Competition injuries in taekwondo: a literature review and suggestions for prevention and surveillance

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ABSTRACT

Objective To review competition injuries in taekwondo and use this information to develop recommendations to reduce the number and severity of injuries in taekwondo competition.

Methods The available literature was searched for prospective studies on taekwondo injuries in adult athletes. An injury was defined as any circumstance for which the athlete sought the assistance of the on-site medical personnel. Injury rates were expressed per athlete-exposures (A–E) and 95% CIs calculated.

Results Total injury rates for elite men varied from 20.6/1000 A–E (95% CI 11.8 to 29.3) to 139.5/1000 A–E (95% CI 94.0 to 185.1). For elite women, the rates varied from 25.3/1000 A–E (95% CI 3.1 to 47.4) to 105.5/1000 A–E (95% CI 89.8 to 121.1). About one-third of all injuries (29.6%) in the men were to the head and neck region, while almost half of the injuries (44.5%) were to the lower extremities. In women, 15.2% of injuries were to the head and neck and 53.1% to the lower extremities. The vast majority of all injuries were contusions (42.7% in the men and 62.7% in the women). Point estimates of rates of head injuries and concussions were found to be higher in taekwondo than in other contact sports such as football (soccer) and American gridiron football. Time-loss injury rates in the men varied from 6.9/1000 A–E (95% CI 1.8 to 11.9) to 33.6/1000 A–E (95% CI 18.9 to 48.3). In the women, they varied from 2.4/1000 A–E (95% CI 2.3 to 7.2) to 23.0/1000 A–E (95% CI 15.7 to 30.4). The turning kick was most often involved in causing injury: 56.9% of all injuries in the men and 49.8% in the women. Lack of blocking skills was identified as one of the main injury mechanisms.

Conclusions Rule changes should be considered and it is recommended that governing bodies employ qualified medical personnel. Establishing an ongoing injury surveillance system in taekwondo should be the first priority.

INTRODUCTION

Full-contact taekwondo (TKD) has been an official medal sport since the 2000 Summer Olympic Games (Sydney), while its demonstration status goes back to the 1988 Games (Seoul). To date, the international sport governing body of taekwondo, the World Taekwondo Federation (WTF), boasts over 200 member nations[1] with more than 80 million practitioners worldwide.[2] It was recently reported that the concussion rate in taekwondo over a 15-year period[3] is four times higher than in American gridiron football[4] over a similar time span (16 years): 9.4/1000 A–E, 95% CI 7.1 to 11.7 versus 2.3/1000 A–E, 95% CI 2.2 to 2.4. Furthermore, overall competition injury rates for taekwondo compared to other full-contact and collision sports, such as American gridiron football and wrestling, are higher.[5–8] This indicates a need for developing approaches to reduce the number and severity of taekwondo injuries through the use of injury surveillance data to design injury prevention measures, as has been done by other sports. However, to this date, a comprehensive worldwide injury surveillance system in conjunction with preventive measures, similar to those of the National Collegiate Athletic Association (NCAA) and Fédération Internationale de Football Association (FIFA) systems, is yet to be instituted for taekwondo.[9]

An example of the use of a comprehensive injury surveillance system in successfully developing injury prevention efforts is the NCAA Injury Surveillance System (ISS), which was started nearly 30 years ago with the cooperation of Certified Athletic Trainers employed at universities nationwide in the USA.[10] As a result of the NCAA ISS, important changes in collegiate sport rules were introduced, such as the 1997 spring gridiron football permissible equipment and contact rules, the 2003 women's lacrosse regulation requiring the use of protective eyewear, as well as the 1995 ice hockey hitting and contact rules. A more direct international effect of the NCAA ISS was to highlight the rise in interest in anterior cruciate ligament (ACL) injuries among female basketball and soccer players,[10] thus leading to a better understanding of ACL injury mechanisms.

Based on the results of the NCAA ISS, it is evident that the institution of this comprehensive effort to identify at risk sports has been effective. Therefore, the purpose of this article is to review competition injuries in elite adult taekwondo athletes based on prospective studies in an effort to provide a rationale for preliminary steps that may be taken to employ a similar ISS in taekwondo, which should also include steps to be taken to reduce the number and severity of taekwondo injuries. To illustrate the dangers of kicks in taekwondo, this review will also highlight the biomechanical implications of these techniques relative to their injury potential.

