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Research article

Differences in Sports Injury Types According to Taekwondo Athlete Types (Sparring, Poomsae, and Demonstration)

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Abstract
The objective of this study was to investigate the range of injuries according to the competition format type of Taekwondo (sparring, poomsae, and demonstration) and compare the level of injuries to provide basic data for preventing injuries among Taekwondo athletes. Data were collected through a survey of 472 Taekwondo athletes using convenience sampling and self-administration methods. The most frequently injured body part was the ankle for sparring (54.03%) and demonstration (55.09%) athletes and the pelvis for poomsae (36.36%) athletes ($x^2 = 111.556$, $p < 0.001$). The most frequent injury type was sprain for poomsae (36.40%) and demonstration (52.30%) athletes and fracture for sparring (49.40%) athletes ($x^2 = 127.752$, $p < 0.001$). The most frequently reported cause of injury was excessive training and chronic fatigue ($x^2 = 50.251$, $p < 0.001$). All three types of athletes showed a higher proportion of injury at the training location than at the competition location. The period for the return to training was ≤1 week for sparring (40.80%) and poomsae (64.10%) athletes but 2 - 3 weeks for demonstration (27.8%) athletes ($x^2 = 45.582$, $p < 0.001$). Diverse strategies, ranging from wearing protective gear to adopting a conditioning strategy and psychological training, are needed for each competition format of Taekwondo to prevent injuries in daily training.

Key words: Taekwondo, Athlete; Sports injuries; Martial arts.

Introduction

Taekwondo is a traditional martial art form in South Korea and a popular sport with approximately 80 million trainees across 206 countries worldwide (Kazemi and Pieter, 2004; Thomas et al., 2017). In contrast to other sports types, Taekwondo involves the use of quick force of the hands and feet to attack the weakest points of the human body (Minghelli et al., 2020; Zhao et al., 2020). This is why fatal sports injuries may occur during Taekwondo training and competition (Covarrubias et al., 2015). Taekwondo can cause various injuries as it requires aggressive encounters with the opponent (Kazemi et al., 2009; Altarriba-Bartes et al., 2014; Fortina et al., 2017).

Taekwondo is categorized into three types: sparring, poomsae, and demonstration. In sparring, victory or defeat is determined by the number of strikes between the players (Kazemi et al., 2009); this entails an extremely high risk of injuries due to external shock or difficult movements, and acute injury may occur due to an imbalance of internal force even in the absence of physical contact (Covarrubias et al., 2015; Lystad et al., 2013; Pieter et al., 2012).

Poomsae is a system of techniques designed for training in attack and defense movements with a virtual opponent. Victory or defeat is determined by the accuracy, proficiency, and force dynamics of the poomsae set (Korea Taekwondo Federation, 2015; World Taekwondo Association, 2015; Yoo et al., 2018). Although poomsae involves no striking, additional scores are given for accurate movements and kicks, and the performance of related movements can result in various injuries (Edgar and Kazemi, 2020; Kazemi et al., 2016).

Demonstration in Taekwondo involves all components of Taekwondo, from the basic movements to sparring, poomsae, self-defense, and breaking. Therefore, in a demonstration, athletes perform high-intensity techniques, including kicks, turning kicks, jumping, and landing (Lee et al., 2020). As a demonstration involves kicks and mid-air movements similar to acrobatics, the risk of injuries during a demonstration is very high (Lee and Shin, 2014).

The athletic techniques and abilities required for a given sport type may demand high-intensity exercises or strong external force in some cases to inflict harm on the body, which may, in turn, result in sports injuries (Bahr and Holme, 2003; Brunner et al., 2019). Taekwondo involves a multitude of attack and defense forms that may generate significant destructive power while requiring athletes to have a substantial level of concentration (Ji, 2016; Cho et al., 2018). In addition, as Taekwondo demands agility and quick adaptation as well as numerous changes in movement direction and high-level changes in technique within a set time and space, the injury type varies, raising concerns regarding the severity of injuries in comparison to those in other sport types (Altarriba-Bartes et al., 2014; Zetaruk et al., 2005). The response measures to prevent and manage sports injuries are crucial, as injuries may reduce not only the performance of athletes with outstanding abilities but also threaten their lives (Emery and Pasanen, 2019; Klein et al., 2020).

Hence, studies have investigated the type and current status of Taekwondo-related sports injuries, but most have focused on the characteristics of injuries to athletes (Zhao et al., 2020; Kazemi et al., 2009; Altarriba-Bartes et al., 2014; Fortina et al., 2017; Ji, 2016; Son et al., 2020; Zhao et al., 2021; Beis et al., 2007). However, they have not clearly distinguished the types of injuries according to the competition format of Taekwondo (sparring, poomsae,

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and demonstration). Thus, this study aimed to compare the characteristics of sports injuries among athletes in each competition format of Taekwondo (sparring, poomsae, and demonstration). This will enable instructors and athletes to identify the risk of injury by event and plan individual training programs for injury prevention and rehabilitation.

