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Original Research

# A survey study on sports injury by age for male athletes in combat sports

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**Abstract**

**Background**: Sports injury is critical for elite athletes, especially those in combat sports, which have high injury risk as the athletes attack their opponents' bodies to win. The purpose of this study was to examine the injury frequency according to the injured area and injury rate on two occasions (training and competitions) by age and sports in male combat athletes.

**Methods**: The subjects in this study comprised 1,263 athletes who were registered as athletes in middle school, high school, university, and professional levels in men's combat sports (boxing, fencing, judo, taekwondo, and wrestling) at the Korean Sports and Olympic Committee. An online-based survey was conducted. We carried out a frequency analysis using the R statistics program, and calculated a 95% confidence interval.

**Results**: The highest injury experience rates were in boxing (59.3%) and taekwondo (72.7%) for professional level, in judo (60.5%) and wrestling (57.7%) for university level, and in fencing (54.8%) for high school level. The results of the analysis showed that injury occurred least frequently in the following body parts: the head in fencing (19.1%) and judo (18.0%), torso in taekwondo (14.1%) and wrestling (18.1%), and lower extremities in boxing (13.7%). The most frequently injured body parts were the lower extremities in fencing (33.1%) and taekwondo (38.9%), upper extremities in judo (30.5%) and wrestling (31.9%), and head in boxing (37.4%). The injury incidence rates during competitions, by age, were 0.03, 0.11, 0.14, and 0.14 for the middle school, high school, university, and professional levels, respectively. The injury incidence rates during competitions, by sports, were 0.06, 0.07, 0.14, 0.15, and 0.16 in judo, wrestling, taekwondo, boxing, and fencing, respectively. The injury incidence rates during training, by age, were 1.33, 1.46, 1.71, and 1.75 for the middle school, high school, university, and professional levels, respectively. The injury incidence rates during training, by sports, were 1.25, 1.36, 1.57, 1.79, and 1.86 in judo, wrestling, fencing, taekwondo, and boxing, respectively. The overall analysis of injury incidence rate is 0.10 during competitions, and 1.52 during training, irrespective of age and sports type.

**Conclusion**: The area of injury and proportion vary according to the type of sports. However, in accordance with the definition of time loss, the injury incidence rate during training was tenfold compared to the IR during competitions, and the injury incidence rate in striking sports was higher than in grappling sports during both training and competitions.

**Keywords**

Male; Athlete; Sports injury; Combat sports; Injury rate

## 1. Introduction

Combat sports have a relatively high injury risk because competitive contact sports, including man-to-man games, require the athletes to attack their opponents to get points or to overpower their competitors in order to win. Even if combat sports are referred to as risky sports, long-term investigations about specific injury rates are insufficient [1].

There are various causes of injury, namely, factors related to physical and mental conditions, such as imbalance of muscle strength, lack of flexibility, mental anxiety, and environmental factors, such as protective equipment and the condition of the stadium [2]. Furthermore, injury is a severe


  

factor that influences the athletes' career. Minor injuries can cause athletes to miss short-term trainings and competitions; serious injuries, however, may require operations and medical treatments that can cause athletes to miss long-term trainings and competitions, or even to retire as an athlete in the worst case scenario. A survey reported that 24% of Norwegian top female retired athletes in 38 sports, stated that their retirement was due to injury [3].

A number of previous studies on fencing and taekwondo [4–6], on adult players [7–9], and on specific events, such as the Olympics and championships [10–12]. Sports injuries often occur not only during competitions but also during trainings; however, there are few studies carried out to investigate these occasions separately.

Therefore, the purpose of this study was to investigate and compare the occurrence of injury during training sessions and during competitions, by sports and by age groups, in male combat sports, and to construct basic data for precaution guidance development, which may help to manage athletes and enable players to improve their performance.