METHODS

The available literature was searched electronically using PubMed for prospective studies on taekwondo injuries in adult athletes. An injury was defined as any circumstance for which the athlete sought the assistance of the on-site medical personnel. This definition was the same across all

Table 1 Competition injury rates per 1000 athlete-exposures (95% CI) in taekwondo athletes

Study	Men (95% CI)	Women (95% CI)
Pieter *et al*[14]	139.5 (94.0 to 185.1)	96.5 (39.5 to 153.5)
Pieter and Zemper[15]	95.1 (84.7 to 105.4)	105.5 (89.8 to 121.1)
Koh *et al*[16]	120.81 (92.91 to 148.7)	90.05 (61.42 to 118.7)
Beis *et al*[17]	20.55 (11.8 to 29.3)	36.41 (18.0 to 54.8)
Kazemi and Pieter[18]	79.91 (53.4 to 106.4)	25.25 (3.1 to 47.4)
Pieter *et al*[19]	168.37 (110.9 to 225.8)	153.01 (124.1 to 181.9)
Yiemsiri *et al*[20]	39.47 (17.6 to 61.4)	32.41 (8.8 to 56.0)
Pieter *et al*[7]	69.51 (55.4 to 83.6)	–

studies reviewed. The following keywords were used to identify relevant literature: taekwondo, injury, concussion, musculoskeletal, head injury. The use of the words 'taekwondo' and 'injury' produced 41 publications and after reviewing the titles and abstracts, nine of them were deemed relevant to the study at hand. Knowing head injuries are among the most serious of TKD injuries, a further search was done with the keywords 'taekwondo' and 'head injury', which revealed 18 publications with two deemed relevant to our study. Additional publications were secured from Google Advanced Scholar. In the absence of research using randomised controlled trials, this review is based mainly on prospective investigations. Injury rates are expressed per 1000 athlete-exposures (A–E) and 95% CIs calculated. One athlete-exposure (A–E) refers to one athlete participating in a bout and exposing him/herself to the possibility of being injured.

In addition to reviewing the available literature, the biomechanical implications of taekwondo kicks relative to their injury potential will be summarised to highlight the need for competition rule changes. The rationale for improved coach education and referee programmes as well as setting up an injury surveillance system will also be presented.

RESULTS

First, a summary of the total injury rates found in the literature reviewed for male and female taekwondo athletes during competition will be presented, followed by data categorised by type of injury, injury location by body region, the mechanism of injury, time-loss injuries as a surrogate for injury severity and finally catastrophic injuries.

Total injury rates

A comparison of taekwondo injury rates based on prospective studies is shown in table 1. Oler *et al*[11] collected their data at one US senior and one junior national championship. However, exposure data were not reported and therefore injury rates cannot be calculated. In addition, injuries for men and women were combined in that study. Based on the information provided, the adult males and females together sustained 7.4 injuries per 100 participants. The number of competitors was estimated by the investigators.

Pieter *et al*[12] investigated British recreational taekwondo athletes and recorded injury rates of 51.3/1000 A–E (95% CI 1.0 to 101.5) and 47.6/1000 A–E (95% CI 18.4 to 113.6) for men and women, respectively. Phillips *et al*[13] studied injuries sustained at the 7th All Africa Games in South Africa. Although a breakdown of participating athletes by gender was provided, the authors reported the total injury rate for both men and women combined as 86.6/1000 A–E. Expressed per number of athletes, the Africans incurred 17.2 injuries/100 participants. Braun[14] covered full-contact taekwondo at a World Cup competition. Collapsed over gender, the athletes sustained 95.5 injuries/1000 A–E.

The most recent study on injuries at the 2008 Olympic Games[15] reported 36% of all injuries occurred during training, while the remainder was registered during competition. Based on the data provided by the authors, the competition injury rate is 53.3/1000 A–E for the combined sample of men and women. The overall combined injury rate of men and women based on the studies reviewed here, including those of the 2008 Olympic Games,[15] 7th All Africa Games[13] and European Cup[14] is 81.4/1000 A–E (95% CI 76.3 to 86.4).