Methods

Study participants

This study investigated the factors related to sports injuries and rehabilitation and the influence of injury on the performance of athletes according to the type of Taekwondo (sparring, poomsae, and demonstration). The participants in this study were athletes in each competition format of Taekwondo in 2021. For the survey, convenience sampling and self-administration methods were used. During data collection, each participant was given a clear description of the purpose of the study and asked whether they were willing to participate in it. The athletes agreed to participate in our study after completely understanding its purpose and methods in accordance with the ethical principles of the Declaration of Helsinki. The survey was conducted for 2 weeks (from February 1 to February 12, 2021). The present researcher and two research assistants distributed a total of 500 survey questionnaires. The survey was administered to a nationally representative group of Korean university students. Because the survey did not collect identifier information, obtaining ethical approval was not required.

Among the collected questionnaires, 28 were excluded due to a lack of sports injuries, incomplete data, or unreliable responses, leaving 472 in the final analysis. The general characteristics of the participants, as analyzed from the questionnaires, are presented in Table 1. The mean age of the participants was 21.42 ± 2.32 years, with 303 males (64.2%) and 169 females (35.8%). The training experience was ≤ 6 years for 89 athletes (18.9%), 6 - 10 years for 205 athletes (43.4%), 11 - 15 years for 146 athletes (30.9%), and ≥16 years for 32 athletes (6.8%). The training hours per day were 1 - 2 h for 98 athletes (20.8%), 3 h for 167 athletes (35.4%), 4 h for 127 athletes (80.0%), and ≥5 h for 80 athletes (16.9%).

This study used a structured questionnaire to investigate sports injuries according to the competition format of Taekwondo (sparring, poomsae, and demonstration). The questionnaire comprised 13 items; five on personal characteristics (age, sex, training experience, athlete type, and daily training hours) (Ji, 2016; Kazemi et al., 2005), four on injury type (injury place/part/type, and cause of injury) (Covarrubias et al., 2015; Kazemi et al., 2009; Kazemi et al. 2005; Geßlein et al., 2020), and four on the influence of injury on performance (time until return to training/game, complete cure or not, and relapse or not) (Pieter et al., 2012).

Data analysis

All questionnaires were collected at the end of the survey, and those with inaccurate or incomplete data were excluded. In all, 472 questionnaires were analyzed. For data analysis, IBM SPSS 23.0 (IBM Corporation, Armonk; NY; USA) was used. A frequency analysis was performed to analyze the demographics. A Chi-squared test was used for crossover analysis of the frequency-related differences and to analyze the characteristics of injuries according to the competition format of Taekwondo. The significance level was set to $p < 0.05$.

Table 1. General characteristics of the study participants.

Characteristics	Section	Frequency (Persons)	Composition (%)	Accumulation (%)
Sex	Male	303	64.2	64.2
	Female	169	35.8	100.0
Athlete type	Sparring	124	26.3	26.3
	Poomsae	132	28.0	54.2
	Demonstration	216	45.8	100.0
Training period	<6 years	89	18.9	18.9
	6–10 years	205	43.4	62.3
	11–15 years	146	30.9	93.2
	≥16 years	32	6.8	100.0
Training hours per day	1–2 hours	98	20.8	20.8
	3 hours	167	35.4	56.1
	4 hours	127	26.9	83.1
	≥ 5 hours	80	16.9	100.0
Characteristics	**Section**	**Sparring**	**Poomsae**	**Demonstration**
Sex	Male	69 (44.4)	69 (52.3)	165 (76.4)
	Female	55 (55.6)	63 (47.7)	51 (23.6)
Training period	<6 years	13 (10.5)	35 (26.5)	41 (19.0)
	6–10 years	79 (63.7)	44 (33.3)	82 (38.0)
	11–15 years	28 (22.6)	44 (33.3)	74 (34.3)
	≥16 years	4 (4.3)	9 (6.8)	19 (8.8)
Training hours per day	1–2 hours	10 (8.1)	40 (30.3)	48 (22.2)
	3 hours	24 (19.4)	54 (40.9)	89 (41.2)
	4 hours	53 (42.7)	31 (23.5)	43 (19.9)
	≥ 5 hours	37 (29.8)	7 (5.3)	36 (16.7)

Data are provided as numbers (%).

