Performance Optimization in Taekwondo: From Laboratory to Field

Chapter: Injuries in Taekwondo
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Abstract

Taekwondo (TKD) is a martial art and contact sport in which the athletes’ goal is to strike the opponent with maximal force while respecting the sports’ rules (i.e., no demonstration form). This fact exposes TKD practitioners to permanent risk of injuries like for the great majority of other contact sports. TKD accidents can have a negative effect on the athletes’ career because of short, medium and even long term activity cessations.

Thus, this chapter aims to detail the characteristics of injuries that occur in TKD (i.e., injury rates, location, and severity), the risk factors of injuries, and finally to suggest some possible countermeasures that might help to prevent and/or to reduce the rate of these injuries.

Introduction

Taekwondo (TKD) is a popular martial art which has been accredited as an Olympic event since the 2000 Olympic Games of Sydney. TKD is a full contact sport where athletes are called to strike their opponents using kicks with full force within the sport’s rules [1]. A typical combat for adults (i.e., male and female) consists of three rounds intercepted with one minute of recovery in-between [1].

The specificity of TKD (i.e., point doubling with strong, circular and heading kicks) exposes the athletes to permanent risk of injuries during both training (specifically in sparring drills) and competitions. In that regard, Kazemi et al., [2] reported that 54% of injuries in TKD occurred during matches while 36% are related to training incidents. These injuries are more frequent in the lower extremities (46.5%) than in upper ones (18%). The rest of injuries occurred in back (10%), and head (3.6%) [2].
These facts led many researchers [3-15] to examine the occurring TKD injuries during training and competitions. It was suggested that the TKD injury rate is lower than that in some sports (e.g., mixed martial arts, snowboard cross) [16,17], and higher than in other ones (e.g., karate, aikido, kung fu, tai chi, soccer, ice hockey, basketball) [11,18,19]. It is therefore important, from a preventive point of view, to identify injury characteristics (i.e., types, body location, and mechanism of injury) and their related risk factors (age, body weight, and level of experience).

Thus, the first part of this chapter identifies and explains the TKD athletes’ injuries characteristics, and their risk factors. The second part presents some suggestions for prevention and surveillance.

**Injury Characteristics**

Studies focusing on occurring injuries during competitions and/or training sessions were based on two research’s parameters: quoting the injury’s definition and the basic formula of injury rates. An injury was defined as “any physical complaint caused by a transfer of energy that exceeds the body’s ability to maintain structural and/or functional integrity during competition or training session” [11,13]. Moreover, Junge et al., [20] recommended another operational injury definition reporting that these accidents are all new or recurring musculoskeletal complaints or concussions incurred during competition or training receiving medical attention, regardless of time loss from competition or training. Injury rates (training, combats, overall) were calculated as injuries per 1000 h of exposure [3-10,12,14,21-24].

**Taekwondo injury rates**

The data analysis of TKD injury rates has concerned a lot of prospective studies [12,14,21-23] and a few retrospective investigations [11,23]. A recent 9-years’ longitudinal study, focused on 904 injuries reported across 58 competitions [25]. Another study conducted by Lystad et al., [11], showed an injury rate of 79.3 injuries per 1000-h during competition. Based on this high injury rate, investigators suggested that TKD cannot be considered a safe sport activity relative to other main sports. In this context, Zetaruk et al., [18] attributed the highest percent of injury’s rate in combat sports (expressed as percentage of participants sustaining injuries) to TKD (59%) when compared to the rates reported in aikido, kung-fu, karate, and tai-chi (51%, 38%, 30%, and 14%, respectively).

Previous researches have shown a high variability of injury rates in TKD between genders (male vs. female) and age categories (i.e., children, youth and adults competitors). Differences in injury rate between various expertise levels will be discussed below.

Table 1 presents the difference of injury rates between genders. Beis et al., [9] found that males sustained fewer injuries than females. A logical explanation could be that men athletes tend to report injuries less than their women counterparts [26].