Recently, in a review by Pieter of taekwondo injuries, no statistical difference was reported between males and females in total injury rate: 88.9 injuries/1000 A–E (95% CI 81.3 to 96.5) for men and 90.3 injuries/1000 A–E (95% CI 79.6 to 101.1) for women,[3] which included both recreational and elite taekwondo athletes. The total injury rate for only elite male taekwondo athletes was 89.4/1000 A–E (95% CI 78.0 to 100.7).[7]

Based on the current review, the injury rates for the elite men and women are 82.8/1000 A–E (95% CI 76.3 to 89.3) and 87.0/1000 A–E (95% CI 76.8 to 97.2), respectively. The investigation by Zemper and Pieter[23] was part of the study by Pieter and Zemper[15] and was not included in the total rate collapsed over studies.

Injury types

Tables 2 and 3 (males and females respectively) display the rates of injury types per 1000 A–E. Of more concern than the most frequently occurring injuries are fractures and head injuries.[8] Table 4 displays concussion injury rates in taekwondo athletes.

Table 2 Competition injury rates per 1000 athlete-exposures for selected injury types in adult male taekwondo athletes

Injury type	Beis *et al*[17]	Kazemi and Pieter[18]	Koh *et al*[16]	Pieter and Zemper[15]	Pieter *et al*[12]	Pieter *et al*[15]	Yiemsiri *et al*[20]
Abrasion	–	2.3	5.0	1.8	–	–	–
Concussion	1.0	6.9	10.1	7.0	12.8	15.5	–
Contusion	10.8	11.4	33.6	46.1	25.6	69.8	16.5
Dislocation	1.0	–	3.4	0.6	–	–	–
Epistaxis	1.0	2.3	–	1.8	–	7.8	–
Fracture*	2.0	–	26.9	10.0	–	15.5	–
Laceration	2.9	11.4	5.0	10.3	12.8	11.6	6.6
Other	–	13.7	6.7	2.6	–	3.9	–
Sprain	1.0	22.8	16.8	10.6	–	15.5	13.2
Strain	–	–	11.7	1.5	–	–	3.3

*Includes suspected fractures.

Table 3 Competition injury rates per 1000 athlete-exposures for selected injury types in adult female taekwondo athletes

Injury type	Beis *et al*[17]	Kazemi and Pieter[18]	Koh *et al*[16]	Pieter and Zemper[15]	Pieter *et al*[12]	Pieter *et al*[15]	Yiemsiri *et al*[20]
Abrasion	12.1	–	–	2.4	–	–	–
Concussion	–	15.2	4.5	2.4	–	8.8	–
Contusion	17.0	–	45.0	56.4	23.8	87.7	9.3
Dislocation	2.4	–	–	0.6	–	–	4.6
Epistaxis	2.4	–	–	5.5	–	–	–
Fracture*	–	–	7.1	8.5	–	–	–
Laceration	2.4	–	4.7	9.1	–	–	4.6
Other	–	–	–	3.6	23.8	–	–
Sprain	–	5.1	21.3	9.1	–	–	4.6
Strain	–	5.1	7.1	3.6	–	–	9.3

*Includes suspected fractures.

Table 4 Competition injury rates per 1000 athlete-exposures (95% CI) for cerebral concussions in taekwondo

Study	Males	Females
Pieter and Lufting[26]	15.3 (4.7 to 25.9)	3.2 (3.1 to 9.6)
Pieter *et al*[14]	15.5 (0.3 to 30.7)	8.8 (8.4 to 26.0)
Pieter *et al*[12]	12.8 (12.3 to 38.0)	–
Pieter and Zemper[15]	7.0 (4.2 to 9.9)	2.4 (0.0 to 4.8)
Koh *et al*[16]	10.0 (6.0 to 26.2)	4.5 (2.1 to 11.0)
Beis *et al*[17]	1.0 (0.9 to 2.9)	–
Koh and Watkinson[27]	55.2 (27.2 to 83.1)	49.3 (12.8 to 85.8)
Kazemi and Pieter[18]	6.9 (0.9 to 14.6)	–

Table 5 Competition injury rates per 1000 athlete-exposures by body region in adult male taekwondo athletes