Results

Sports injury location according to the competition format of Taekwondo

Crossover analysis was performed to analyze the differences in the location at which the athletes sustained injury according to the Taekwondo competition format. The results showed significant differences in injury location between sparring, poomsae, and demonstration ($x^2 = 18.162$, $p < 0.001$) (Figure 1; Supplementary Table S1). The rate of injury at the training location was the highest in poomsae athletes (97.0%, n = 128), followed by demonstration (92.6%, n = 200) and sparring (82.3%, n = 102) (Figure 1) athletes. However, the most common location of injuries was the training location for all athletes.

Sport s injury by body part according to the competition format of Taekwondo

A crossover analysis was performed to analyze the differences in injuries by body part according to the competition format of Taekwondo (Figure 2; Supplementary Table S2). The results showed significant differences in injuries by body part among sparring, poomsae, and demonstration ($\chi^2 = 111.556$, $p < 0.001$). For sparring athletes, the most frequently affected body part was the ankle (n = 67, 54.03%), followed by the knee (n = 20, 16.13%), wrist (n = 18, 14.52%), and pelvis (n = 9, 7.25%). For demonstration athletes, the most frequently affected body part was the ankle (n = 119, 55.09%), followed by the knee (n = 53, 24.54%), pelvis (n = 17, 7.87%), and trunk (n = 15, 6.94%). For poomsae athletes, the most frequently affected body part was the pelvis (n = 48, 36.36%), followed by the ankle (n = 35, 26.52%), knee (n = 30, 27.73%), and trunk (n = 12, 9.09%).

Sports injury type according to the competition format of Taekwondo

A crossover analysis was performed to analyze the differences in injury type according to the competition format of Taekwondo athletes. The results (Figure 3; Supplementary data Table S3) showed significant differences in injury type among sparring, poomsae, and demonstration athletes ($\chi^2 = 127.752$, $p < 0.001$). For sparring athletes, the most frequent injury type was fracture (n = 60, 49.4%), followed by sprain (n = 30, 24.2%) and contusion (n = 17, 13.7%).

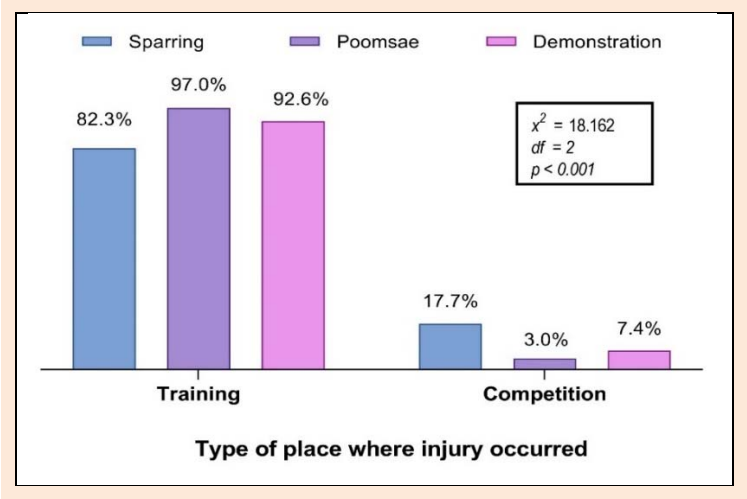

Figure 1. Location of injury according to Taekwondo athlete type.

