforts to prevent and deal with sports injuries.

Sports injuries commonly occur in athletes during competition and practice routines. Moreover, as [4] argued, the causes of injuries include cumulative fatigue from repeated training, the lack of warm-up exercises, and the absence of motivation during the competition. In addition, Ageberg et al. [5] reported that injuries vary according to the characteristics of each sport, and risk of injury is related to dynamic interaction with the opponent and high levels of training exposure. Ref. [6] surveyed the injuries of athletes

who participated in the 2012 London Olympic Games and found that Taekwondo, soccer, and bicycle motocross (BMX) athletes more frequently suffered injuries.

In particular, Taekwondo, which causes many sports injuries, involves one-on-one competition with an opponent. According to the characteristics of Taekwondo competition, sports damage frequently occurs while hitting an opponent, or while putting down the foot after engaging in a foot maneuver. About 66.7% of participants suffer injuries, experiencing more lower-limb than upper-limb injuries [7].

In Taekwondo competitions, sports injuries commonly involve three sites in the lower extremities: the ankles, knees, and thighs [8]. These sports injuries appear to have a significant impact on the levels of stress, anxiety, and confidence, and on the degree of sport continuation among Taekwondo athletes [9]. In addition, sports injury is also an important concern for coaches.

Several previous studies on sports injuries in Taekwondo events were conducted during certain competitions or events, such as the World Cup or national team events [7]. In Korea, a study was conducted on sports injury in high school athletes [9]. These studies provided data on sports injury and its prevention; however, they did not identify detailed characteristics regarding the mechanism of the injuries that occur in athletes. In addition, as the regulations of Taekwondo competitions continue to change, the performance skills and training methods of the athletes change correspondingly. Therefore, it may be appropriate to study the recent trends in sports injuries in Taekwondo.

In this study, we aimed to determine the frequency and characteristics of lower extremity injuries in high school Taekwondo athletes. Hence, an extensive investigation was conducted regarding the frequency of sports injury, the cause of the sports injury (such as injury by person), non-contact injury, the degree of injury (such as if it required surgery, a cast, rest, etc.), and time of injury (during competition or during practice).

## 2. Research Methods

### 2.1. Research Participants

To achieve this research aim, a simple random sampling method was used as this is the most representative method sampling a dataset. This method gives equal probability to each datum. Approximately 3000 data points were collected, and 500 samples were selected out of these, each data point having a 1/6 chance of being sampled. A random table was used.

Questionnaires were distributed to 500 high school Taekwondo athletes who participated in the study. The sample size of 500 was calculated based on the number of high school Taekwondo athletes registered at the Korea Sports Council [10]. This included 3314 athletes (men: 2315; women: 999) and 373 samples were required to meet the 95% confidence interval and 5% sampling error. We explained the purpose and outline of the research to the participants before distributing the questionnaire. The participants responded to the survey only if they voluntarily agreed after hearing this explanation. Out of the 500 selected participants, 27 were excluded from the research data owing to the rejection of responses and unreliability in responding to the questionnaires. Finally, 473 (male athletes: 367, and female athletes: 106) had a 4% sampling error for 3314 high school Taekwondo athletes. The demographic characteristics of the study participants are listed in Table 1.

### 2.2. Research Tool

The questionnaire tools were developed to identify the characteristics of lower extremity injuries in Taekwondo athletes. The first step in developing the survey questions was to identify and analyze the sports injuries (parts, forms, causes, etc.) occurring in sports events by conducting a literature review to produce survey areas and formulate basic questions. In the second phase, an expert group, including athletes with experience in sports injury, Taekwondo experts, and professors with experience in creating questionnaires, reviewed and agreed on the survey area and basic questions produced in the first

phase. A preliminary survey of 20 high school Taekwondo athletes was conducted with the developed questionnaires. In this phase, the final 29 questions were finally established after identifying the problems (misunderstanding, question difficulties, etc.) that arose from the survey responses and opinions of the survey. The questionnaire finally included demographic questions (sex, affiliation, athlete's career, winning experience, and participated events), injury-related questions (on the ankles, knees, and thighs) based on the time of injury, and post-injury treatment questions based on the cause of injury (injury caused by direct contact or indirect contact with the opponent). The questionnaires for assessing lower extremity injuries in high school Taekwondo athletes are shown in Table 2.

