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Sports Injuries and Illnesses After Implementation of the Web-Based Surveillance System in World Taekwondo

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Context: Taekwondo epidemiology studies have been in short supply since the rule changes introduced by World Taekwondo in 2017.

Objective: To describe injury and illness patterns at the 2017 World Taekwondo Championships (WTC) in Muju, South Korea, after the implementation of the web-based surveillance system by World Taekwondo.

Design: Prospective cohort study.

Setting: All injuries and illnesses were recorded during the 2017 WTC using a web-based system developed by the International Olympic Committee.

Patients or Other Participants: A total of 971 athletes who participated in the 2017 WTC.

Main Outcome Measure(s): Profiles and mechanisms of injury and illness in the 2017 WTC.

Results: We analyzed a total of 131 injuries and 26 illnesses, corresponding to an overall clinical incidence of 13.5 (95% CI = 11.2, 15.8) injuries and 2.7 (95% CI = 1.6 3.7) illnesses per 100 athletes and an overall incidence rate of 19.3 (95% CI = 16.0, 22.6) injuries and 3.8 (95% CI = 2.4, 5.3) illnesses per 1000 athlete-days. Most injuries occurred in the lower extremities (n = 61, 46.6%), and knee injuries were most frequent (n = 26, 19.8%). Among head and trunk injuries (n = 39, 29.8%), face injuries (n = 32, 24.4%) were most common, whereas among upper extremity injuries (n = 31, 23.7%), finger injuries (n = 8, 6.1%) were seen most often. Contusions (n = 44, 33.6%) were the most frequent injury type, followed by fractures and ligamentous ruptures or sprains. The most common injury mechanism was contact with another athlete (n = 97, 74.0%), whereas the least common was concussion (n = 5). The major affected system was the respiratory system (n = 11, 42.3%), with major symptoms being pain (n = 11, 42.3%) and fever (n = 7, 26.9%). Environmental factors were the most typical cause of illness (n = 15, 57.7%).

Conclusions: The web-based surveillance system used at the 2017 WTC revealed that 13.5 per 100 athletes (77.8/1000 athlete-exposures, 13.9/1000 minute-exposures) had new or recurrent injuries, whereas 2.7 per 100 athletes became ill.

Key Words: epidemiologic studies, incidence, injury prevention

Key Points

- The clinical incidence of injury and illness after the implementation of the web-based surveillance systems revealed 13.5 injuries and 2.7 illnesses per 100 athletes during the 2017 World Taekwondo Championships
- The knee and the ankle were the most common injury sites in the lower extremities (46.6%).
- After the introduction of the protector and scoring system in 2017, the injury rate dropped. The most frequent injury types, sites, and causes were then (1) 33.6% contusion, face, 15 contact mechanisms; (2) 23.7% fracture, finger, 6 contact mechanisms; and (3) 16.0% ligamentous ruptures, knee, 10 contact or noncontact mechanisms.
- Implementation of the web-based injury and illness surveillance system at the World Taekwondo Championships will allow for a more careful investigation of injury trends over time, including the evaluation of developments such as rule changes.

Of all 28 Olympic sports, taekwondo has been among the top 5 sports with the highest injury incidences during the last 3 Olympic Games (Beijing 2008, London 2012, and Rio de Janeiro 2016).[1–3] These results prompted the International Olympic Committee (IOC) to address the safety of taekwondo athletes.[3] Since the previous Olympic Games in Rio de Janeiro, competition rules and scoring systems have been adjusted and additional physical protection has been mandated.[4] These rules were implemented at the 2017 World Taekwondo Championships (2017 WTC) in Muju, South Korea, and promoted by World Taekwondo (WT).[5] The injury rate at the 1999 Edmonton WTC was 19.5%; however, this was long before implementation of the competition rule changes and standard injury- and illness-surveillance system.[6]

Injury reports from previous competitions, including the Olympics, and other epidemiologic studies have had several drawbacks. First, these studies did not comply with the standardized reporting protocols (ie, they did not include the exposure time at each competition).[3,7] Second, because the injuries and illnesses were reported by the venue's medical staff or team physicians, some bias might have occurred in reporting and diagnosis.[3] Third, many medical personnel hired by organizing committees lacked sufficient knowledge and did not specialize in sport-related injuries.[6] Therefore, prospective epidemiologic studies are necessary at the Olympics and World Championships to assess the risk factors associated with, and to more accurately diagnose, athletes' injuries and illnesses.[7–9]