Study	Head and neck	Upper extremities	Trunk	Lower extremities
Pieter *et al*[14]	46.5	11.6	11.6	58.1
Pieter *et al*[12]	38.5	12.8	–	–
Pieter and Zemper[15]	28.8	12.3	10.6	43.4
Koh *et al*[16]	28.5	31.9	8.4	50.3
Beis *et al*[17]	6.9	3.9	2.9	6.9
Kazemi and Pieter[18]	24.9	6.9	11.4	32.0
Pieter *et al*[19]	–	5.1	5.1	158.2
Yiemsiri *et al*[20]	3.3	9.9	–	26.3

Men (9.4/1000 A–E (95% CI 7.1 to 11.7) were at a higher risk than women (4.6/1000 A–E, 95% CI 2.6 to 6.5) of incurring cerebral concussions (RR=1.9 (95% CI 1.1 to 3.4, p=0.020).[9] It should be noted that a fatal outcome of head injury is a distinct possibility.[11 20 21] As mentioned above, the point estimate of the incidence rate of concussions in men over 15 years is up to four times higher than in American gridiron football over a 16-year period.[4]

Injury location

Tables 5 and 6 show injury rates by body region. Within the lower extremities, the foot (instep) was especially at risk in both males and females.[12 14 15 28] Before the inclusion of the electronic chest protector scoring system, which requires the use of a non-protective 'sensor sock', taekwondo competitions called for the use of WTF-approved foot protectors/padding, which was the case when the above injury rates were reported. To the best of our knowledge, however, the effect of the electronic 'sensor socks' on foot injury rates has not been investigated.

Injury mechanisms

Early research showed that the most common injury mechanisms were receiving and delivering a blow,[15 23 29] which were recently reported by Yiemsiri *et al*[20] as well. Receiving a blow also was most commonly involved in time-loss injuries.[26] Table 7 displays the per cent distribution of taekwondo techniques most frequently implicated in injury.

A rotational technique, a spinning hook kick, led to the fatal injury reported by Oler *et al*.[11] Zandbergen[30] found that the turning kick was implicated in 40% of all reported time-loss injuries, followed by the spinning hook kick (23%), axe kick (12%) and other kicks (25%). It should be noted that this study was carried out before the athletes were required to wear protective equipment other than the chest protector.

Recent biomechanical studies on the effects of these kicks on head injury display alarming injury potential.[31 32] Fife *et al*[31] showed the clench axe kick led to linear accelerations that exceed the uppercut in boxing (33.3±11.1 g vs 24.1±12.5 g.[33] This technique was reported to be implicated in cerebral concussions in taekwondo.[34] Another study by Fife *et al*[32] revealed that the linear acceleration of the turning kick is of concern with a range of 60.5–217.3g, while the Head Injury Criterion (HIC) of the same kick was 128.4–1608.7. HIC refers to the risk of a person sustaining a head injury as a result of impact acceleration of the head. An HIC of 1000 is suggested to be life threatening.[33]

Time-loss

Time-loss injuries are considered a direct indication of the severity of injury and overall debilitation to the injured athletes.[35] The exact days off were reported for injuries to the feet,[14 28] head and neck,[36] concussions[34] as well as overall time loss.[12 37] Furthermore, a comparison with time-loss injuries in other sports[8 22] may demonstrate issues of injury management and prevention, leading to further opportunities for injury prevention strategies by national, regional and international governing bodies. Table 8 shows the competition time-loss injury rates in taekwondo while table 9 displays the exact days lost from training and/or competition.

Taekwondo men (25.6/1000 A–E, 95% CI 9.9 to 61.2) were reported to be at a higher risk of sustaining time-loss injuries than their female counterparts (23.8/1000 A–E, 95% CI 22.9 to 70.5) (RR=1.5, 95% CI 1.1 to 2.1, p=0.006), although their point estimates did not significantly differ statistically.[9] The large CIs in the individual studies comprising the total CI for the men and women is suggested to have contributed to the results. Taking steps toward an ISS for taekwondo will be important in order to shed light on the effect of any future prevention strategies regarding injuries in this sport.