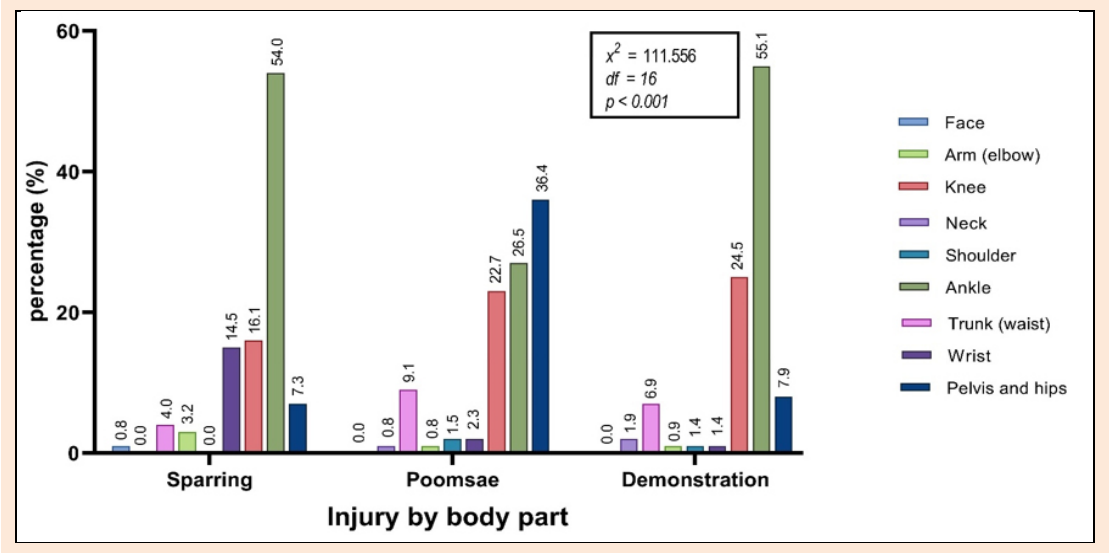

Figure 2. Sports injury by body part according to Taekwondo athlete type.

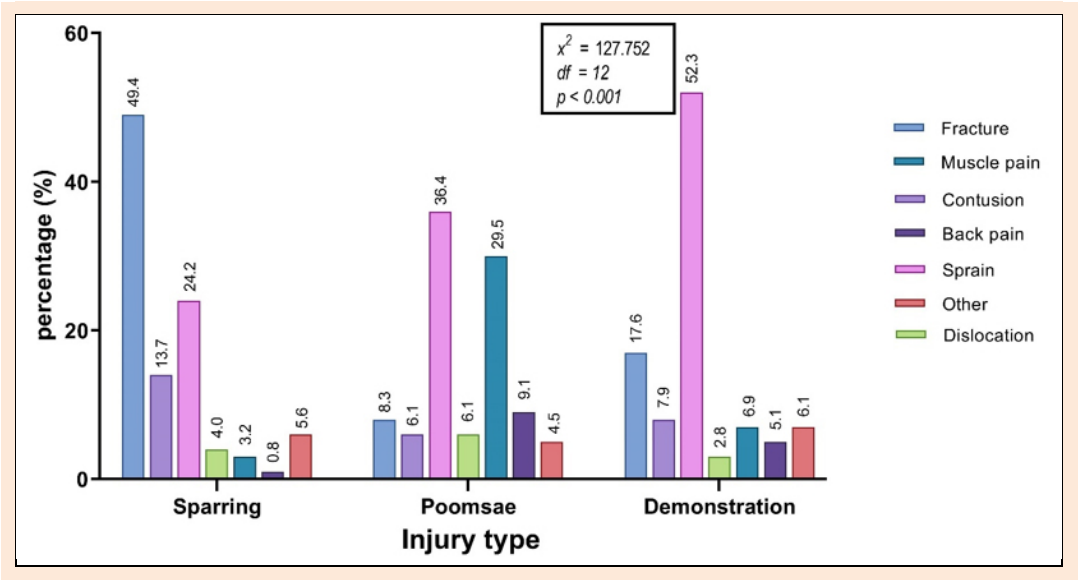

Figure 3. Sports injuries according to Taekwondo athlete type.

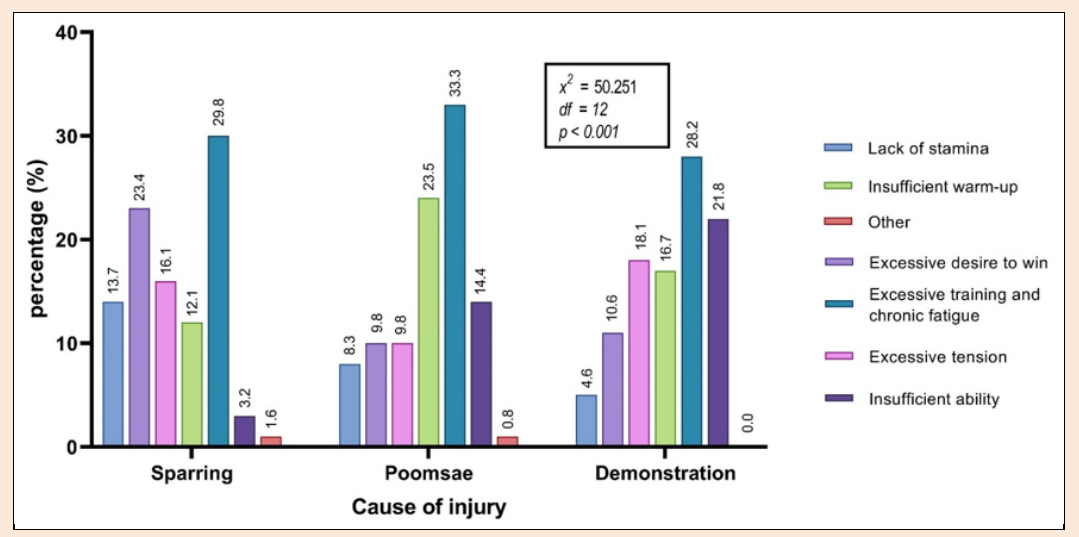

Figure 4. Causes of injury type according to Taekwondo athlete type.