In 2016, WT changed the competition scoring rules, which may have resulted in more aggressive match styles than those observed under the earlier rules.[4] The new competition rules have been reported to affect the location, type, mechanism, and incidence of competition-related injuries because taekwondo athletes have changed their game strategies and subsequent training methods.[7,10] This led to the WT's developing and initiating a web-based injury and illness surveillance system in 2017 to identify athlete injuries and illnesses after the implementation of the new competition rules. Also, the Medical and Anti-Doping Committee of WT taught medical staff about the web-based injury- and illness-surveillance system, emergency manual, and on-site ultrasound for more accurate diagnosis.

In this study, we aimed to analyze the incidence and patterns of injuries and illnesses that occurred during the 2017 WTC after the implementation of the web-based surveillance system by WT. This information can provide the first step in designing an injury-prevention program that is based on the new competition rules and the protector and scoring system (PSS) now in use. At the 2017 WTC, the PSS consisted of a chest protector and electronic headgear to fully automate the scoring system; however, at the London and Beijing Olympics, the PSS did not include headgear.[5]

METHODS

In this prospective cohort study, we modified the IOC injury- and illness-surveillance system for better compatibility with taekwondo[3]; our modified system was implemented during the 2017 WTC, which was held from June 24 through 30, 2017, in Muju.

We enrolled all taekwondo athletes who participated in the 2017 WTC and collected data from 929 scheduled games; 87 matches did not take place because the athletes either failed to pass the weight restrictions or withdrew from the competition.

We used 2 methods to collect data. First, we asked all national team physicians to report the daily occurrence of new injuries and illnesses either on paper or using an online database (wtfiss.com) approved by WT. Second, we collected data from athletes who had ever been treated by the Organizing Committee's medical staff, supervised by WT medical officers, for any injury or illness at the venue's medical center or by specialists at designated hospitals organized by the Muju Taekwondo Organizing Committee. At 5 taekwondo courts, we had 5 sports medicine specialists (MDs) and 5 athletic trainers (ATs), and thus, 1 MD and 1 AT at each court. We received additional detailed information from the venue medical staff regarding the mechanism of injury and recorded the injury-related information and the affected area. The MD and AT were responsible for monitoring all injuries and the possibility of injury occurrence at the entry and exit points for each court. We had a Mindray M7 (version 2015; Mindray North America) portable ultrasound machine in the venue's medical room for accurate injury diagnosis. We recorded injury data on-site and from any designated local hospitals to which injured taekwondo athletes were transferred. The medical staff also signed the medical information release form for all injured athletes. We received approval from the Yonsei University Institutional Review Board, which declared it is ethical to collect the athletes' injury and illness data (IRB no. 7001988-201708-HR-245-04).

Paper and online forms for reporting injuries and illnesses were modeled on those used during the 2016 Rio Olympics.[1,3] We designated each injury or illness as *new* (preexisting conditions and athletes who were not fully rehabilitated were not recorded) or *recurring* (the athlete had returned to full participation after a previous condition) musculoskeletal complaints, concussions, and other medical conditions (injuries or illnesses) that occurred during competition and training at the 2017 WTC and received medical attention, regardless of the consequences regarding absence from competition or training.[11] As in the previous Olympic Games epidemiologic study, when a single incident caused multiple injury types, only the most severe diagnosis was recorded, as determined by the research team on the basis of all available clinical data for analysis.[2] We defined the severities of injury and illness by time loss from competition and training as <1, 1 to 3, 4 to 7, or >7 days and estimated the categorization only according to the nature of the injury at the time of diagnosis.[3,12,13]