## 2. Materials and methods

### 2.1 Participants

This study extracted a quota sample (non-probability sampling) from athletes in middle school, high school, university, and professional levels in men's combat sports (boxing, fencing, judo, taekwondo, and wrestling) who were registered at the Korean Sports and Olympic Committee (KOC); we, then, collected data from 1,263 athletes by using snowball sampling. The purpose and process of the study were explained to the participants of the survey, and consent was received for the collection and use of personal information, which included voluntary participation in the study; the questionnaire was filled in a self-administration method. Since data sets on the questionnaire did not include private identifying information, such as mobile phone number, home address, and affiliation, ethical approval was not required. Collected personal information included the participants' sex, birth year, age group, and sports. The study was approved by an institutional review board, and ethical approval was waived. Table 1 shows the age distribution of the participants, classified according to sports type.

### 2.2 Measurement tool

The measurement tool of this study was an online questionnaire. It was modified to the updated domestic situation of combat sports athletes through expert meetings, by referring to previous researches [13–17], in investigating elite athletes' injury occurrence experiences. The tool was designed to select singular and plural responses, depending on the characteristics of the questions. The definition of injury in this study was time loss [18–21], which was the failure to participate in competitions or trainings for at least 24 hours within 12 months since September 2018. The injury incidence rate (IR) was divided into two items: the rate during competitions {*Number of Injuries* / [*Average Number of Competitions per Year* × *Average Number of Games per Year* (i.e. *the number of matches*)]}; and the rate during training [{*Number of Injuries* / (*Average Training Days per Week* × *Average Training Time per Day*)} × 1,000] [4, 22, 23]. To calculate those items, the frequency of IR was identified by classifying the average number of training days per week, average training duration per day, number of matches and competitions that they participated in, and competition or training situation. The survey was conducted through an online form to easily access and shorten the response time, and was divided into sections, depending on the body parts, so that the sections about individuals' non-injured areas can be omitted, and only those about the injured areas be answered according to whether an injury incident occurred or not. Although the response time for each athlete varied with their individual injured parts and frequency of injuries, the average was approximately 15 min.

**TABLE 1. Frequency of sports injury occurrence**

| Sports | Age group | n | % | Yes | | No | |
|---|---|---|---|---|---|---|---|
| | | | | n | % | n | % |
| Boxing | M | 9 | 5.2 | 1 | 11.1 | 8 | 88.9 |
| (n = 173) | H | 95 | 54.9 | 40 | 42.1 | 55 | 57.9 |
| | U | 42 | 24.3 | 20 | 47.6 | 22 | 52.4 |
| | P | 27 | 15.6 | 16 | 59.3 | 11 | 40.7 |
| Fencing | M | 22 | 16.1 | 4 | 18.2 | 18 | 81.8 |
| (n = 137) | H | 31 | 22.6 | 17 | 54.8 | 14 | 45.2 |
| | U | 63 | 46.0 | 32 | 50.8 | 31 | 49.2 |
| | P | 21 | 15.3 | 9 | 42.9 | 12 | 57.1 |
| Judo | M | 88 | 27.8 | 31 | 35.2 | 57 | 64.8 |
| (n = 317) | H | 141 | 44.5 | 68 | 48.2 | 73 | 51.8 |
| | U | 76 | 24.0 | 46 | 60.5 | 30 | 39.5 |
| | P | 12 | 3.8 | 4 | 33.3 | 8 | 66.7 |
| Taekwondo | M | 42 | 15.5 | 19 | 45.2 | 23 | 54.8 |
| (n = 271) | H | 146 | 53.9 | 68 | 46.6 | 78 | 53.4 |
| | U | 72 | 26.6 | 40 | 55.6 | 32 | 44.4 |
| | P | 11 | 4.1 | 8 | 72.7 | 3 | 27.3 |
| Wrestling | M | 123 | 33.7 | 51 | 41.5 | 72 | 58.5 |
| (n = 365) | H | 150 | 41.1 | 59 | 39.3 | 91 | 60.7 |
| | U | 71 | 19.5 | 41 | 57.7 | 30 | 42.3 |
| | P | 21 | 5.8 | 11 | 52.4 | 10 | 47.6 |
| Total | | 1263 | 100 | 585 | 46.3 | 678 | 53.7 |

M: Middle school, H: High school, U: University, P: Professional.

