Injuries in martial arts: a comparison of five styles

M N Zetaruk, M A Violán, D Zurakowski and L J Micheli

Br. J. Sports Med. 2005;39;29-33
doi:10.1136/bjsm.2003.010322

ORIGINAL ARTICLE

Injuries in martial arts: a comparison of five styles

M N Zetaruk, M A Violán, D Zurakowski, L J Micheli

Br J Sports Med 2005;**39**:29–33. doi: 10.1136/bjsm.2003.010322

See end of article for authors' affiliations

Correspondence to: Dr Zetaruk, Pediatric Sports and Dance Medicine Program, Children's Hospital, 840 Sherbrook Street, Winnipeg MB, R3A 1S1, Canada; mzetaruk@shaw.ca

Accepted 6 January 2004

Objective: To compare five martial arts with respect to injury outcomes.
Methods: A one year retrospective cohort was studied using an injury survey. Data on 263 martial arts participants (Shotokan karate, n = 114; aikido, n = 47; tae kwon do, n = 49; kung fu, n = 39; tai chi, n = 14) were analysed. Predictor variables included age, sex, training frequency ($\leqslant$3 h/week *v* >3 h/week), experience (<3 years *v* $\geqslant$3 years), and martial art style. Outcome measures were injuries requiring time off from training, major injuries ($\geqslant$7 days off), multiple injuries ($\geqslant$3), body region, and type of injury. Logistic regression was used to determine odds ratios (OR) and confidence intervals (CI). Fisher's exact test was used for comparisons between styles, with a Bonferroni correction for multiple comparisons.
Results: The rate of injuries, expressed as percentage of participants sustaining an injury that required time off training a year, varied according to style: 59% tae kwon do, 51% aikido, 38% kung fu, 30% karate, and 14% tai chi. There was a threefold increased risk of injury and multiple injury in tae kwon do than karate ($p<0.001$). Subjects $\geqslant$18 years of age were at greater risk of injury than younger ones ($p<0.05$; OR 3.95; CI 1.48 to 9.52). Martial artists with at least three years experience were twice as likely to sustain injury than less experienced students ($p<0.005$; OR 2.46; CI 1.51 to 4.02). Training >3 h/week was also a significant predictor of injury ($p<0.05$; OR 1.85; CI 1.13 to 3.05). Compared with karate, the risks of head/neck injury, upper extremity injury, and soft tissue injury were all higher in aikido ($p<0.005$), and the risks of head/neck, groin, and upper and lower extremity injuries were higher in tae kwon do ($p<0.001$). No sex differences were found for any of the outcomes studied.
Conclusions: There is a higher rate of injury in tae kwon do than Shotokan karate. Different martial arts have significantly different types and distribution of injuries. Martial arts appear to be safe for young athletes, particularly those at beginner or intermediate levels.

Participation in the martial arts has grown rapidly over the past 10–15 years, with an estimated 8 million Americans currently involved in one of the many styles practiced today.[1 2] Increasing numbers of women are moving up through the ranks in order to maintain fitness and provide skills for self defence. In part, because of the media's portrayal of martial arts, children are also becoming interested in this form of activity.[1]

There are many benefits to participation in the martial arts, such as the development of discipline, respect, strength, coordination, balance, and flexibility.[3 4] However, it is not clear from the literature what risks are involved with regular training. Although some research has been carried out to determine the risks of injury in martial arts, most studies have focused on tournaments,[1 5 6] as this appears to be the setting that poses the greatest risk of injury.[7] Many martial artists never participate in competitions, however, so the data obtained from such studies cannot be extrapolated to all participants. In addition, previous studies have often failed to identify either the specific style of martial arts, simply calling it ''karate'', or they have grouped several different styles together as one sport.[1 2 8] These studies have limited applicability to most martial artists, as injury rates and patterns in full contact styles are probably very different from non-contact ones,[9 10] and the injuries sustained in styles that use joint locks and throws may be quite different from those that use kicks, punches, and blocking techniques. The purpose of this study was to determine the risk of injury in five commonly practiced martial art styles, to compare these risks and to identify significant risk factors in order to reduce the likelihood of injury among martial artists. Unlike many previous studies, this study did not exclusively examine the risk of injury during tournaments; rather, the risk over a period of regular training, with tournaments comprising only a fraction of the total exposure, was evaluated.