For poomsae athletes, the most frequent injury type was sprain (n = 48, 36.4%), followed by muscle pain (n = 39, 29.5%), back pain (n = 12, 9.1%), and fracture (n = 11, 8.3%). For demonstration athletes, the most frequent injury type was sprain (n = 113, 52.3%), followed by fracture (n = 38, 17.6%), contusion (n = 17, 7.9%), and muscle pain (n = 15, 6.9%).

Causes of injury type according to the competition format of Taekwondo

A crossover analysis was performed to analyze the causes of injury according to the competition format of Taekwondo. The results (Figure 4; Supplementary Table S4) showed significant differences in the causes of injury among sparring, poomsae, and demonstration athletes (χ^2 = 50.251, p < 0.001). For sparring athletes, the most frequent cause of injury was excessive training and chronic fatigue (n = 37, 29.8%), followed by excessive desire to win (n = 29, 23.4%) and excessive tension (n = 20, 16.1%). For poomsae athletes, the most frequent cause of injury was excessive training and chronic fatigue (n = 44, 33.3%), followed by insufficient warm-up (n = 31, 23.5%), insufficient ability (n = 19, 14.4%), excessive desire to win (n = 13, 9.8%), and excessive tension (n = 13, 9.8%). For demonstration athletes, the most frequent cause of injury was excessive training and chronic fatigue (n = 61, 28.2%), followed by insufficient ability (n = 47, 21.8%), excessive tension (n = 39, 18.1%), and insufficient warm-up (n = 36, 16.7%).

Time until return to training according to the competition format of Taekwondo

A crossover analysis was performed to analyze the time until the return to training according to the Taekwondo competition format. The results (Figure 5; Supplementary Table S5) showed significant differences in the time until return to training among sparring, poomsae, and demonstration athletes (χ^2 = 45.582, p < 0.001). A relatively similar pattern was found for the sparring and poomsae athletes, where most injured athletes required 1 week or less to return to training (sparring, n = 50, 40.8%, poomsae, n = 45, 64.1%), followed by 2 - 3 weeks (sparring, n = 25,

20.2%; poomsae, n = 33, 25.0%), and 4 weeks (sparring, n = 23, 18.5%, poomsae, n = 21, 15.9%). Conversely, most demonstration athletes required 2 - 3 weeks (n = 60, 27.8%), followed by 2 - 3 months (n = 44, 20.4%) and 1 week or less (n = 35, 16.2%).

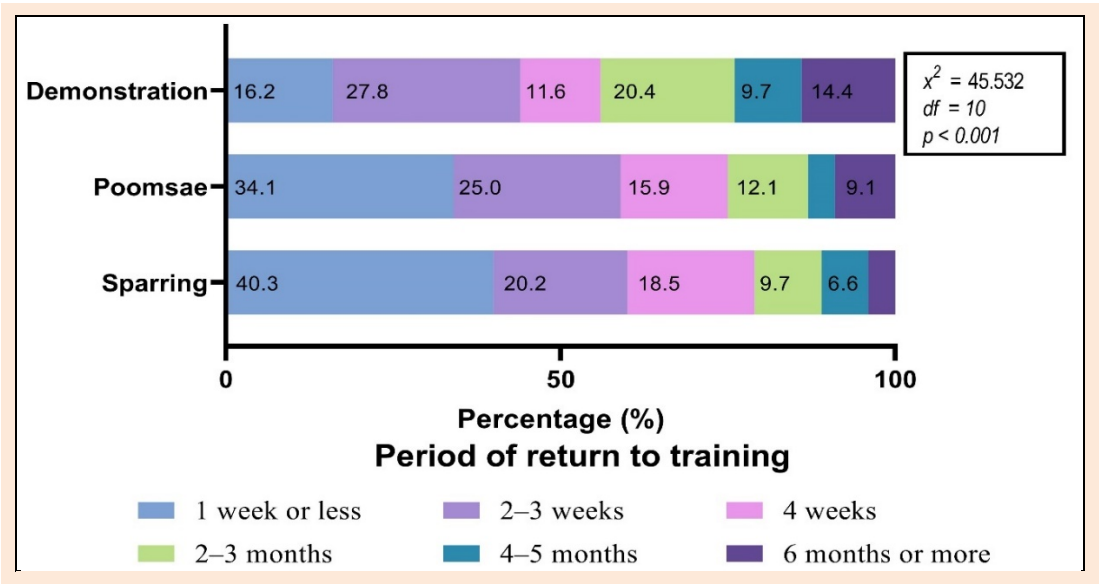

Figure 5. Time required to return to training based on Taekwondo athlete type.