### 2.3 Procedure

This study carried out an online survey for about two months since November 2019. The target sample was selected among the athletes who registered as elite players at the KOC in 2019, and a 90% confidence level and 10% margin of error was set for each sport and age. In this study, 86.9% athletes (64.2% in boxing, 60.7% in fencing, 106.0% in judo, 75.7% in taekwondo, and 125.8% in wrestling) responded to form the target sample (274 boxers, 257 fencers, 300 judo players, 362 taekwondo players, and 291 wrestlers). A total of 1,263 responses were used for the study, after excluding 27 responses from the entire data, which were either unreliable

**TABLE 2. Frequency and proportion of sports injury according to the injured area (multiple answers were allowed)**

| Location Of Injury | Frequency (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Age group | | | | Sports | | | | |
| | M | H | U | P | Boxing | Fencing | Judo | Taekwondo | Wrestling |
| Head | 27 (16.9) | 82 (20.0) | 74 (25.2) | 25 (28.4) | 52 (37.4) | 22 (19.1) | 43 (18.0) | 33 (16.7) | 58 (22.3) |
| Torso | 27 (16.9) | 77 (18.8) | 56 (19.0) | 18 (20.5) | 25 (18.0) | 26 (22.6) | 52 (21.8) | 28 (14.1) | 47 (18.1) |
| Upper Extremity | 59 (36.9) | 134 (32.8) | 74 (25.2) | 21 (23.9) | 43 (30.9) | 29 (25.2) | 73 (30.5) | 60 (30.3) | 83 (31.9) |
| Lower Extremity | 47 (29.3) | 116 (28.4) | 90 (30.6) | 24 (27.2) | 19 (13.7) | 38 (33.1) | 71 (29.7) | 77 (38.9) | 72 (27.7) |
| Total | 160 (100) | 409 (100) | 294 (100) | 88 (100) | 139 (100) | 115 (100) | 239 (100) | 198 (100) | 260 (100) |

M: Middle school, H: High school, U: University, P: Professional.

or a duplicate submission. Based on the number of selected target samples from a quota sample, the link to the questionnaire was sent to the respective associations and universities through text messages after requesting their participation in the survey. Considering the cases in both middle and high school students who might not fully understand the questions, the researchers visited the schools and competition sites in person to conduct the survey using the QR code and the questionnaire link.

### 2.4 Statistical analysis

The data collected in this study were analyzed using the R statistics program. The analysis was performed to determine whether the injuries had occurred or not, and whether the frequency of injury related to age group and the type of sports. The IR was calculated using the formula according to the two occasions (competitions and training), and a 95% confidence interval was calculated.

## 3. RESULTS

### 3.1 Injury occurrence experiences

Table 1 presents the injury experiences of the male combat sports athletes. There were 585 athletes (46.3%) who had experienced injuries, whereas 678 athletes (53.7%) had not experienced injuries. The highest incidence rates were in boxing (59.3%) and taekwondo (72.7%) for the professional level, in judo (60.5%) and wrestling (57.7%) for the university level, and in fencing (54.8%) for the high school level.

### 3.2 Frequency of sports injury depending on injured area

Table 2 shows the results of sports injury frequency depending on the injured area classified by the age group and the type of sports. The frequency rates of injuries to the torso accounted for the smallest proportions in all ages (middle school 16.9%, high school 18.8%, university 19.0%, and professional 20.5%). The middle school and high school groups had experienced upper extremity injury the most, with rates of 36.9% and 32.8%, respectively. The lower extremity was, however, the most frequently injured part in the university group, with a rate of 30.6%. The professional group stated that the highest number of injuries was in the head area, with a rate of 28.4%.