We assessed taekwondo-related injury and illness variables using univariate analysis and descriptive statistics. Injury and illness rates were calculated after evaluating the overall competition and training, with the clinical incidence provided as injuries and illnesses per 100 athletes during the 2017 WTC.[3,14] In addition, we calculated the number of injuries or illnesses per 1000 athlete-days, in which *athlete-days* represented the total number of athletes multiplied by 7 days.[2,3] Moreover, the *incidence rate* (IR) of competition was expressed as the number of injuries per 1000 *athlete-exposures* (AEs; 1 exposure is 1 athlete participating in 1 match) and per 1000 *minute-exposures* (MEs; 1 minute of exposure is 1 athlete participating in a match for 1 minute).[7,14] The IR of a competition match was the average injury risk for 1 individual athlete per 1000 AEs (No. of injuries/No. of total AEs in match) $\times$ 1000,[14,15] whereas that of competition minutes was the average injury risk for 1 individual athlete per 1000 minutes of exposure (No. of injuries/No. of total MEs in match) $\times$ 1000.[7,14] The competitions at the WTC comprised 3 rounds of 2 minutes, each with a 1-minute break.[4] We calculated the total MEs in each match using only the actual fight time.[7] We calculated the incidence rate ratio (IRR) and 95% CIs to measure the strength of the associations between men and women.[14] The IRR for men to women was calculated as a rate value per 1000 AEs. We

Table 1. Injury and Illness Rates at the 2017 World Taekwondo Championships in Muju, South Korea

Variable	Males	Females	Total
Participating athletes, No.	593	378	971
Athlete-days, No.	4151	2646	6797
Athlete-exposures, No.	1000	684	1684
Minute-exposures, min	5434	3996	9430
Injuries in competition, No.	90	41	131
Injury incidence (95% CI)			
Clinical incidence/100 athletes[a]	15.2 (12.0, 18.3)	10.8 (7.5, 14.2)	13.5 (11.2, 15.8)
Rate/1000 athlete-days	21.7 (17.2, 26.2)	15.5 (10.8, 20.2)	19.3 (16.0, 22.6)
Rate/1000 AEs	90.0 (71.4, 108.6)	59.9 (41.6, 78.3)	77.8 (64.5, 91.1)
Rate/1000 MEs	16.6 (13.1, 20.0)	10.3 (7.1, 13.4)	13.9 (11.5, 16.3)
Incidence rate ratio/1000 AEs	1.50 (1.04, 2.17)	1.00	NA
Illnesses in competition, No.	16	10	26
Illness incidence (95% CI)			
Clinical incidence/100 athletes	2.7 (1.4, 4.0)	2.6 (1.0, 4.3)	2.7 (1.6, 3.7)
Rate/1000 athlete-days	3.9 (2.0, 5.7)	3.8 (1.4, 6.1)	3.8 (2.4, 5.3)
Rate/1000 AEs	16.0 (8.2, 23.8)	14.6 (5.6, 23.7)	15.4 (9.5, 21.4)
Incidence rate ratio/1000 AEs	1.10 (0.50, 2.41)	1.00	NA

Abbreviations: AE, athlete-exposures; ME, minute-exposures; NA, not applicable.

performed all statistical analyses using SPSS (version 24.0; IBM Corp) and considered significance to be 2-tailed P values of $<.05$.

RESULTS

In total, 971 athletes participated in the 2017 WTC. Of those, 593 (61%) were men and 378 (39%) were women, with an average age of 22.9 (23.3 and 22.3, respectively) years. A total of 842 matches and 4716 MEs occurred in competitions during the 2017 WTC. The weight divisions with the greatest numbers of participants were <68 kg for men and <57 kg for women.

We recorded a total of 131 injuries and 26 illnesses, for an overall clinical incidence of 13.5 injuries (95% CI = 11.2, 15.8) and 2.7 illnesses (95% CI = 1.6, 3.7) per 100 athletes. This corresponds to 19.3 injuries (95% CI = 16.0, 22.6) and 3.8 illnesses (95% CI = 2.4, 5.3) per 1000 athlete-days (Table 1). On average, 8.9% (n = 86) of all athletes sustained at least 1 injury, and 2.0% (n = 19) experienced an illness.

During the competition, we noted 77.8 (95% CI = 64.5, 91.1) injuries per 1000 AEs, with higher rates in men (90.0/1000 AEs, 95% CI = 71.4, 108.6) than in women (59.9/1000 AEs, 95% CI = 41.6, 78.3). Furthermore, the total injuries per 1000 MEs were 13.9 (95% CI = 11.5, 16.3), with higher rates observed in men (16.6/1000 MEs, 95% CI = 13.1, 20.0) than in women (10.3/1000 MEs, 95% CI = 7.1, 13.4). Male athletes were at a higher risk of injury during competition than female athletes (IRR = 1.50; 95% CI = 1.04, 2.17). The illness IRRs in male and female athletes were similar (IRR = 1.10; 95% CI = 0.50, 2.41; Table 1).