**Table 1.** Demographic characteristics of research participants.

Classification			Case Number (Persons)	Ratio (%)
Sex	Male		367	77.6
	Female		106	22.4
Event in career	Regional Competition		137	29.0
	National Competition		328	69.3
	Asian Region Competition		5	1.1
	World Championship		3	0.6
Weight class	Men's	Lightweight	299	63.2
		Heavyweight	68	14.4
	Women's	Lightweight	73	15.4
		Heavyweight	33	7.0

**Table 2.** Questionnaire developed to assess sports injury in lower extremities.

Areas		Categories	Number of Questions
Background questions		Sex, affiliation, athlete’s career, winning experience, and weight class	5
Ankle	Injury by person *	Injury status, injury frequency, injury period, and post-injury treatment method	8
	Non-contact injury **		
Knee	Injury by person *	Injury status, injury frequency, injury period, and post-injury treatment method	8
	Non-contact injury **		
Thigh	Injury by person *	Injury status, injury frequency, injury period, and post-injury treatment method	8
	Non-contact injury **		
Total			29

\* Injury by person: The athlete inflicts an impact on the opponent and injures their limb or when the opponent contacts the athlete and causes an injury. \*\* Non-contact injury: An injury that occurs when the mechanism of the injury does not involve contact with the opponent, such as when they twist an ankle or rotate a knee while weight bearing.

### 2.3. Data Processing

Frequency analysis was performed using Microsoft office Excel 2019 software (Redmond, WA, USA) to evaluate the lower extremity injuries in these athletes, and the ratio was calculated as follows: First, the rate was calculated based on the total number of cases frequency of injury/total number of cases  $\times 100$ ), and other variables such as re-injury and exercise were calculated based on the frequency of injury experiences (frequency of re-injury/frequency of injury $\times 100$ ). Second, a chi-square test ( $\chi^2$ ) was conducted to verify the differences in the weight classes using IBM SPSS 25.0. The statistical significance level was set at 0.05. Meanwhile, throughout the course of the study, data confidentiality was thoroughly protected.

### 3. Results

#### 3.1. Analysis of the Causes of Lower Extremity Sports Injury in High School Taekwondo Athletes

Tables 3–5 shows the results of the frequency analysis of the causes of lower extremity sport injuries in high male, female) school taekwondo athletes.

**Table 3.** Frequency analysis of the types of lower extremity sports injuries in high school Taekwondo athletes (n = 473).

Classification		Injury by Person (A)			Non-Contact Injury (B)			A + B *		
		Ankle (n, %)	Knee (n, %)	Thigh (n, %)	Ankle (n, %)	Knee (n, %)	Thigh (n, %)	Ankle (n, %)	Knee (n, %)	Thigh (n, %)
Injury experiences		79 (21.2)	117 (31.4)	141 (37.8)	67 (18.0)	48 (12.9)	17 (4.6)	201 (53.9)	62 (16.6)	16 (4.3)
Re-injury **		65 (82.3)	72 (61.5)	117 (83.0)	51 (76.1)	4 (8.3)	5 (29.4)			
Injury during practice		67 (84.8)	96 (82.1)	125 (88.7)	54 (80.6)	24 (50.0)	10 (58.8)			
Injury during competition		59 (74.7)	78 (66.7)	106 (75.2)	23 (34.3)	43 (89.6)	4 (23.5)			
Recovery method	Surgery	2 (2.5)	7 (6.0)	2 (1.4)	3 (4.5)	4 (25.0)	0 (0.0)			
	Cast	18 (22.8)	9 (7.7)	3 (2.1)	15 (22.4)	12 (25.0)	0 (0.0)			
	Therapy	40 (50.6)	73 (62.4)	62 (44.0)	34 (50.7)	0 (0.0)	6 (35.3)			
	Rest	16 (20.3)	24 (20.5)	55 (39.0)	13 (19.4)	26 (54.2)	9 (52.9)			
	Other	3 (3.8)	4 (3.4)	19 (13.5)	2 (3.0)	6 (12.5)	2 (11.8)			

\* A + B indicates athletes who have injury experiences involving both injury by person and non-contact injury. \*\* Re-injury: The athlete reports that there had been a previous injury.