The five styles studied included Shotokan karate, Olympic style tae kwon do, aikido, kung fu, and tai chi. Shotokan karate and aikido are traditional Japanese martial arts. The greatest difference between these two styles is that Shotokan karate, a non-contact style, uses strikes and blocking techniques from a low stance, whereas aikido uses joint locks and throwing techniques. The throwing techniques of aikido necessitate the use of soft training surfaces such as tatamis or mats. Each of the other martial arts styles is traditionally performed on a wooden floor, although mats may be used in both tae kwon do and Shotokan karate tournaments. Tae kwon do, which originated in Korea, also uses strikes and blocks; however, it is distinguished from Shotokan karate by its emphasis on high kicks. In fact, 80% of the competitive techniques used in tae kwon do are kicks.[11] The tae kwon do school that was included in this study practices Olympic-style, full contact sparring and therefore requires protective equipment including head gear, chest protectors, shin pads, and padding for hands and feet. None of the other martial arts studied used protective equipment during training; however, Shotokan karateka often wear mouthguards and occasionally light weight sparring gloves for tournaments. Kung fu and tai chi both find their origins in China. Kung fu is similar to Shotokan karate in its use of punches, kicks, and blocks, but differs in its use of traditional weapons and in the extremely low stances seen at the school studied. Tai chi was included in the study because of its widespread popularity among people of all ages. Tai chi differs from all of the other styles included in the study in that in its most common form, there is no physical opponent present.

METHODS

Subjects

A total of 263 participants (response rate 84%) were recruited from martial artists participating in Shotokan karate, tae

Table 1 Injury rates by style

Style	No	Injury	Major injury	Multiple injuries
Karate	114	34 (29.8)	19 (16.7)	21 (18.4)
TKD	49	29 (59.2)*	13 (26.5)	22 (44.9)*
Aikido	47	24 (51.1)	13 (27.7)	15 (31.9)
Kung fu	39	15 (38.5)	7 (17.9)	9 (23.1)
Tai chi	14	2 (14.3)	1 (7.1)	0 (0.0)
Total	263	104 (39.5)	53 (20.2)	67 (25.5)

Values are number of participants with outcome (%).
*p<0.001 compared with Shotokan karate.
TKD, tae kwon do

kwon do, aikido, kung fu, or tai chi at the time of the study. Subjects were informed of the purpose of the study and of the confidentiality of their responses. It was made clear by the investigators and instructors in each school that participation in the study was entirely voluntary.

Survey

Data on injuries were obtained using surveys. The surveys consisted of two sections: personal data (age, sex, martial art style, rank, number of years of training, and number of hours of training a week) and injury data. The latter was a checklist of injuries grouped by body region. For each injury, subjects indicated how much, if any, time off from training was required. They also indicated if casting or surgery was necessary. Only those that required any time off from training or competition were considered injuries for the purposes of rate determination. Any injuries that required a minimum of seven days off were classified as major, as were any injuries requiring immobilisation or surgery. Concussions were also considered major injuries, regardless of the amount of time off from training. Multiple injuries occurred when the same athlete reported three or more injuries. All reported injuries, regardless of time loss, were included in analysis of type and body distribution of injury.

Statistical analysis

Variables examined included sex, martial art style, rank, years of experience, and number of hours of training a week. Main outcome measures included presence or absence of injuries, major injuries, multiple injuries, body regions injured, and types of injury. p Values were based on Fisher's exact test. To adjust for multiple comparisons, a Bonferroni correction was applied; therefore, a two tailed $p<0.008$ was considered significant. Univariate and stepwise multiple logistic regression were used to determine the significant predictors of three outcomes: injury, major injury, and multiple injuries. The odds ratio (OR) and 95% confidence intervals (CI) were calculated to establish the strength of association for significant multivariate predictors of injury. Two way interactions between age and experience were found with regard to major and multiple injuries. Therefore estimated probabilities for these combinations were derived from the regression equations.

RESULTS

The 263 surveys analysed were distributed as follows: Shotokan karate 114, tae kwon do 49, aikido 47, kung fu 39, and tai chi 14. Because of the very small number of students who trained exclusively in tai chi, this martial art was excluded from comparison with the other styles. A descriptive summary of injuries is included in the study. Injuries in each martial art were compared with those in Shotokan karate, as the latter made up the largest group in the study. The injury rates varied depending on the martial art style, with 29 students in tae kwon do sustaining time loss injuries (59%), 24 in aikido (51%), 15 in kung fu (38%), 34 in Shotokan karate (30%), and only two students in tai chi (14%) reporting injuries (table 1). Only 10% (n = 4) of martial artists <18 years of age sustained injuries that required time off from training, and all of these athletes trained at least three hours a week.