The difference of injury rates are also observed between countries. For instance, Greek TKD athletes [9,14] have the lowest injury rates when compared with American [3,7], European [5], Canadian [21], Thai [22], Australian [23], British [27], and Turkish TKD athletes [28]. This difference may be due to the expertise level (i.e., elite, recreational) [12,26], the level of skill [21], the physical preparation [12], the improvement of safety equipments and, rules and regulations’ variations over time [14].
Table 1: Total injury rates (training and competitions) per 1000-h athlete-exposures (95% Confidence Interval) for Taekwondo athletes.

<table>
<thead>
<tr>
<th>Study</th>
<th>Men</th>
<th>Women</th>
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<tbody>
<tr>
<td>Zemper and Pieter [3]</td>
<td>127.4 (79 to 175)</td>
<td>90.15 (51 to 130)</td>
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<tr>
<td>Pieter et al., [5]</td>
<td>139.5 (94.0 to 185.1)</td>
<td>96.5 (39.5 to 153.5)</td>
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<tr>
<td>Pieter et al., [27]</td>
<td>51.3 (91.0 to 101.5)</td>
<td>47.6 (18.4 to 113.6)</td>
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<tr>
<td>Pieter and Zemper [7]</td>
<td>95.1 (84.7 to 105.4)</td>
<td>105.5 (89.8 to 121.1)</td>
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<tr>
<td>Koh et al., [9]</td>
<td>120.81 (92.91 to 148.7)</td>
<td>90.05 (61.42 to 118.7)</td>
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<tr>
<td>Beis et al., [10]</td>
<td>20.55 (11.8 to 29.3)</td>
<td>36.41 (18 to 54.8)</td>
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<tr>
<td>Kazemi and Pieter [21]</td>
<td>79.91 (53.4 to 106.4)</td>
<td>25.25 (3.1 to 47.4)</td>
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<tr>
<td>Pieter et al., [10]</td>
<td>168.37 (110.9 to 225.8)</td>
<td>153.01 (124.1 to 181.9)</td>
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<tr>
<td>Yiemsiri et al., [22]</td>
<td>39.47 (17.6 to 61.4)</td>
<td>32.41 (8.8 to 56)</td>
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<tr>
<td>Ziaee et al., [12]</td>
<td>69.51 (55.4 to 83.6)</td>
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<td>Lystad et al., [23]</td>
<td>59.93 (51.16 to 69.77)</td>
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<td>Varkiani et al., [14]</td>
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**Injury location, types and mechanism**

In an attempt to well understand and to be more effective in treating injuries, some standardized classification systems were used in sports injury investigations to identify and classify injuries. The Orchard Sports Injury Classification System (OSICS) and the Sport Medicine Diagnostic Coding System (SMDCS) [11,15] are the common systems used in the scientific literature.

Based on these systems, injuries in TKD may be classified by location, body region (i.e., anatomical region) and type (i.e., pathology). Moreover, classification can be based on the injury mechanism. Lystad et al., [11] reported that part of injuries might be caused by violation of competitions’ rules and other injuries might be due to an overuse or a traumatic event. These injuries could be occurring during both training and competition. In the same context, Kazemi et al., [2] reported that 54% of injuries were sustained during competitions, while 36% were related to training incidents. In a recent retrospective investigation, Altarriba-Bartes et al., [15] proved contradictory percentages concerning the injury timing and revealed that the percentage of injuries that occurred during training sessions were 61.1% (n=1026 injuries) while when the pre-competition period was concerned (i.e., 15 days before the competition’s beginning) the value was lower (23.3%; n=391 injuries) and finally an even lower percentage (15.6; n=261 injuries) was attributed to the competition period. These findings could be explained by the high importance of competitors’ protection imposed by the World Taekwondo Federation (WTF) during combats [14]. Nevertheless, competition protection equipment is rarely used during training sessions. That’s why, it is recommended to use the real situations (using official TKD equipment) during training sessions as per competition. It is interesting to notice that most of the injuries that occurred in TKD are acute or “of sudden onset”, while the other type is qualified as “of gradual onset” [29].