For male athletes, the weight division with the largest number of injuries was <68 kg (n = 19, 21.1%); however, the highest injury rate per 1000 AEs was in the weight division of >87 kg (155.6/1000 AEs). For female athletes, the weight division with the largest number of injuries was <62 kg (n = 12, 29.3%), yet the highest injury rate per 1000 AEs was in the weight division of >73 kg (161.8/1000 AEs).

The lower extremities (n = 61, 46.6%) were most commonly injured, with the knee (n = 26, 19.8% of the total injuries) being the most frequently injured area, followed by the ankle (n = 12, 9.2%). In the head and trunk region (n = 39, 29.8%), the face was the most often injured area (n = 32, 24.4%), followed by the head (n = 5, 3.8%). Moreover, in the upper extremities (n = 31, 23.7%), the fingers were the most commonly injured area (n = 8, 6.1%), followed by the hand (n = 7, 5.3%).

Contusions, hematomas, and bruises were the most frequent injury types (n = 44, 33.6%), followed by fractures (n = 31, 23.7%), ligamentous ruptures and sprains (n = 21, 16.0%), and muscle ruptures and strains (n = 14, 10.7%; Table 2). The face was the most common site for a contusion, hematoma, or bruise, which occurred primarily due to contact with the opponent during an offensive or defensive move. The fingers, forearms, and wrists were the most typical sites of fractures due to contact with the opponent during defense blocking, whereas the knees and ankles were the most usual sites for ligamentous ruptures and sprains or muscle ruptures or strains due to contact or noncontact. Of the 5 reported concussions, 3 were mild, and fortunately, the other 2 athletes who were transported to the hospital sustained injuries that resulted in no time loss from competition (Table 2).

As shown in the Figure, we observed that the most common injury mechanism was contact with another athlete (n = 97, 74.0%), followed by noncontact (n = 18, 13.7%), which included injuries from footwork during offensive or defensive moves and from avoiding contact. Men were more prone to contact injuries from opponents, whereas women were more prone to noncontact injuries. Twelve (9.2%) athletes were unsure of the cause of their injuries in terms of contact or noncontact with their opponent.

Of all injuries, we estimated that 34.4% (n = 45) would result in no time loss from competition or training, 65.6% (n = 86) of injuries would result in an absence from competition or training for 1–3 days, 17.6% (n = 23) for 4–7 days, and 30.5% (n = 40) for >7 days. Furthermore, we classified 48.1% (n = 63) of injuries as severe, with an estimated time loss of >7 days from competition or training. These injuries comprised 31 fractures, 21 ligamentous ruptures or sprains, 10 muscle and tendon

Table 2. Diagnosis by Injury Site at the 2017 World Taekwondo Championships in Muju, South Korea

Diagnosis	Males (% of Total)	Injury Site (No.)	Females (% of Total)	Injury Site (No.)	Total	Injury Site (No.)
Contusion/hematoma/bruise	30 (33.3)	Face (12), thigh (7), pelvic (2), foot/toe (1), neck (1), ribs (1), forearm (1), hand (1), lumbar (1), hip (1), groin (1), ankle (1)	14 (34.1)	Face (9), thigh (2), foot/toe (2), hand (1)	44 (33.6)	Face (21), thigh (9), foot/toe (3), pelvic (2), hand (2), neck (1), ribs (1), forearm (1), lumbar (1), hip (1), groin (1), ankle (1)
Fracture	22 (24.4)	Finger (4), ankle (4), face (3), knee (3), hand (2), thumb (2), forearm (2), wrist (1), ribs (1)	9 (22.0)	Finger (2), face (2), ankle (1), knee (1), hand (1), thumb (1), wrist (1)	31 (23.7)	Finger (6), face (5), ankle (5), knee (4), hand (3), thumb (3), forearm (2), wrist (2), ribs (1)
Ligamentous rupture/sprain	14 (15.6)	Knee (5), ankle (5), thumb (2), hand (1), finger (1)	7 (17.1)	Knee (5), ankle (1), thumb (1)	21 (16.0)	Knee (10), ankle (6), thumb (3), hand (1), finger (1)
Muscle tendon rupture/strain/tendinosis	9 (10.0)	Knee (3), thigh (2), lower leg (1), wrist (1), hip (1), foot/toe (1)	5 (12.2)	Knee (1), thigh (1), lower leg (1), hand (1), finger (1)	14 (10.7)	Knee (4), thigh (3), lower leg (2), wrist (1), hand (1), finger (1), hip (1), foot/toe (1)
Laceration/abrasion/skin lesion	5 (5.6)	Face (4), foot/toe (1)	1 (2.4)	Face (1)	6 (4.6)	Face (5), foot/toe (1)
Concussion	4 (4.4)	Head/brain (4)	1 (2.4)	Head/brain (1)	5 (3.8)	Head/brain (5)
Lesion of meniscus	2 (2.2)	Knee (1), wrist (1)	1 (2.4)	Knee (1)	3 (2.3)	Knee (2), wrist (1)
Dislocation/subluxation	1 (1.1)	Shoulder (1)	1 (2.4)	Knee (1)	2 (1.5)	Shoulder (1), knee (1)
Arthritis/synovitis/bursitis	1 (1.1)	Wrist (1)	0 (0.0)	NA	1 (0.8)	Wrist (1)
Other bone injuries	1 (1.1)	Knee (1)	0 (0.0)	NA	1 (0.8)	Knee (1)
Muscle cramps/spasm	1 (1.1)	Upper back (1)	0 (0.0)	NA	1 (0.8)	Upper back (1)
Nerve/spinal cord injuries	0 (0)	NA	1 (2.4)	Forearm (1)	1 (0.8)	Forearm (1)
Other	0 (0.0)	NA	1 (2.4)	Face (1)	1 (0.8)	Face (1)
Total	90 (100)	NA	41 (100)	NA	131 (100)	NA