Table 6 Competition injury rates per 1000 athlete-exposures by body region in adult female taekwondo athletes

Study	Head and neck	Upper extremities	Trunk	Lower extremities
Pieter *et al*[14]	8.8	8.8	17.5	61.4
Pieter *et al*[12]	23.8	–	–	23.8
Pieter and Zemper[15]	26.7	16.5	4.9	56.4
Koh *et al*[16]	7.1	16.6	2.4	64.0
Beis *et al*[17]	4.9	4.9	2.4	20.3
Kazemi and Pieter[18]	–	–	–	25.3
Pieter *et al*[19]	–	32.8	–	109.3
Yiemsiri *et al*[20]	4.6	13.9	–	13.9

Table 7 Percent distribution of taekwondo techniques most often implicated in competition injuries

	Pieter *et al*[14]		Pieter *et al*[12]		Koh *et al*[16]		Beis *et al*[17]		Pieter *et al*[19]	
Type of kick	M*	F*	M	F	M	F	M	F	M	F
Turning	66.7	63.6	25.0	50.0	56.5	65.8	47.6	20.0	90.9	89.3
Spinning hook	2.8	–	–	–	1.5	5.3	9.5	–	–	–
Spinning back	8.33	36.4	–	–	1.5	2.6	9.5	6.7	–	–
Axe	2.8	–	–	–	2.9	2.6	4.8	6.7	–	–
Side	–	–	–	–	11.6	7.9	–	–	–	–
Other	19.37	–	75.0	50.0	26.0	15.8	28.6	66.6	9.1	10.7

*F, females; M, males.

Table 8 Competition injury rates per 1000 athlete-exposures for taekwondo time-loss injuries

Study	Males	Females
Pieter and Lufting[26]	22.9 (9.9 to 35.9)	9.7 (1.3 to 20.6)
Pieter[4]	33.5 (27.3 to 39.6)	23.0 (15.7 to 30.4)
Pieter *et al*[15]	27.1 (7.0 to 47.2)	8.8 (8.4 to 26.0)
Pieter and Bercades[37]	25.6 (9.9 to 61.2)	23.8 (22.9 to 70.5)
Koh *et al*[17]	33.6 (18.9 to 48.3)	14.2 (2.8 to 25.6)
Pieter *et al*[19]	20.4 (0.4 to 40.4)	21.7 (0.4 to 43.0)
Beis *et al*[18]	6.9 (1.8 to 11.9)	2.4 (2.3 to 7.2)

The point estimate time-loss injury rate of male taekwondo athletes when all studies are combined (25.6/1000 A–E, 95% CI 9.9 to 61.2) is higher than that of collegiate football (soccer) players (18.8/1000 A–E, 95% CI 18.3 to 19.2) when collapsed over division and season,[39] although the difference is not statistically significant. However, it is not higher than American gridiron football (35.9/1000 A–E, 95% CI 35.5 to 36.3).[40] However, the taekwondo women recorded a statistically significantly higher point estimate time-loss injury rate (23.8/1000 A–E, 95% CI 22.9 to 70.5) compared with their counterparts in collegiate football (soccer) (16.4/1000 A–E, 95% CI 16.0 to 16.9)[26] as well as ice hockey (12.6/1000 A–E, 95% CI 11.1 to 14.1).[39] The discrepancy between the taekwondo men and women is suggested to be due to the large CIs.

Catastrophic injuries

Information regarding catastrophic injuries in martial arts is virtually absent and what is available is anecdotal in nature. Two earlier deaths in taekwondo were described by Schmidt[41] after one or more kicks to the unprotected trunk area. The practitioners were engaged in light contact sparring. Both deaths involved males. One cardiac-related death occurred in Spain.[42] The victim was a 22-year-old male with no apparent pathological condition that would have made him more susceptible to a fatal injury. Another death was found by Oler *et al*[11] and most recently via the media, with one adult[24] and one 17-year-old novice competitor.[25] In reviewing the literature, only one non-fatal catastrophic injury appears to have been reported.[43]

DISCUSSION

Preliminary suggestions for injury prevention

A well-accepted approach to injury prevention is provided by Van Mechelen.[44] Based on this approach, we recommend adoption of several measures, including conducting longitudinal studies of taekwondo injuries, preferably according to the following pattern: (1) determine the extent of the injury problem through the use of a well-designed injury surveillance system; (2) determine the aetiology and mechanism of injuries using data from the injury surveillance system; (3) introduce preventive measures based on information from the previous steps; and (4) assess their effectiveness by repeating step one.[44] These steps, along with the recommendations below, are considered to be a necessary first attempt to reduce injury incidence and severity in taekwondo worldwide.