Concerning injury’s location, most of the studies in TKD showed that lower limbs are the most frequent region injured with a variation in percentage between studies. Indeed, Kazemi et al., [25] reported that the most common injured body region was the lowest limbs (54.7% of total of injuries found in this previous study) followed by head and neck (23.3%). The least frequent regions were upper extremities (12.2%) and torso (9.8%). These findings
are in concordance with those reported by Lysatd et al., [11] who showed that injuries to the lower limbs were more frequent than to the head among athletes having at least the “black belt” level compared to those “under-black belt” [11]. Shirani et al., [30] highlighted that, through their study, 29.6% of injuries detected occurred in the head and neck regions, while 44.5% of all injuries found appeared in the lower extremities. The injuries reported in this previous study included facial laceration, bone fractures (nose, mandible and zygoma), dental injuries (displacement, luxation, fracture, and avulsion), and mandibular dislocation. Recently, Altarriba-Bartes et al., [15] confirmed that lower limbs (i.e., lower leg, foot, ankle, knee and thigh) were the most injured body regions in TKD with a percentage of 70.7% of total of injuries. The recent literature review of Pieter et al., [13] confirmed that the lower limbs sustain most of the occurring injuries. Head- and neck- injuries ranked the second most and often injured body parts. This finding could be explained by the specificity of TKD since lower limbs are more used than upper limbs to score points during combats. They also often target the head’ region explaining that after the lower limbs, the head is highly concerned by injuries.

In contrast to previous findings, another study [23] revealed that upper limbs were the most frequent injury region. In addition, Oler et al., [31] found that head and necks injuries were ranked among the most frequent injuries. Previous authors have shown that the practice of a contact sport (e.g., taekwondo) results in 3 times higher risk of orofacial injuries than for a non-contact sport (e.g., volleyball) [e.g., 24% vs. 8%, for TKD and volley-ball, respectively] [32]. Two other investigations [12,14] have identified injuries occurring among Iranian TKD athletes. In this context, Varkiani et al., [14] reported that upper extremities were the most commonly injured body region (36.4% of the total number of injuries) followed by lower extremities, head and neck with equal values (27.3%) and finally the torso (9.1%). This result was explained by the fact that Iranian male TKD athletes may use their upper limbs more frequently than athletes from other nations to defend against the opponents’ kicks. Therefore, they were more vulnerable to more upper limbs’ injuries [14].

Moreover, it was noticed that there was a divergence in injuries rates before and after 2009 [14] as a fact of socks used for foot and ankle simultaneously with electronic Hugo protection. Thus, these measures were the cause of a noticeable decrease in injuries risks and thus, rates. Besides, Alizadeh MH [33] affirmed that, as a consequence of electronic Hugo’s use in competition, TKD athletes do no more need to strike powerfully the opponent, and just have to impact the opponent with adequate rate of force for obtaining points.

For the injury type, an analysis of the literature highlighted that the most common type of injury was contusion [7,9,11,14,15,25] with a rate ranging from 29.3% to 36.25% (n= 319 injuries) [14,25]. The second injury’s type commonly occurring in TKD was joints’ sprains (18.86%, n=166 injuries) [23]. Another recent study [34] supported similar results to the previous ones. To explain these findings, authors indicated that the greatest numbers of offensive and defensive techniques are the main cause of this injury type’s increase. Moreover, strain could happen as the result of kicking actions above the waist or above the opponent’s head to obtain highest scores in TKD [18].

Furthermore, epistaxis was found in TKD especially among males [10]. Cerebral concussions were reported more among male TKD athletes while they are less frequent in females [35].