Abbreviation: NA, not applicable.

ruptures or strains, and 1 multiple contusion (Table 2). Among all athletes with injuries and illnesses, 27 athletes (19 injuries, 8 illnesses) were transferred to hospitals for a more thorough examination after a primary checkup in the field medical office.

A total of 11 (42.3%) and 5 (19.2%) illnesses affected the respiratory system and gastrointestinal system, respectively. The major symptoms were pain (n = 11, 42.3%) and fever (n = 7, 26.9%). Environmental factors (eg, humidity or

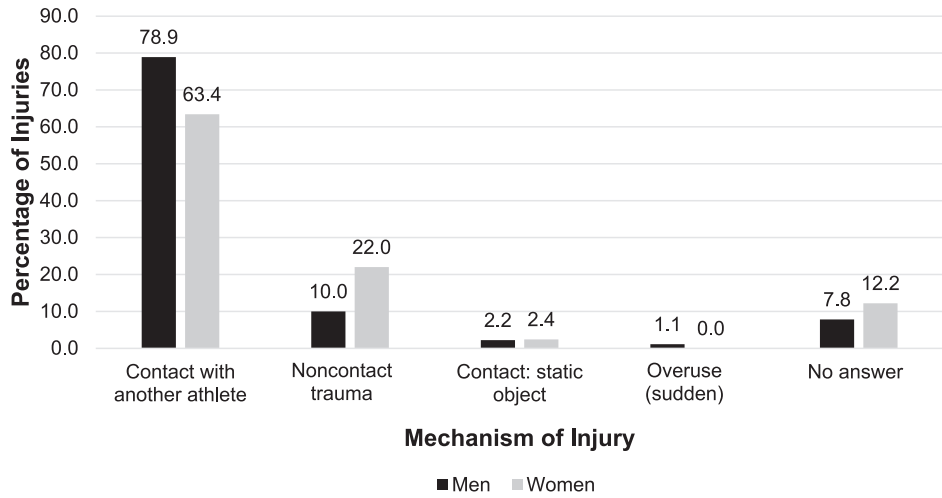

Figure. Injury mechanisms at the competition at the 2017 World Taekwondo Championships in Muju, South Korea.