Coach and referee education requirements

Guidelines are needed for minimum coursework requirements for future coaches,[46] including basic injury prevention and management.[46] Proper instruction and coaching by trained and certified individuals is recommended[47] as no current coach education coursework by the WTF is dedicated to the most

Table 9 Time-loss injury rates by gender and days lost (based on 9)

	Men			Women		
	Time lost			Time lost		
Study/body part	≤7 days	8–20 days	≥21 days	≤7 days	8–20 days	≥21 days
Head and neck[38]	7.6 (4.7 to 10.6)	2.9 (1.1 to 4.8)	2.1 (0.5 to 3.6)	5.5 (1.9 to 9.0)	1.8 (0.2 to 3.9)	1.2 (0.5 to 2.9)
Foot[39]	2.1 (0.5 to 3.6)	0.6 (0.2 to 1.4)	1.5 (0.2 to 2.8)	1.2 (0.5 to 2.9)	–	1.2 (0.5 to 2.9)
Overall[37]	25.6 (9.9 to 61.2)	–	–	23.8 (22.9 to 70.5)	–	–
Concussion[34]	3.2 (1.3 to 5.1)	0.9 (0.1 to 1.9)	1.2 (0.0 to 2.3)	1.8 (0.2 to 3.9)	–	–
Overall[38]	–	–	20.4 (0.4 to 40.4)	–	–	21.7 (0.4 to 43.0)

up-to-date scientific understanding of coaching science and related injury management. Taekwondo coaches should be thoroughly educated according to the latest scientific insights and should keep abreast of recent developments by reading the appropriate coaching and research literature on a regular basis, as is currently being done by several professional sports organisations that require up-to-date continuing education.[48–50]

Currently, the education requirements for WTF-certified referees mainly consist of learning standard hand signals and game regulations. Furthermore, there is no review of past referee performance at the end of each competition to rectify any problems that may have surfaced during competitions.[51] Moon[51] suggested that a comprehensive programme should be developed to overhaul the current 'education' of referees and a committee established independent of any organisations or groups within taekwondo governing bodies to curb the widespread abuse of the referee system. Although an electronic telemetry chest protector for scoring was introduced in 2008, the validity and reliability of this system has not been established, while its effect on fairness is yet to be objectively analysed.[52]

Preparticipation examination and improved medical care

It is recommended to have preparticipation examinations (PPE) for all those who have plans to enter competition. This PPE should be conducted once a year thereafter and, additionally to assess whether the athlete is fit to return to competition after serious injury.[53] As recommended by the International Symposium on Concussion in Sport, specifically trained sideline medical staff should employ the use of a standardised concussion assessment method: standardised concussion assessment test 2 (SCAT2).[54] To implement the use of the SCAT2, baseline scores on this test for comparative use in the event of a head injury for all registered athletes should be required as part of a more comprehensive athlete registration, education and PPE process. Athletes participating in taekwondo competitions should be educated relative to injury risks and should be strongly discouraged from entering competition prematurely.[11]

Additional preventive measures should include improved medical care and on-field recognition and treatment of head and neck injuries.[11 56] A recent report of concussion management and assessment protocols used by American and South Korean medical personnel employed at national taekwondo competitions indicated 63% of Korean tournament medical personnel were either registered nurses or emergency medical technicians,[46] who are not globally recognised[54 56] as professionals capable of correctly identifying, diagnosing and managing sport-related concussion. Furthermore, Fife and Harter[46] revealed that 46% of South Korean medical personnel indicated that the tournament at which the survey took place was their first time providing medical care at such events. To further complicate this issue, the WTF now claims to have approved the enactment of the International Olympic Committee (IOC) Medical Code (recommended for all member associations in January, 2006) as of 4th April 2012, although a memorandum of agreement between a traditional medical association in Korea (ie, traditional Chinese medicine) was recently (24 October 2011) used as the official agency responsible for medical care at WTF-sanctioned competitions.[57] Instead of using staff untrained in the diagnosis and management of injuries, the IOC[22] recommend that appropriately trained and qualified medical personnel be used, while a standardised protocol be used for assessment and return to play decisions following head and neck injury. Examples of such protocols are those that were developed by the International Symposium on Concussion in Sport,[54] which is supported by FIFA and the National Football League (NFL, the American professional gridiron football league).[58]

In view of the extent and seriousness of competition injuries in taekwondo, it is vital to adhere to standards set by the IOC[22] and the National Athletic Trainers' Association (the American professional organisation for certified sports physiotherapists) in terms of qualified medical personnel to provide emergency care for high-risk sports.[57] The lack of qualified medical personnel employed at tournaments[46] further highlights the need to improve medical care for these athletes.