Discussion

This study was the first to investigate the differences in injury according to the competition format of Taekwondo (sparring, poomsae, and demonstration) and specify the typical injury for these formats. The study results showed significant differences in the injured body part, injury type, cause of injury, and period for return to training among the different competition formats. Ankle injuries were most frequent among sparring athletes, while pelvic injuries were most common for poomsae athletes. A sprain was the most frequent injury type in poomsae and demonstration athletes, but a fracture was the most frequent injury type in sparring athletes. Excessive training and chronic fatigue were the most frequently reported causes of injury across all athletes. The period for the return to training was mostly 1 week or less for sparring and poomsae athletes but 2 - 3 weeks for demonstration athletes. The results suggested that different strategies should be planned for each type of Taekwondo athlete to prevent injuries during Taekwondo training and competition.

All three types of athletes showed a higher proportion of injury at the training location than at the competition location (Figure 1). Many previous studies have reported injuries that occurred during tournament games (Kazemi et al., 2009; Ji, 2016; Beis et al., 2007). Conversely, almost no study has yet compared the injuries in training and competition. In this study, the injuries were shown to occur most frequently at training, irrespective of the type of athletes. This is presumed to be because acquiring technical skills and practice games mainly occur during training. Notably, sparring athletes rarely wear protective gear in training. In addition, the protective gear for poomsae and demonstration athletes has not been adequately developed, despite these athletes training for extremely dangerous techniques (Jeong, 2017). The results indicated that far more efforts should be taken in daily training to prevent injuries among athletes. Moreover, the instructor should mandate the wearing of protective gear in the training space (Beis et al., 2007), and suitable protective gear should be developed for each competition format of Taekwondo.

The most frequently injured body parts were the ankle and knee for sparring and demonstration athletes and the pelvis and knee for poomsae athletes. In previous studies, the most frequently injured parts were the lower limb structures, including the ankle and knee, for sparring athletes (Kazemi and Pieter, 2004; Lystad et al., 2013). In a study on injury mechanisms in sparring athletes, lower limb injuries mostly occurred when or where kicking was performed to gain the attack score (Ji, 2016). In demonstration athletes, on the other hand, the impact force during the landing of 10-fold or higher than the body weight is generated on the ankle when the athlete lands on the floor after the highest possible jump, resulting in ankle fractures (Lee et al., 2020; Zhang et al., 2000). Such elaborate foot and jumping techniques, including landing after mid-air movements, are likely to increase the frequency of ankle and knee injuries (Lee et al., 2020). Meanwhile, the pelvis was the most frequently injured body part for poomsae athletes, likely due to the performance of movements that exceed the suitable range of motion since kicking movements that exceed the joint's range of motion are often given high scores in poomsae (World Taekwondo Federation, 2015; Edgar and Kazemi, 2020). Despite poomsae being the only noncontact competition format of Taekwondo, poomsae athletes face a variety of injuries, indicating the need for various strategies, such as taping and muscular strengthening, to prevent injuries.

In contrast to previous studies, the most frequent injury type was fracture for sparring athletes, followed by sprain and contusion. Ji (2016) found that the most frequent

injury type for sparring athletes was a contusion, followed by sprain and fracture; other studies have also found contusion to be the most frequent injury in sparring athletes (Thomas et al., 2017; Zhao et al., 2020). The different injury patterns reported in previous studies can be attributed to data collection on injuries during tournament games. Fractures have been reported mainly in hand and ankle sparring athletes (Geßlein et al., 2020). While the lower limbs are mainly used in kicking for a head and body attack, the upper limbs are primarily used in defense (Lystad et al., 2009). Meanwhile, the most frequent injury type for poomsae and demonstration athletes was a sprain. Kazemi et al. (2016) reported that sprain was the most frequently occurring injury in poomsae athletes who participated in global competitions in the last 3 years. This appears to be due to the high frequency of performance of movements that exceed the joint's range of motion in poomsae (Edgar and Kazemi, 2020; Kazemi et al., 2016). As poomsae is based on high scores for hyper-mobility and perfection of performance, poomsae athletes are thought to suffer from sprains frequently since they use strenuous techniques. Meanwhile, to the best of our knowledge, no study has yet reported on injuries in demonstration athletes. Nonetheless, Edgar and Kazemi (2020) pointed out the dangers of excessive training by reporting cases of a knee ligament sprain in world-class athletes. The athletes of the demonstration team practice thousands of kicking movements a day to master a high level of performance, and this excessive training may cause the muscles and ligaments to exceed physical limitations with consequent gradual damage (Kazemi et al., 2016).