However, these results were not in accordance with other findings from others studies [21,36] where the sprain injuries were reported to be the more common injury’ type within men athletes.
Besides, it is very important to report that most of the studies related to injuries in TKD competitions focused only on elite adult athletes [3,5,7,9,14,21-23,27,28]. In terms of junior-level accidents, recent studies have reported a total number of 3910 technical actions scored with 1354 that were high kicks. Among those kicks, 38 were the cause of mild injuries that allowed the fight to continue while only 7 were the cause of combat end with a Knock Out (KO) and/or head injury. The reduced number of KOs found in this study (0.56% in men and 0.27% among women) was attributed not only to the multiple weight classes (10 for the men and 10 for the women) but also to the refereeing, the clear and sufficient touching of the target to win points [37].

There with, recent analysis showed that receiving a blow (defensive kick) resulted in significantly more injuries followed by the offensive kick (delivering a blow) as the second most common cause of injury [27]. It is also suggested that roundhouse kick was the most likely technique implicated in the injury cause [9]. Moreover, Kazemi et al., [25] reported that 43.94% of injuries (n= 337) were caused by receiving a blow and 34.68% of injuries (n= 266) were attributed to delivering a blow. Likewise, Lystad et al., [11] noticed that the rates of injuries that are related to defensive and offensive kicks’ mechanism were 44.1/1000 A-E (athlete-exposures) and 25.5/1000 A-E respectively.

**Injury severity: Time-loss and catastrophic injuries**

Fuller et al., [38,39] defined the injury severity as the number of days that have elapsed from the date of injury to the date of the player’s return to full participation in training and combat play. Injuries’ severity are usually grouped as: Slight (0-1 days), Minimal (2-3 days), Mild (4-7 days), Moderate (8-28 days), Severe (> 28 days), Career-ending and Non-fatal catastrophic injuries [37,38]. In contrast, Lystad et al., [11] criticized other definitions proposed in previous investigations. Therefore, authors criticized the scale of 0-10 proposed by Sherrill [40] based on the missing time during the competition’s participation and the classification suggested by Koh et al., [8] (i.e., Mild, moderate and severe defined as “no time lost”, “some disruption” and “discontinued participation”, respectively.

Table 2 presents inter and intra-group comparison for TKD time-loss injuries. All investigations highlighted that TKD male athletes were at a higher risk of suffering from time-loss injuries than female ones [3-8,24] in contrast to the study of Pieter et al., [41] where values were approximately similar (20.41/1000 A-E vs. 21.74/1000 A-E for men and women, respectively). This divergence under gender can be reported to the large confidence interval as explained by Beis et al., [24]. Whereas, the time-loss injury rate mentioned in the study of Beis et al., [24] were lower than the values reported in previous studies [3-8,42]. These findings may be due to the adjustment of rules and regulations associated with the use of new equipments such as electronic Hugo, specific gloves and socks as it was reported by Varkiani et al., [14].

There is a data paucity concerning the time loss involved in relation to injury’s types [35,42,43]. Proceeding chronologically, Pieter and Zemper [42] reported that foot injuries occurred among men (35.7%) and women (50%) led to time loss of 21 days or more. In addition, Pieter and Zemper [35] suggested that the largest part of cerebral concussions led to time loss of 7 days or less for both male and female athletes, whereas, concussions caused a time loss of 21 days or more from practice for men only [35]. Finally, for head and neck injuries, they may led to time loss in arrange of 7 days or less to 21 days or more [43].

For age categories, Beis et al., [24] found that the female juniors’ TKD athletes (14-17
years) had a higher time-loss injury rate than their adult counterparts (over 18 years); with no difference between men (i.e., senior) and junior boys.

In comparison to other sports, both men and women TKD athletes tend to record higher points estimating time-loss injury rate [13]. For example, there was a significant difference between female TKD athletes and female collegiate football (23.8/1000 A-E vs. 16.4/1000 A-E respectively) [4]. However, there were no significant recorded difference between male TKD athletes and their counterparts in collegiate football [24]. It should be noted that, in spite of the difference between TKD and Karate, the combined rates for men and women in time-loss injury were similar [41,44] and no explanation was found by analyzing the literature. Regardless to this result, the investigators have to be cautious when they are comparing the risk of injury across different sports with significant variability through studies from the methodological point of view (i.e., the method of data collection including the classification and the mechanisms of injury) [16].