Table 3. The Affected Systems, Main Symptoms, and Causes of Illnesses at the 2017 World Taekwondo Championships in Muju, South Korea

Variable	No. (% of Total Illnesses)		
	Males (n = 16)	Females (n = 10)	Total (n = 26)
Affected system			
Respiratory/ear, nose, throat	6 (37.5)	5 (50.0)	11 (42.3)
Gastrointestinal	4 (25.0)	1 (10.0)	5 (19.2)
Urogenital/gynecological	0 (0)	1 (10.0)	1 (3.8)
Allergic/immunological	1 (6.3)	1 (10.0)	2 (7.7)
Metabolic/endocrinology	1 (6.3)	1 (10.0)	2 (7.7)
Musculoskeletal	1 (6.3)	1 (10.0)	2 (7.7)
Dental	2 (12.5)	0 (0)	2 (7.7)
No answer	1 (6.3)	0 (0)	1 (3.8)
Main symptom			
Fever	4 (25.0)	3 (30.0)	7 (26.9)
Pain	7 (43.8)	4 (40.0)	11 (42.3)
Diarrhea, vomiting	1 (6.3)	2 (20.0)	3 (11.5)
Hyperthermia	1 (6.3)	0 (0)	1 (3.8)
Dehydration	1 (6.3)	1 (10.0)	2 (7.7)
Lethargy, dizziness	1 (6.3)	0 (0)	1 (3.8)
No answer	1 (6.3)	0 (0)	1 (3.8)
Cause of illness			
Infection	6 (37.5)	4 (40.0)	10 (38.5)
Environmental	9 (56.3)	6 (60.0)	15 (57.7)
No answer	1 (6.3)	0 (0)	1 (3.8)

climate) were the most common cause of illness (n = 15, 57.7%), followed by infections (n = 10, 38.5%; Table 3).

DISCUSSION

Our aim was to analyze injuries and illnesses after the implementation of the web-based surveillance system at the 2017 WTC. Of all 971 taekwondo athletes, 8.9% and 2.0% experienced at least 1 injury or illness, respectively, during the 2017 WTC, with an overall clinical incidence of 13.5 injuries and 2.7 illnesses per 100 athletes. Among both men and women, heavyweight athletes had a higher injury rate than low-weight athletes, which is believed to be a result of the former's ability to create a more powerful impact.

The injury IRs at the 2017 WTC (77.8/1000 AEs and 13.9/1000 MEs) were lower than those at the 1999 WTC (108.1/1000 AEs and 12.2/1000 MEs)[6] and Rio de Janeiro 2016 (100/1000 AEs and 16.8/1000 MEs).[3] Although the competition rules at the 2017 WTC and Rio de Janeiro 2016 were the same, the injury IRs were different: 77.8/1000 AEs versus 100/1000 AEs. Similarly, the injury IRs in the competitions at the 2017 WTC were lower than those at Beijing 2008 (114.9/1000 AEs)[1] and London 2012 (164.5/1000 AEs).[2]

Several combat-sports associations have published data on injury rates during their national and world championships.[8] The injury rate at the 2017 WTC (77.8/1000 AEs and 13.9/1000 MEs) was higher than that at the 2013 World Karate Championships in Guadalajara, Mexico (53.3/1000 AEs and 23.7/1000 MEs), and at the 2015 World Karate Championships in Jakarta, Indonesia (23.2/1000 AEs and 9.2/1000 MEs).[8]

At the 2017 WTC, the PSS consisted of a chest protector and electronic headgear to fully automate the scoring system.[5] We believe that because the electronic headgear sensor requires only slight contact between the foot sensor and the headgear to register a scored point, the athletes can deliver kicks at lower forces than used previously to score head kicks.

It is interesting that the severe injuries were fractures of either the ankles or fingers, whereas the mild injuries were contusions of the face, all of which occurred from contact with an opponent. Moreover, we noted that ligamentous ruptures or sprains and musculotendinous injuries (ruptures, tears, strains, or tendinosis) to the knee or ankle were common. These occurred both with and without opponent contact. Furthermore, many ligamentous injuries in the ankle and knee occurred due to kicking of the leg. We attribute the smaller number of concussions (5 mild injuries) to the use of electronic headgear, which automates the scoring of head kicks.[16]

We found that the results of a literature review[7] of 8 studies (data from 5856 male and 2126 female athletes) were similar to our data regarding injury rates, such as those in the lower extremities (48.3/1000 AEs), head and trunk region (34.8/1000 AEs), and upper extremities (16.7/1000 AEs). In addition, the rates of contusions, abrasions, and lacerations (65.4/1000 AEs), sprains and strains (19.0/1000 AEs), and fractures (9.7/1000 AEs) were similar to those previously reported (7509 men and 2852 women).[7]