The most frequent cause of injury in all athletes was excessive training and chronic fatigue. Numerous previous studies reported excessive training as the cause of injury in Taekwondo athletes (Covarrubias et al., 2015; Edgar and Kazemi, 2020). In line with this, the results of this study showed that approximately 80% of participating athletes trained for 3 hours or more per day, indicating a considerably high level of training (Supplementary Table S2). For elite athletes, a high level of training is necessary for improved performance. However, such training should be accompanied by proper rest and conditioning training. Notably, after the daily style-specific training, the athletes should be guided to perform muscular strengthening, balance training, and plyometric training to prevent injuries (Lee et al., 2020; Brunner et al., 2019; Castañeda-Babarro et al., 2021).

Furthermore, the most frequent cause of injury for sparring athletes was excessive desire to win and excessive tension. In addition, a previous study reported that excessive tension prevents athletes from performing to their original level of performance (Li et al., 2019). This indicates the need for psychological strategies to resolve the excessive tension or desire to win among sparring athletes.

For poomsae athletes, the cause of injury with relatively high frequency was insufficient warm-up or ability. This may be attributed to negligence in performing warm-up exercises, as poomsae athletes are required to perform relatively few movements that cause stress. In general, poomsae athletes perform warm-up and cool-down exercises individually. As the warm-up and cool-down exercises positively influence the injury rate (Schlüter-Brust et al., 2011), instructors should always include warm-up and cool-down exercises as part of the entire training program.

The most frequent cause of injury for demonstration athletes was the insufficient ability and excessive tension. Lee et al. (2020) reported that athletes with insufficient ability often experience injuries while performing complex movements, such as jumping over high position obstacles or mid-air kicking; this supports the result of this study. In addition, excessive tension appears to cause injuries through unnatural movements, as it reduces coordination among movements (Li et al., 2019).

Therefore, to prevent the cause of injury in athletes, the amount of training should be reduced, and athletes must be given a mandatory period of warm-up exercise. Psychological strategies should be developed to prevent an excessive desire to win and excessive tension.

Regarding return to training, sparring and poomsae athletes mostly required 1 week or less to return to training, while some required 2–3 weeks. Demonstration athletes mostly required 2–3 weeks, while some required 2–3 months. For athletes, the loss of time due to injury not only affects their future performance and outcome but also negatively affects their athletic career. In this study, most athletes were shown to have returned to training within 2–3 weeks, but the relapse rate was relatively high at approximately 65.5% (Supplementary Table S5). This is presumed to be due to the high probability of the athletes' return without a complete cure or the lack of stepwise rehabilitation training after injury. Therefore, a complete cure after injury should be confirmed, and athletes should be given continuous and step-by-step rehabilitation training to prevent relapse, ensure complete recovery, and prevent further injuries. A high number of demonstration athletes responded that 2–3 months were required for the return to training, highlighting the high severity of injury in demonstration athletes. Thus, various plans should be implemented for demonstration athletes, such as wearing protective gear during training, performing mandatory warm-up and cool-down exercises, and fostering an active response for recovery.

Conclusion

This study showed that injuries by body part, injury type, location of the injury, cause of injury, and period for return to training varied according to the competition format of Taekwondo (sparring, poomsae, and demonstration). Hence, different strategies need to be developed according to the competition format of Taekwondo athletes to prevent injuries. The results also emphasize wearing protective gear, conditioning strategies, and psychological training. With scientifically based diversified strategies, the instructors and athletes can help increase performance while extending their athletic careers. As the participants of this study were university Taekwondo athletes, the results may not be generalizable to all Taekwondo athletes. Therefore, a follow-up study that expands the research population to the entire group by random selection of probability sampling is required.

Acknowledgements

The experiments complied with the current laws of the country in which they were performed. The authors have no conflicts of interest to declare. The datasets generated and analyzed during the current study are not publicly available, but are available from the corresponding author who was an organizer of the study.

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Key points

- Injuries by body part, injury type, location of the injury, cause of injury, and period for return to training varied according to the competition format of Taekwondo (sparring, poomsae, and demonstration).
- Different strategies need to be developed according to the competition format of Taekwondo athletes to prevent injuries.
- Wearing protective gear, conditioning strategies, and psychological training should be encouraged.
- With diversified strategies, instructors and athletes can achieve outstanding results as well as have long and healthy athletic careers.

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Supplementary Tables

Table S1. Location of injury according to Taekwondo athlete type.