Based on the scientific literature, the results published cannot be sufficient in order to bring a clear idea about catastrophic injuries in martial arts in general and particularly in TKD. As a result to kicking to the unprotected trunk area in a light contact sparring, Schmidt [45] highlighted the death of two males TKD athletes. Then, Oler et al., [31], in a prospective research, reported one death. Moreover, Birrer [46] talked about six deaths. The limitation of the two studies previously cited [31,46] is that they didn’t present clear gender and age characteristics of the dead athletes. In Spain, another death related to cardiac problems was reported [47]. Cohen et al., [48] reported only one case after a severe head trauma pain; the athlete was a 23 year old man. Despite the death’s numbers cited above those studies, this may not hide the lack of relative data (i.e., the number of competition, the number of competitors, the number of deaths per hours of athlete-exposures). The previous investigations have to take into account those variables.

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<tr>
<td>Zemper and Pieter [3]</td>
<td>23.58 (5.09 to 42.07)</td>
<td>13.51 (1.78 to 28.80)</td>
</tr>
<tr>
<td>Pieter and Lufting [4]</td>
<td>22.90(9.94 to 35.86)</td>
<td>9.68(1.27 to 20.63)</td>
</tr>
<tr>
<td>Pieter et al. [5]</td>
<td>27.13(7.03 to 47.23)</td>
<td>8.77(8.42 to 25.96)</td>
</tr>
<tr>
<td>Pieter and Bercades [6]</td>
<td>25.64(9.90 to 61.18)</td>
<td>23.81(22.86 to 70.48)</td>
</tr>
<tr>
<td>Pieter and Zemper [7]</td>
<td>33.45(27.31 to 39.51)</td>
<td>23.03(15.71 to 30.35)</td>
</tr>
<tr>
<td>Koh et al. [8]</td>
<td>33.56 (18.85 to 48.27)</td>
<td>14.22 (2.84 to 25.60)</td>
</tr>
<tr>
<td>Beis et al. [40]</td>
<td>6.85 (1.78 to 11.92)</td>
<td>2.43 (2.33 to 7.19)</td>
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Table 2: Competition injury rates per 1000 hours of athlete-exposures (95% Confidence Interval) for Taekwondo time-loss injuries.

**Injury Risk Factors**

There are some evidences that adjustable risk factors including lack of preseason training, lack of security equipments in some competitions associated with psychosocial aspects are among the risk factors that can increase injuries in TKD [49]. Nevertheless, the evidence for others risk factors (e.g., age, sex, level of experience, body weight and previous injury) were not well studied [19].

It is interesting to note that a study showed that the time of day had no effect on injuries outcome [14]. In the other hand, Varkiani et al. [14] found that most of injuries were sustained in the early season (45.5%, n= 10 injuries) followed by late season (36.4%, n= 8 injuries). As it
was the first investigation which focused on studying these parameters in TKD, an explanation of this result raises the problem of the lack of preseason training or overload training [14,49]. In addition, Altarriba-Bartes et al. [15] attributed a significant relation between injuries type, injury location and the annual quarter as an important risk factor. Furthermore, Altarriba-Bartes et al. [15] reported, for both males and females, a percentage injury of 34.5 (n=579 athletes), 28.48 (n=478 athletes), 14.89 (n=250 athletes) and 22.1 (n=371 athletes) during the first, the second, the third and the fourth quarter of the year respectively. The variability under these quarters was attributed to the competitive calendar [15]. Moreover, Ziaee et al. [12] found that, among Iranian TKD athletes, most of injuries occurred in the third round (49.5 %) of the combat in comparison to the second (43.1%) and the first one (7.5%). This fact may be related to fatigue. Such an interpretation could be supported by a previous study [49] which has shown that fatigued individuals are vulnerable to injury.