**Table 4.** Frequency analysis of the types of lower extremity injuries in male high school Taekwondo athletes.

Classification		Injury by Person (A)			Non-Contact Injury (B)			A + B *		
		Ankle (n, %)	Knee (n, %)	Thighs (n, %)	Ankle (n, %)	Knee (n, %)	Thighs (n, %)	Ankle (n, %)	Knee (n, %)	Thighs (n, %)
Lightweight (n = 299)										
Injury experience		61 (20.4)	71 (23.7)	89 (29.8)	31 (10.4)	31 (10.4)	9 (3.0)	110 (36.8)	34 (11.4)	10 (3.3)
Re-injury **		53 (86.9)	42 (59.2)	71 (79.8)	0 (0.0)	7 (22.6)	6 (66.7)			
Injury during practice		57 (93.4)	55 (77.5)	77 (86.5)	23 (74.2)	16 (51.6)	6 (66.7)			
Injury during competition		47 (77.0)	46 (64.8)	68 (76.4)	11 (35.5)	7 (22.6)	1 (11.1)			
Heavyweight (n = 68)										
Injury experience		11 (16.2)	19 (27.9)	17 (25.0)	8 (11.8)	6 (8.8)	3 (4.4)	33 (48.5)	12 (17.6)	3 (2.9)
Re-injury		8 (72.7)	14 (73.7)	11 (64.7)	7 (87.5)	2 (33.3)	1 (33.3)			
Injury during practice		8 (72.7)	17 (89.5)	16 (94.1)	6 (75.0)	5 (83.3)	2 (66.7)			
Injury during competition		8 (72.7)	14 (73.7)	13 (76.5)	2 (25.0)	2 (33.0)	3 (100)			

\* A + B indicates athletes who have injury experiences involving both injury by person and non-contact injury. \*\* Re-injury: The athlete reports that there had been a previous injury.

**Table 5.** Frequency analysis of the types of lower extremity sports injuries in female high school Taekwondo athletes.

Classification	Injury by Person (A)			Non-Contact Injury (B)			A + B *		
	Ankle (n, %)	Knee (n, %)	Thighs (n, %)	Ankle (n, %)	Knee (n, %)	Thighs (n, %)	Ankle (n, %)	Knee (n, %)	Thighs (n, %)
Lightweight (n = 73)									
Injury experience	6 (8.8)	16 (21.9)	23 (31.5)	20 (27.4)	7 (9.6)	2 (2.7)	38 (45.2)	11 (15.1)	3 (4.1)
Re-injury **	3 (50.0)	7 (43.8)	18 (78.3)	16 (80.0)	3 (42.9)	1 (50.0)			
Injury during practice	4 (66.7)	13 (81.3)	23 (100)	18 (90.0)	5 (71.4)	1 (50.0)			
Injury during competition	3 (50.0)	9 (56.3)	15 (65.2)	7 (35.0)	1 (14.3)	0 (0.0)			
Heavyweight (n = 33)									
Injury experience	1 (3.0)	11 (33.3)	12 (36.4)	8 (24.2)	4 (12.1)	3 (9.1)	20 (60.6)	5 (15.2)	0 (0.0)
Re-injury	1 (100)	9 (81.8)	12 (100)	6 (75.0)	3 (75.0)	2 (66.7)			
Injury during practice	1 (100)	11 (100)	11 (91.7)	7 (87.5)	2 (50.0)	1 (33.3)			
Injury during competition	1 (100)	9 (81.8)	10 (83.3)	3 (37.5)	0 (0.0)	0 (0.0)			

\* A + B indicates athletes who have injury experiences involving both injury by person and non-contact injury. \*\* Re-injury: The athlete reports that there had been a previous injury.

### 3.2. Comparison of the Causes of Sports Injury (Injury by a Person vs. Non-Contact Injury according to the Weight Class of Taekwondo Athletes)

Table 6 shows a comparison of the causes of lower extremity injuries according to the weight classes of the Taekwondo athletes for both sexes. In male athletes, the ankles were mostly involved in injuries caused by a person, whereas in female athletes, non-contact ankle injuries were frequently noted. In addition, a cross-analysis showed that  $\chi^2 = 43.248$ ,  $p < 0.001$ , which demonstrates that the weight classes of both sexes had a statistically significant association with the causes of sports injury. In contrast, both the knee and thigh were involved the most in injuries caused by a person, but there was no statistically significant difference.

**Table 6.** Comparative analysis of the types of lower extremity sports injuries according to the weight class in high school Taekwondo athletes.