Standardised medical care

Head injury and its potentially debilitating consequences, such as acute injuries of skull fracture, haemmorrhage and the effects of repetitive concussions (i.e., subsequent manifestation of chronic traumatic encephalopathy**)** deserve special attention. Prospective studies[26 27 34 59 60] reported injury rates for cerebral concussions in taekwondo with men being at a higher risk than women (9.4/1000 A–E (95% CI 7.1 to 11.7) vs 4.6/1000 A–E (95% CI 2.6 to 6.5)) (RR=1.9, 95% CI 1.1 to 3.4)[4] (table 4). Even though other sports report lower incidence rates when compared with TKD, their sport governing bodies, for example, NFL[58] and FIFA,[54] have taken strict precautionary measures, such as rule modifications and improved sideline medical assessment methods.

Standardisation of protective equipment and safety testing

Improved protection (ie, properly fitted and regularly tested protective equipment) may also help reduce the chances of head and neck injuries.[55] However, to this date, only one report[61] on the safety performance of the official WTF-approved taekwondo headgear exists, indicating that none passed the standardised impact attenuation testing (i.e., ASTM F-2397-04).

What this study adds

- Perspective for the 80 million taekwondo participants who may be exposed to concussion, where the incidence rate is reported to be up to four times higher than in American gridiron football.
- A comprehensive look into the traumatic injuries sustained in taekwondo, such as bone fractures and head injuries.
- Recommendation for an international injury surveillance system to be set up by taekwondo governing bodies in an effort to understand the nature of injuries so that preventive measures may be implemented effectively.
- Standards of medical coverage and head injury treatment are recommended for competitions, as are being adopted by other sport governing bodies.

Rule changes

Changes in rules have been suggested many times,[11 15 16 18 29 34 37 45 59] to promote a possible decrease in head injuries. However, over the last 10 years, rule changes instead have been implemented in an effort to 'improve the sport to a global standard' and to 'become a permanent fixture in the Olympic programme'[62] that award competitors more points (up from 1 to 4 points as of this writing) for successful spinning kicks to the head,[63] which would appear to be counterproductive with regard to reducing the number and severity of head injuries. This has resulted in a reported increase in the use of kicking techniques aimed to the head[63] as well as possible concussions.[64] Attention should again be brought to the recent biomechanical studies of head blows in taekwondo that confirm spinning kicks lead to higher accelerations and HIC values than various boxing punches[33 65] and head-to-head collisions in sports such as American gridiron football[66] and ice hockey.[67]

Defensive manoeuvers for injury prevention

More than 20 years ago, a lack of blocking skills was identified as being related to injuries and correction of this lack was presented as a preventive measure.[23] Subsequent studies also emphasised improving blocking skills to help prevent injuries including those leading to time loss.[11 29] However, more recent research seems to indicate that no changes have been made over the years; deficient blocking skills are still among the most frequent mechanisms of both general[16] and severe injuries.[59] Koh and Watkinson[27] reported that lack of blocking skills or lack of evasive manoeuvers was involved in 99% of total concussions. Furthermore, all of the head blows incurred during the semifinals and finals of the 1999 world championships were due to the absence of blocking skills.[59]

CONCLUSIONS

This review identifies previously reported injury rates in taekwondo that surpass rates reported in other high-impact sports. Of particular concern are the traumatic injuries; for example, fractures and head injuries, which also occur at higher rates than in other sports. From a medical standpoint, this report suggests a heightened responsibility of taekwondo governing bodies to comply with the most recent scientific findings and with IOC standards to ensure athletes have the safest arena possible in which to compete.

To date, no injury tracking system or any standardised injury management protocol exists in taekwondo. It is strongly recommended that such an injury tracking system be implemented and that medical and safety guidelines be established to ensure the protection of taekwondo athletes worldwide.

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