Variables	Sparring (n)	Poomsae (n)	Demonstration (n)	Total (N)	x^2	df	p
Training location	102 (82.3%)	128 (97.0%)	200 (92.6%)	430 (91.1%)			
Competition location	22 (17.7%)	4 (3.0%)	16 (7.4%)	42 (8.9%)	18.162	2	0.000
Total	124 (100.0%)	132 (100.0%)	216 (100.0%)	472 (100.0%)			

Table S2. Sports injury by body part according to the Taekwondo athlete type.

Variables	Sparring (n)	Poomsae (n)	Demonstration (n)	Total (N)	x^2	df	p
Face	1 (0.81%)	0 (0.00%)	0 (0.00%)	1 (0.21%)			
Neck	0 (0.00%)	1 (0.76%)	4 (1.85%)	5 (1.06%)			
Trunk (waist)	5 (4.00%)	12 (9.09%)	15 (6.94%)	32 (6.78%)			
Arm(elbow)	4 (4.03%)	1 (0.76%)	2 (0.93%)	7 (1.48%			
Shoulder	0 (0.00%)	2 (1.52%)	3 (1.39%)	5 (1.1%)			
Wrist	18 (14.52%)	3 (2.27%)	3 (1.39%)	24 (5.08%)	111.556	16	0.000
Knee	20 (16.13%)	30 (27.73%)	53 (24.54%)	103 (21.82%)			
Ankle	67 (54.03%)	35 (26.52%)	119 (55.09%)	221 (46.82%)			
Pelvis and hips	9 (7.26%)	48 (36.36%)	17 (7.87%)	74 (15.68%)			
Total	124 (100%)	132 (100%)	216 (100%)	472 (100%)			

Table S3. Sports injuries according to Taekwondo athlete type.

Variables	Sparring (n)	Poomsae (n)	Demonstration (n)	Total (N)	x2	df	p
Fracture	60 (49.4%)	11 (8.3%)	38 (17.6%)	100 (23.1%)	127.752	12	0.000
Contusion	17 (13.7%)	8 (6.1%)	17 (7.9%)	42 (8.9%)			
Sprain	30 (24.2%)	48 (36.4%)	113 (52.3%)	191 (40.5%)			
Dislocation	5 (4.0%)	8 (6.1%)	6 (2.8%)	19 (4.0%)			
Muscle pain	4 (3.2%)	39 (29.5%)	15 (6.9%)	58 (12.3%)			
Back pain	1 (0.8%)	12 (9.1%)	11 (5.1%)	24 (5.1%)			
Other	7 (5.6%)	6 (4.5%)	16 (7.4%)	29 (6.1%)			
Total	124 (100.0%)	132 (100.0%)	216 (100.0%)	472 (100.0%)			

Table S4. Causes of injury according to Taekwondo athlete type.

Variables	Sparring (n)	Poomsae (n)	Demonstration (n)	Total (N)	x2	df	p
Lack of stamina	17 (13.7%)	11 (8.3%)	10 (4.6%)	38 (8.1%)	50.251	12	0.000
Excessive desire to win	29 (23.4%)	13 (9.8%)	23 (10.6%)	65 (13.8%)			
Excessive tension	20 (16.1%)	13 (9.8%)	39 (18.1%)	72 (15.3%)			
Insufficient warm-up	15 (12.1%)	31 (23.5%)	36 (16.7%)	82 (17.4%)			
Excessive training and chronic fatigue	37 (29.8%)	44 (33.3%)	61 (28.2%)	142 (30.1%)			
Insufficient ability	4 (3.2%)	19 (14.4%)	47 (21.8%)	70 (14.8%)			
Other	2 (1.6%)	1 (0.8%)	0 (0.0%)	3 (0.6%)			
Total	124 (100.0%)	132 (100.0%)	216 (100.0%)	472 (100.0%)			

Table S5. Time required to return to training based on Taekwondo athlete type.

Variables	Sparring (n)	Poomsae (n)	Demonstration (n)	Total (N)	x2	df	p
1 week or less	50 (40.3%)	45 (34.1%)	35 (16.2%)	130 (27.5%)	45.532	10	0.000
2–3 weeks	25 (20.2%)	33 (25.0%)	60 (27.8%)	118 (25.0%)			
4 weeks	23 (18.5%)	21 (15.9%)	25 (11.6%)	69 (14.6%)			
2–3 months	12 (9.7%)	16 (12.1%)	44 (20.4%)	72 (15.3%)			
4–5 months	8 (6.6%)	5 (3.8%)	21 (9.7%)	34 (7.2%)			
6 months or more	6 (4.8%)	12 (9.1%)	31 (14.4%)	49 (10.4%)			
Total	124 (100.0%)	132 (100.0%)	216 (100.0%)	472 (100.0%)			