The results of the analysis, based on the type of sports, showed that the least frequently injured areas were the head in fencing (19.1%) and judo (18.0%), the torso in taekwondo (14.1%) and wrestling (18.1%), and the lower extremities in boxing (13.7%). The most frequently injured areas, on the other hand, were the lower extremities in fencing (33.1%) and taekwondo (38.9%), the upper extremities in judo (30.5%) and wrestling (31.9%), and the head in boxing (37.4%).

### 3.3 Injury incidence rate (IR)

The IR according to the age group was calculated based on two occasions: during the competitions and during the training sessions. The results of the analysis (see Table 3) showed that the older the athletes were, the higher the IR during both occasions in all the listed sports; specifically, the IRs during competitions were 0.03, 0.11, 0.14, and 0.14 for the middle school, high school, university, and professional levels, respectively, and the IRs during trainings were 1.33, 1.46, 1.71, and 1.75 for the middle school, high school, university, and professional levels, respectively. On the other hand, the results of the analysis, according to the type of sports regardless of age showed that the IRs during competitions were 0.06, 0.07, 0.14, 0.15, and 0.16 in judo, wrestling, taekwondo, boxing, and fencing, respectively; the IRs during trainings were 1.25, 1.36, 1.57, 1.79, and 1.86 in judo, wrestling, fencing, taekwondo, and boxing, respectively. The overall analysis of IR was 0.10 during competitions and 1.52 during trainings, irrespective of the age group and the type of sports.

### 3.4 Injury rate during competitions

In terms of age, it was found that during competitions, both middle school (0.00) and university (0.08) levels had their lowest IRs in boxing, whereas their highest IRs were in taekwondo with values of 0.04 and 0.21, respectively. In addition,

**TABLE 3. Injury Incidence Rate (IR)**

| Age group | IIS | Boxing | | Fencing | | Judo | | Taekwondo | | Wrestling | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | IR | 95% CI | IR | 95% CI | IR | 95% CI | IR | 95% CI | IR | 95% CI | IR | 95% CI |
| M | C | 0.00 | 0.00<br>0.00 | 0.01 | -0.01<br>0.03 | 0.02 | 0.00<br>0.04 | 0.04 | 0.01<br>0.07 | 0.03 | 0.01<br>0.05 | 0.03 | 0.02<br>0.04 |
| | T | 0.53 | -0.63<br>1.69 | 0.70 | -0.46<br>1.86 | 1.55 | 0.38<br>2.72 | 2.35 | 0.59<br>4.11 | 0.98 | 0.59<br>1.37 | 1.33 | 0.84<br>1.82 |
| H | C | 0.17 | 0.06<br>0.28 | 0.31 | -0.17<br>0.79 | 0.04 | 0.02<br>0.06 | 0.14 | 0.08<br>0.20 | 0.06 | 0.00<br>0.12 | 0.11 | 0.07<br>0.15 |
| | T | 1.75 | 0.95<br>2.55 | 1.59 | 0.31<br>2.87 | 1.07 | 0.70<br>1.44 | 1.45 | 0.79<br>2.11 | 1.63 | 1.00<br>2.26 | 1.46 | 1.16<br>1.76 |
| U | C | 0.08 | 0.04<br>0.12 | 0.18 | 0.06<br>0.30 | 0.14 | 0.01<br>0.27 | 0.21 | 0.07<br>0.35 | 0.09 | 0.02<br>0.16 | 0.14 | 0.09<br>0.19 |
| | T | 1.36 | 0.36<br>2.36 | 2.30 | 0.98<br>3.62 | 1.43 | 0.78<br>2.08 | 2.17 | 1.01<br>3.33 | 1.25 | 0.75<br>1.75 | 1.71 | 1.28<br>2.14 |
| P | C | 0.23 | 0.03<br>0.43 | 0.05 | -0.01<br>0.11 | 0.03 | -0.03<br>0.09 | 0.05 | 0.01<br>0.09 | 0.24 | -0.02<br>0.50 | 0.14 | 0.05<br>0.23 |
| | T | 3.43 | -0.84<br>7.70 | 0.40 | 0.04<br>0.76 | 0.16 | -0.02<br>0.34 | 1.55 | 0.25<br>2.85 | 1.94 | 0.29<br>3.59 | 1.75 | 0.41<br>3.09 |
| Total | C | 0.15 | 0.08<br>0.22 | 0.16 | 0.04<br>0.28 | 0.06 | 0.02<br>0.10 | 0.14 | 0.09<br>0.19 | 0.07 | 0.04<br>0.10 | 0.10 | 0.08<br>0.12 |
| | T | 1.86 | 1.02<br>2.70 | 1.57 | 0.87<br>2.27 | 1.25 | 0.85<br>1.65 | 1.79 | 1.24<br>2.34 | 1.36 | 1.04<br>1.68 | 1.52 | 1.29<br>1.75 |