Classification	A	B	A + B *	No Injury	df	$\chi^2$	p
Ankle (n, %)							
Men's lightweight	61 (20.4)	31 (10.4)	110 (36.8)	97 (32.4)	9	43.248	<0.001
Men's heavyweight	11 (16.2)	8 (11.8)	33 (48.5)	16 (23.5)			
Women's lightweight	6 (8.2)	20 (27.4)	38 (52.1)	9 (12.3)			
Women's heavyweight	1 (3.0)	8 (24.2)	20 (60.6)	4 (12.2)			

Table 6. Cont.

Classification	A	B	A + B *	No Injury	df	$\chi^2$	p
Knee (n, %)							
Men's lightweight	71 (23.7)	31 (10.4)	34 (11.4)	163 (54.5)	9	5.916	0.748
Men's heavyweight	19 (27.9)	6 (8.8)	12 (17.6)	31 (45.6)			
Women's lightweight	16 (21.9)	7 (9.6)	11 (15.1)	39 (53.4)			
Women's heavyweight	11 (33.3)	4 (12.1)	5 (15.2)	13 (39.4)			
Thigh (n, %)							
Men's lightweight	89 (29.8)	9 (3.0)	10 (3.3)	191 (63.9)	9	6.387	0.701
Men's heavyweight	17 (25.0)	3 (4.4)	3 (4.4)	45 (66.2)			
Women's lightweight	23 (31.5)	2 (2.7)	3 (4.1)	45 (61.6)			
Women's heavyweight	12 (36.4)	3 (9.1)	0 (0.0)	18 (54.5)			
A: Contact injury, B: non-contact injury							

\* A + B indicates athletes who have injury experiences involving both injury by person and non-contact injury.

#### 4. Discussion and Conclusions

This study was designed to identify the characteristics and causes of sports injuries in 473 high school Taekwondo athletes who were surveyed on their experience with sports injuries, causes (injury by person vs. non-contact injury), re-injury rate, injury period, and injury mechanism. We found that sports injuries caused by a person occurred more frequently than non-contact injuries. This can be explained by the nature of the Taekwondo competition. When competing with an opponent, we found that interperson injuries by an individual are inevitably frequent, which agrees with the results of a study by [11]. In addition, national Taekwondo athletes (mostly adults) were reported to sustain several injuries in the lower extremities, including the ankles, knees, and thighs [7]; however, here, high school athletes are reported to injure the knees most, followed by the thighs and ankles. Therefore, sports injuries may be directly associated with the career levels of the athletes, but further research is warranted to determine the exact correlation.

In contrast, with respect to injuries by a person, high school Taekwondo athletes experienced more injuries during practice than during competition. In the 2012 London Olympic Games, a higher number of injuries occurred during practice (66.7%) than during competitions (33.3%) [3]. This is because in all competitive sports, including Taekwondo, athletes spend more time training than competing. The results of our present study showed that there were many non-contact re-injuries of the ankle. The non-contact injuries of the thigh that occur frequently during competition are indications that athletes may require more proprioceptive training [12] and balance training [13], which could allow athletes to properly place their feet on the mat after a striking movement, such as after performing a kick. Non-contact injuries of the anterior cruciate ligaments have been investigated in several studies as they frequently occur in soccer [14]. The occurrence of non-contact knee injuries in high school Taekwondo athletes stresses the necessity of an injury-prevention strategy and program, especially as 66.7% of athletes with previous injuries were found to suffer chronic pain [15]. Therefore, to reduce the occurrence of chronic pain in high school athletes, various programs need to be implemented to prevent injuries. Moreover, ankles were found to have a high re-injury rate, even with non-contact



injuries. Therefore, prevention and training are necessary to reduce the prevalence of chronic pain among athletes.

An analysis of the causes of injury in both sexes according to weight class and injury site showed no differences in any areas, except in the ankles. Ankle injuries were thought to occur more frequently in heavyweight competitions; however, in this research, the results showed that ankle injuries were more numerous in lightweight men's competitions. This can be explained by the strategies applied in the competitions and, moreover, by the different training methods of athletes in different weight classes. In particular, the lightweight class, with a higher number of step movements and kicks, had a greater number of ankle injuries than the heavyweight class.

This study has some limitations. The injuries were limited to the lower extremities, and the research method was a self-survey. In addition, as sports damage was not studied according to age, it seems necessary to include this in future studies. Nevertheless, this study's [16,17] strength is in the method by which we investigated the student athletes, which was not followed in prior studies. We also identified the mechanisms of injury in the athletes by differentiating between the causes (injury by person vs. non-contact injury). We think that the results of this study can provide basic data to be used for implementing programs or training guidelines to prevent sports injuries in the future.

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