Focusing on the relationship between age, body weight and injury rates, it was hypothesized that this relation would be linear [28]. Authors affirmed that by advancing in age, athletes are expected to increase their body weight and strength so that can be a cause of an increase in the injury rate despite that this suggestion was not confirmed statistically in later investigations [9]. In contrast, other studies supported the suggestion that within age classification, junior TKD athletes were more vulnerable to injuries than children [51]. Moreover, Shiff et al. [52] reported that men and women were at a greater risk of injury in comparison to boys and girls respectively; this can suggest that the age is among factors that can influence the injuries’ occurrence. Furthermore, Caine et al. [53] highlighted that the heaviest weight produced greater forces so that can harm the soft tissue and the joints. In the same idea, as males are heavier than females, they may be more vulnerable to be injured [53]. Recently, with the use of an electronic Hugo, TKD athletes had not to kick powerfully and they were asked to touch the targets in the electronic Hugo with a moderate and adequate power [14,32, 36]. The reasons cited above may explain the decrease in injury rates during recent researches with the 2 genders [14].

Finally, athlete experience may also affect the injury risk [40]. This assertion was suggested by Kazemi et al. [24] who showed that athletes in the level of colored belts suffered more from injuries while receiving a kick, while black belt athletes tended to suffer from injury when delivering a kick.

Counter-Measures to TKD Injuries

In the light of studies results dealing with the identification of different types of injuries that occur during TKD combats and/or training, it is important to take some preventive measures to reduce the rate of these accidents. Many studies [8,11-14,23,33,40,41] identifying the more frequent injuries in TKD competitions and their causes, provided some effective recommendations to fight against these problems. These countermeasures can be classified into: measures related to medical cares, to some decisions that can be possibly taken by TKD governing bodies (e.g., TKD federations) and to the education of athletes, coaches, and referees. In this context, Burke et al. [54] highlighted that TKD tournaments that emphasize limited contact, protective equipment, and medical supervision are relatively safe.

In TKD combats, the rate and severity of injuries need a big medical intervention since some injuries (e.g., concussion, ligaments tear and serious contusion) cannot be treated by only using a simple medical intervention. For this reason, many studies [4,30,34] recommended
that medical supervision is paramount and obligatory during TKD competitions to reduce the incidence of serious injuries.

Moreover, the competition organizers should provide appropriate medical assistance during combats and doctors should have the authority on the basis of the severity of the injury to stop one participant or fighter if they judge his inability to continue fighting [54]. Furthermore, Burke et al. [54] suggested that it is very useful that the medical profession who is assisting during the TKD competition can have the authority to take initiative to meet judges before the beginning of competitions, inform them about the severity of some injuries and therefore show them the importance of how they can help to reduce incidence of injuries by closely monitoring combats. Finally, it is recommended that TKD national governing bodies assign medical personnel who had extensive direct experience with the sport of TKD to provide medical services at national level tournaments [55].

From a protection point of view, it is obligatory that TKD athletes wear protective equipments reducing therefore the risk of being slightly or seriously injured during training and/or competition. Burke et al. [54] found that the decrease on the rate of injuries during TKD competition were attributed to the requirements to wear safety padding to protect the head, hands, elbows, feet, and groin. For example, the use of padding for feet amongst TKD athletes helps to reduce injuries to this body region [54]. Likewise, mouth guards should be mandatory at all competitions to help preventing from dental and orofacial injuries as well as reducing the incidence severity of brain injuries [31]. It is suggested that protective equipments should be improved for an objective to decrease the risk of injuries. For this aim, some studies [1,31,55] tried to test the efficiency of some protective equipments used in TKD competitions. It was showed that some protective equipments (i.e., forearm guards) used in TKD were more effective than others (i.e., foot protectors) [1] and that the headgears used are not so effective to protect competitors suggesting then that TKD headgear manufacturers and sport governing bodies should consider improving the design of anterior helmet properties [56].