M: Middle School, H: High School, U: University, P: Professional, C: Competition, T: Training. IIS: Injury Incidence Situation, IR: Injury Incidence Rate.

both high school (0.04) and professional levels (0.03) had their lowest IRs in judo, and the highest IRs in the high school (0.31) and professional (0.24) levels were in fencing and wrestling, respectively. Furthermore, the middle school level had the lowest IR in all of the sports listed: 0.00 in boxing, 0.01 in fencing, 0.02 in judo, 0.03 in wrestling, and 0.04 in taekwondo.

### 3.5 Injury rate during trainings

According to the age group, during trainings, high school (1.07) and professional (0.16) levels had their lowest IRs in judo, while their highest IRs were in boxing, with values of 1.75 and 3.43, respectively. The middle school level had its lowest IR in boxing (0.53) and its highest IR in taekwondo (2.35). The university level had its lowest IR in wrestling (1.25) and its highest IR in fencing (2.30).

## 4. Discussion

This study examined the actual state of injury occurrences in male combat sports athletes, according to age groups (middle and high schools, university and professional) and types of sports (boxing, fencing, judo, taekwondo, and wrestling) to understand injury experiences, such as the frequency of sports injury depending on injured area and the IR.

The number of athletes who had experienced injury was 585 (46.3%), while the number of those who have not was 678 (53.7%). According to Chung's study [4], 43.6% of the 399 middle and high school fencers reported that they had been injured, while 56.4% reported they had not, which was similar to the findings of our study. Furthermore, more injuries occurred in high school athletes than those in middle school ($P < 0.001$), and high school (54.8%) athletes had the highest injury experience rate in fencing according to this research. Thus, the findings from this study agreed with those of the cited previous study.

Korean elite fencers' injury frequency rates were 47.2% for the lower extremity, 26.4% for the upper extremity, 21.4% for the torso, and 5.0% for the head and neck [24]. Moreover, fencers in middle and high schools are more likely to get injured in the ankles (18.2%), followed by thighs/groin (12.7%), knees (12.1%), waist (11.9%), and more. On the other hand, of the 472 cases, only 7 (1.5%) had injuries that occurred in the head area (i.e. head, face, or neck) [4]. It seems that the high injury incidence rates of the lower limb in fencing appear within certain circumstances, such as rapid attack techniques during trainings and matches. For instance, the techniques activate the ankle muscles first when moving forward in an instant [25, 26], and it is known that the skills cause overload on the ankles [27].

There are a number of lower extremity injuries in taekwondo (51%), since feet are mostly used to attack the opponent's trunk or head [28–31]. Injuries to the head and face occurred less frequently in Judo and Brazilian Jiu-jitsu (4%) [14, 32–35] due to the ban on striking head parts [28–31]. This study showed that the rate of injury frequency on the head was at the lowest in fencing (19.1%) and judo (18.0%), and on lower limbs was at the highest in fencing (33.1%) and Taekwondo (38.9%), which is consistent with those of the cited previous study. Martial arts, striking, and kicking sports are performed by specific skills, and they mainly kick and punch the opponents' head and trunk [14]. Therefore,

hands and feet are likely to get injured [36]. It might also be attributed to the specific usages of the hands in defense methods and of the legs in attack methods.