Also consistent with earlier research,[6,7] the most frequent types of injury in this study were musculoskeletal contusions, sprains, and bone fractures. Therefore, we suggest that it is important to improve protective equipment, such as headgear, forearm pads, and shin protectors, to prevent contact injuries to the face, fingers, knees, and ankles.[17–19] To address noncontact injuries, we advise additional neuromuscular exercises and chronic injury management as part of each athlete's training regimen.[20,21]

At the 2017 WTC, we estimated that 65% of the injuries would result in at least 1 day of time loss from competition or training, which was higher than that recorded at Rio 2016 (40%) and London 2012 (35%). Taekwondo athletes at the 2017 WTC sustained more injuries of greater severity than those at Rio 2016 or London 2012. Injury severity (n = 63, 48.1%) by diagnosis ordered as follows: bone fractures > ligamentous ruptures and sprains > muscle and tendon ruptures, which was similar to that at the Olympics and other taekwondo competitions.[13,22,23] Given the high number of severe injuries, we recommend that for the athletes' safety, competitions must maintain a regular injury- and illness-surveillance system to continuously identify and prevent serious injuries, evaluate and improve protective equipment, and test implementation of injury-prevention programs.[7,16]

Injury mechanisms in taekwondo competitions were similar among weight divisions and between sexes.[24] For example, injury mechanisms at national taekwondo events, such as the Canadian National Championships, Thailand National Championships, and Greek National Championships, were similar, occurring mostly from contact with the opponent.[15,25,26] At the 2017 WTC, we observed that most of the contact injuries were acute, whereas noncontact and overuse injuries with a sudden onset accounted for 14.5% of overall injuries. Contact between athletes caused the majority of injuries; thus, to reduce them, training of the athletes should include techniques to improve the efficiency and safety of blocking and avoidance.[6,16] Moreover, to prevent severe knee and ankle noncontact injuries,

neuromuscular and proprioceptive training should be conducted.[20,27]

At the 2017 WTC, the IR of illnesses was relatively low compared with the injury rate. The overall percentage of athletes with illnesses at the 2017 WTC (3%) was lower than that at Rio 2016 (5%), Sochi 2014 (8%), and London 2012 (7%).[2,3,13] As at previous World Championships and Olympics, most illnesses at the 2017 WTC were caused by an environmental change (eg, humidity or climate) or a respiratory or gastrointestinal system infection. The overall rates were similar to those observed at the International Association of Athletics Federations World Athletics Championships 2009, London 2012, and Rio de Janeiro 2016.[2,3,28] We hypothesized that these illnesses were caused by a combination of long flights and environmental and climatic changes, further compounded by demands to limit food and water because of the weigh-ins before the competition.[7,13,28]

We based the methods used to research the injury and illness surveillance system on the IOC's recommendations. First, we used the WTC online electronic system for rapid collection and accurate coding of injury and disease data from all medical offices. Second, continuous recommendations by and education of WT staff were necessary to support and encourage team physicians in each country to use the system efficiently. Third, it was necessary to have appropriate medical equipment at on-site medical offices to accurately diagnose injuries. Fourth, it was important to minimize errors while entering data in the system. Fifth, the athlete's risk exposure time (number and minutes of match games) should be provided instead of the number of injuries according to the athlete, such as in the method used in Olympics research.[3,29]

We conducted this study with a web-based injury- and illness-surveillance system that allowed more accurate diagnoses of injuries occurring in the field using ultrasound during the 2017 WTC. Because MDs and ATs, who specialize in sport-related injuries, were available on-site, they diagnosed and recorded the injuries. The injury- and illness-surveillance system is ideal for use at large world championships to observe the effect of any changes in the competition, such as a new PSS or new rules, which can alter injury profiles and game strategies. However, our study had several limitations, including intentionally or unintentionally missing injury and illness reporting during competition or training and only occasional clarity of the mechanisms and severity of injuries and illnesses occurring during competition (recall bias). The factors involved in injury severity were based on estimated time loss rather than the actual time loss. Moreover, when an athlete presented with multiple injuries, we recorded only the most severe injury; this might have resulted in underestimating the injury incidence and overestimating the severity of injuries.

CONCLUSIONS

After the implementation of the web-based surveillance system at the 2017 WTC, the new or recurrent injury clinical incidence was 13.5/100 athletes and the illness clinical incidence was 2.7/100 athletes. Continuous athlete injury and illness surveillance is recommended at all international and domestic taekwondo competitions in the future to collect more epidemiologic data to inform the development of effective injury-prevention measures.

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