In order to prevent and reduce injuries, the re-evaluation of current TKD competition rules by the governing bodies [30,34] could be an effective method. The Changes in rules have been suggested several times as a way which can contribute to minimize the injuries occurrence in TKD tournaments [30,34,53]. Governing bodies should, instead of making change in rules in an attempt to improve “the sport to a global standard” [13], make changes to reduce the risks caused by its practice. For example, as the head injuries are among the most serious accidents that can occur during TKD competitions, this can be due to the frequent use of high techniques (i.e., at the level of head) to obtain more points (up to 4 points). Thus, this rule can be the cause of frequent injuries by frequent use of kicks to the head and consequently a change in rules can reduce blows to the head/face and then helps to reduce serious injuries [30,34]. Moreover, the organizers (i.e., the world Taekwondo Federation) can provide rules of engagement which do not allow blows to the face and allow only light contact to other target areas [54]. Another possible change could promote the use of closed fist instead of using open hands in TKD which could results in reduced fractures to the hands and fingers [34].

Moreover, the education of coaches, referees and athletes seems to be also another important aspect on which Organizing bodies can work for a best prevention of injuries. Coaches, referees and athletes should be educated with respect to injuries, their mechanisms and how to manage them [55] with a minimum standard of qualification degrees for coaches and referees [30]. TKD coaches should be educated according to the latest scientific insight and they should follow the updated research literature. Moreover, the education required for
referees should not be limited to the game’ rules and hand signals, but a program for referees’ education should also be considered [13]. Furthermore, McLatchie et al. [57] suggested that referees should have a competition experience, preferably at the national level as a minimum requirement, to better assessing the risky activities during combats in terms of the blows’ nature and other aspects of the match.

Another important factor which can help to prevent youth and children from risk of injuries is to prohibit children from entering to combats prematurely [28,30] and they should be well educated about how using techniques especially those that cause injuries (e.g., roundhouse kicks) as well as more adequate game planning and blocking skills [28,58].

**Basic Prevention of Injuries**

**Injury prevention**

Injuries are an inherent part of any martial art including TKD, and, unfortunately, occur far too often. They are especially prevalent among beginners who may not be physically fit or who may never have been exposed to the complexities of a martial art. There are several things that can be done to prevent, treat and rehabilitate common minor injuries to soft tissues [59]. The first step of injuries prevention is to have a physical examination before beginning any strenuous martial art training. The next step is to develop general conditioning. Indeed, for instance, suddenly, participating in five hard workouts a week after years of inactivity is inviting a major injury. Methodical exercise should be used to build up the correct balance of flexibility, strength and endurance. To accomplish this, the athlete’s body should be stressed at gradually increasing levels of exertion and intensity. It is important to strike a balance between the amount of exertion applied and the body’s ability to adapt to it. If this balance is misjudged, the body will start breaking down and injuries will result [59].

**Flexibility**

Some TKD techniques (e.g. Neryo Chagui) require a certain amount of flexibility, and can easily cause injury if they are attempted without it. A regimen of only strength training can cause flexibility and joint mobility to suffer, since strong, tight muscles are shorter and restrict the range of motion. Appropriate stretching exercises can lead to greater agility and a larger range of motion, allowing the practitioner to perform a wider range of techniques [60].

**Warming-up and cooling down**

Also warm-up exercises are an essential part of TKD training, not only to prevent injuries but also to enhance performance [61]. Warming the body with exercise opens muscles’ blood vessels, enabling 50% to 60% greater blood flow. This allows a higher rate of oxygen exchange between the blood and muscles to occur, which permits better endurance and performance. After working out, the body should be allowed to cool down and relax. Doing this prevents light headedness or fainting from sudden abrupt changes in activity. As part of the cooling-down process, breathing should be slowed and relaxed to allow the heart and lungs to return to normal activity.

**Proper technique**

It is important to learn any new technique correctly. Proper instruction should be obtained from a knowledgeable source, even for something as simple as punching - injuries can, and
often do, occur because of improper form or execution [59]. In some cases, proper execution of techniques may be impossible, as everyone’s skeletal system and musculature are different, and all have their limitation.