In other studies, low injury frequency rate in the lower extremities and high injury frequency rate in the head (84%) are noted in boxing, which allows strikes to the head [28–31]. In addition, the main target point to knock out is at the lower jaw [37]. Due to the face kicking techniques, 90% of boxing injury and 57.8% of kickboxing injury take up in head and neck areas [23]. Of the 71% of injuries that happened to the head (95% CI -3.7 to 89.4), 47% of them were concussions [38]. These findings are also agreed to this research, which found that in boxing, least frequently injured parts were the lower limbs (13.7%) and the most frequently injured part was the head (37.4%).

The upper extremities were found to be the most frequently injured parts in judo (30.5%) and wrestling (31.9%) in this research. Around 40% of injuries in grappling and throwing sports, the parent sports for Brazilian jiu-jitsu, judo, and wrestling, appeared to be in the upper limbs [14, 32–35, 39]; fighting through grabbing especially cause damage to the hands and fingers [30, 32–34]. Some rules in judo have been changed to restrict attacks and defenses related to the legs by the International Judo Federation as of 2009 [40]. Furthermore, defenders try not to fall on their backs as it might bring defeat in the fight, and resisting against falling down on backs generates multiple types of injuries. In general, landing on their outstretched arm causes glenohumeral dislocations, and falling on the top of the shoulder exposes those who have immature bones (e.g., children and adolescents) to the danger of acromioclavicular, sternoclavicular disjunctions, or clavicle fractures. There are other factors apart from falling, such as a wrong defense (e.g., leaning with a bent arm on the ground) that causes elbows to get dislocated, and an armlock that may cause medical collateral ligament (MCL) lesions [34]. Therefore, the high rate of injury frequency in the upper extremity may have been caused by the modification of the game rules as well as the characteristics of skills in judo.

In wrestling, the rates of injury frequency in the upper and lower extremities, torso, and head/face are 44.3%, 20.5%, 17.9% and 16.9% [35], respectively, which agrees with our findings. This could be related to the fact that wrestling causes many shoulder injuries, since there is a lot of usage of the upper body part. For instance, the techniques and training are focused on the upper part of the Greco-Roman style; a lower position compared to Greco-Roman should be retained to attack the opponent's lower part by utilizing the upper body actively in freestyle wrestling [41].

This study found that the torso accounted for the smallest proportion of injuries in taekwondo (14.1%) and wrestling (18.1%). Taekwondo requires the usage of protective gears on the torso in competitions, which may be the reason why the torso was the least frequently injured area. There was a statistically significant difference reported by a previous study (n = 4,635, 5,212 games) in terms of the effects of protective devices for the hands and feet for about 3 years. The rates of injury frequency were different between those with and without gears. The number of injured players with protectors, according to the injured body part, were 30 (19.4%) on the hand, 26 (16.8%) on the knee, 18 (11.6%) on the ankle, and 16 (10.3%) on the foot; on the other hand, the number of injured players without protectors, also according to the injured body part, were 23 (5.2%) on the face, 14 (5.2%) on the knee, 13 (12.8%) on hand, and 4 (5.5%) on foot [42]. In previous studies for wrestlers, [12, 43–51] the IRs were reported to be 11.9/1,000 AE in the head and neck, 7.1/1000 AE in upper extremity, 7/1,000 AE in the lower extremity, and 4.8/1,000 AE in the torso. In other words, the injury frequency rate, characterized by injury situation and severity, is more likely influenced by game regulations, including target areas and allowed skills, and it is affected by the usage of different body parts, such as head/neck, trunk, and extremities [23].