**Monitoring training load, recovery and overtraining**

An adequate training load planning and an optimal recovery decrease significantly the injury rate throughout the year especially during the holy month of Ramadan [62-65]. In other chapter of the present book, Haddad et al. [66] have presented a model for monitoring training load, overtraining and recovery in TKD with simple and practical methods such as rating of perceived exertion [67, 68] Hooper Index (ratings for the quality of sleep, quantity of fatigue, sleep and delayed onset muscle soreness [69], and Total Quality Recovery (TQR). Other common objective methods based on heart rate for monitoring training load can also be used in TKD [70].

**Nutrition and fluids**

Good diet and hydration can enhance sport performance [71]. The basic training diet should be sufficient to: provide enough energy and nutrients to meet the demands of training and exercise; enhance adaptation and recovery between training sessions; include a wide variety of foods like wholegrain breads and cereals, vegetables (particularly leafy green varieties), fruit, lean meat and low-fat dairy products to enhance long term nutrition habits and behaviors; enable the athlete to achieve optimal body weight and body fat levels for performance; provide adequate fluids to ensure maximum hydration before, during and after exercise and promote the short and long-term health of athletes. Drinking fluids is an essential part of training, especially since the body is composed of 65% water [72]. Even a 2%-4% drop in body weight due to fluids loss will affect performance. Dehydration from strenuous exercise or heart affects the entire body, especially the circulation system. Fluids are also necessary to regulate body temperature. When the body loses fluids, it is less able to dissipate heat, and the nervous system, causing neuromuscular impulses to contract muscles too much or not enough, which can cause injury [73].

**Taping**

Taping is used to prevent injuries during training or competition. It is also frequently used to prevent injuries recurrence. Taekwondo athletes use taping to prevent ankle, instep, and toe injuries during training or competition. The materials required for taping include scissors; fleece pads or layered gauze; sponges or pads made of cotton, gauze, or foam rubber. Athletes who have minor injuries from training may decide to proceed in a competition despite their injuries; therefore, some taping may be required [74].

**Conclusion**

TKD is a contact sport which involves both upper and lower extremities in striking situations. Like in other sports, injuries are a common incident which can occur during training and/or competition. Regardless to protection equipments that are obligatory according to rules associated with other measures (i.e., hugo, groin guard, forearm guards, shin guards, hand protector sensing socks, a mouth guard and a head protector), the injuries rate in TKD is still remains high compared to other sports and to other martial arts (e.g., karate, kung fu). It has been reported that the upper limbs were the most commonly injured body region and
that contusion was the most common injury type occurring in TKD due to the use of defensive kicks. Furthermore, it was also showed that some of these injuries led to time loss injuries. In fact, literature showed that there was a difference between genders (males have fewer injuries than females), age categories (female juniors’ TKD athletes had a higher time-loss injury rate than their adult counterparts), body weight divisions (increasing in body weight and strength may cause an increasing in injury rate), level of experience (colored belts suffered more from injuries due to a defensive kick, while black belt competitors tend to suffer from injury due to an offensive kick). Some investigations highlight the principal risk factors of injuries sustained in TKD (e.g., lack of preseason training, lack of protective equipments in some competitions and events, competitions’ rules).

Based on that epidemiological information, it would be of interest to implement an injury tracking system with the aim to improving the safety of TKD athletes all over the world. Preventive measures could be taken in attempting to reduce the rate of these incidents. This concerns providing medical assistance, the use of security equipments (e.g., mouth guards, foot protectors..) with some proposals for making changes in rules from TKD governing bodies (e.g., WTF). Furthermore, one of the important preservative factors would be the education of referees and coaches who should have a minimum of training and experience to direct a match or conduct a specific TKD training program and not be limited to rules knowledge. Other researches in this field are required to improve knowledge about these incidents and to provide more solutions to keep TKD more safety.

References