The overall analysis of IR was 0.10 during competitions and 1.52 during trainings across all age groups and types of sports in this study. These results are in line with those of Kim *et al.* [52], who reported 17.4% of injuries for male national athletes (17 sports) during competitions and 82.6% during training. Another study showed that higher IRs were noted in men's wrestling during practices than games [44]. The IRs during trainings were relatively higher than during competitions. They tend to skip trainings to achieve the best conditions for the forthcoming game. However, they are likely to neglect injuries during matches, even though they have injuries.

According to other studies on the correlation of IR with age, there is an interrelationship between them: in judo, the older the group, the higher the IRs; OR 1.04, 95% CI 1.01-1.08; [53] OR 0.91, 95% CI 0.82-1.00, $P = 0.045$ [54]. In terms of ages, the ages of 14-30 years got the high injury frequency rates, while those aged up to 13 years took 9.2% in boxing; the group of 14-22 years had an IR of 69.3%, followed by 24.5% for those up to 13 years of wrestling [35]. These outcomes correspond with the results of our analysis. It was supposed that athletes in higher grades tend to challenge new skills or feel more responsible for novel movements than the younger ones [54].

In the Rio 2016 Summer Olympic Games, the results of the survey on the injury frequency of 11,274 athletes from 207 nations showed the following values: 30.1% (n = 86) in boxing, 23.6% (n = 30) in taekwondo, 12.6% (n = 44) in wrestling, 11.3% (n = 44) in judo, and 8.3% (n = 17) in fencing [55]. These findings are consistent with the findings of this study, except in fencing; the values of the IRs were 0.16, 0.15, 0.14, 0.07, and 0.06 in fencing, boxing, taekwondo, wrestling, and judo, respectively, during competitions.

Although there have been many studies on injuries of combat athletes at specific ages at home and abroad, research by age group is needed. Sports injury epidemiology during certain competitions takes the most part of the research, whereas there is a remarkable lack of research during training periods [52]. Thus, further research is needed to understand the injury situations and to suggest precautions against in-

juries according to specific age groups.

In the study of the 4,635 taekwondo players mentioned earlier, there was a significant difference in IRs: the protectors decreased the number of injuries, especially to the hands, feet, and ankles ($P < 0.05$), and this diminution reduced the usage of sports tapes and dressing bandages ($P < 0.05$). In addition, it was claimed that the equipment helped to reduce sprain, laceration, and pain; however, no significant difference ($P > 0.05$) was found in the previous study [42]. This finding may not be specific to taekwondo; furthermore, some measures within the limits that do not affect the performance should be arranged to decrease the frequency of common injury to certain areas (e.g. utilization and transformation of guards). Lastly, persistent efforts are needed by upskilling and applying training programs to enhance particular body parts with high IRs according to specific type of sports.

As it is a retrospective study, there were several limitations in this study, specifically, unavoidable recall bias. In addition, this study was planned to be proceeded by snowball sampling based on a selected target sample among the athletes registered at the KOC through a quota sample of a non-probability sampling; thus, this should be considered in generalizing and interpreting the results of this study.

## 5. Conclusions

This study found that half of the combat sports athletes recently experienced injuries once in a year. Although there are differences in the combat sports, the overall context is that injury experience is likely to increase continuously from the middle school until the university group, while the experience decreases in the professional. Injury area and proportion vary according to sport type. However, in accordance with the definition of time loss, the IR during trainings was tenfold compared to the IR during competitions, and the IRs in striking sports were higher than grappling sports during both trainings and competitions.

## Author contributions

Conceptualization, methodology, data curation and formal analysis, investigation, Soyoung Park, Yeonsoo Kim, Seungseok Woo, and On Lee.; writing—original draft preparation, writing—review and editing, Soyoung Park and On Lee. All authors have read and agreed to the published version of the manuscript.

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## Conflict of interest

The authors declare no conflicts of interest.

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