The greatest numbers of athletes with major injuries were seen in aikido and tae kwon do, with rates of 28% and 26% respectively. Kung fu (18%) and Shotokan karate (17%) had similar rates of major injuries. Only one subject sustained a major injury (strained neck muscle) in tai chi (7%). As the mechanism of injury was not specified by this martial artist, one can only surmise that it was the result of the sustained, intense muscular contraction observed in experienced practitioners of tai chi. Tae kwon do students were the most likely to sustain multiple injuries (50%), followed by aikido (32%), kung fu (23%), and Shotokan karate (18%). There were no cases of multiple injuries in tai chi . There was only one subject in the entire study who sustained a concussion. This was a black belt female martial artist with 15 years of experience in Shotokan karate. From the history, this was diagnosed as a grade 1 concussion[12] which did not result in loss of consciousness or amnesia. None of the younger group sustained major injuries, but two (5%) reported three or more injuries. Both of these athletes trained for more than three hours a week.

A comparison between styles of the proportion of injuries was performed using Fisher's exact test. Tai chi was excluded from statistical analysis. Students in Shotokan karate were at

Table 2 Region of injury

Style	No	Upper extremity	Lower extremity	Groin	Trunk	Head/neck
Karate	114	19 (16.7)	26 (22.8)	1 (0.9)	17 (14.9)	11 (9.6)
TKD	49	20 (40.8)*	28 (57.1)*	9 (18.4)*	12 (24.5)	15 (30.6)*
Aikido	47	20 (42.6)*	16 (34.0)	3 (6.4)	12 (25.5)	15 (31.9)*
Kung fu	39	8 (20.5)	14 (35.9)	2 (5.1)	5 (12.8)	4 (10.3)
Tai chi	14	1 (7.1)	1 (7.1)	0 (0.0)	1 (7.1)	1 (7.1)
Total	263	68 (25.9)	85 (32.3)	15 (5.7)	47 (17.9)	46 (17.5)

Values are number of participants with outcome (%).
*p<0.001 compared with Shotokan karate.
TKD, tae kwon do.

Table 3 Predictors of injury

	Univariate	Multivariate		
Variable	p Value	p Value	OR	95% CI
Age	<0.0001	0.010	3.95	1.48 to 9.52
Sex	0.25	NS		
Experience	<0.0001	0.003	2.46	1.51 to 4.02
Hours/week	<0.0001	0.045	1.85	1.13 to 3.05
Rank	0.07	NS		
Style	<0.001	0.009*	3.34	1.52 to 7.32

*Tae kwon do *v* Shotokan karate only.
NS, not significant.
Age: ⩾18 years *v* <18 years.
Experience: ⩾3 years *v* <3 years.
Hours/week: >3 hours *v* ⩽3 hours.
Rank: Black belt *v* lower belts.

significantly lower risk of injury and multiple injuries than those in tae kwon do (p<0.001). There were no significant differences between major injuries among the various styles.

All self reported injuries, regardless of time loss, were categorised by type into bruises, injuries of muscle-tendon units or ligaments (''soft tissue injuries''), or fractures. Regarding bruises, the only significant difference occurred between karate and tae kwon do with only 17% of Shotokan karate students sustaining bruises compared with 43% of tae kwon do students (p<0.001). Shotokan karate students were also less likely to sustain soft tissue injuries than aikido students (25% and 51% respectively; p<0.005). There were no significant differences in rates of fracture between styles.

Self reported injuries, regardless of time off, were also divided by body regions, including head and neck, upper extremities, lower extremities, trunk, and groin. Table 2 shows rates for each region. Injuries to the head and neck region were less likely to occur in Shotokan karate (10%) than in either tae kwon do (31%) or aikido (32%) (p<0.005). Shotokan karate students were also less likely than tae kwon do students to sustain injuries to the upper extremities, lower extremities, and groin area (p<0.001). Aikido students appeared to be at greater risk of upper extremity injuries than Shotokan karate students (p<0.001).

To determine significant predictors of injury, the following variables were considered: age (<18 *v* ⩾18 years), sex, experience (<3 years in the sport *v* ⩾3), frequency of training (⩽3 hours a week *v* >3), rank (black belts *v* lower ranks), and martial art style. Tables 3 and 4 show the univariate and multivariate analyses for injuries and multiple injuries. Older students (⩾18 years) appear to have a fourfold greater risk of injury than younger athletes (p<0.05; OR 3.95; CI 1.48 to 9.52), and those with at least three years of experience are at twice the risk of less experienced students (p<0.005; OR 2.46; CI 1.51 to 4.02). Frequency of training was found to be a significant predictor of injury as well (p<0.05; OR 1.85; CI 1.13 to 3.05). On multivariate analysis, martial art style was only a predictor for tae kwon do *v* Shotokan karate, with tae kwon do students being more than three times as likely to sustain injuries (p<0.01; OR 3.34; CI 1.52 to 7.32).

Table 5 Injury by age and experience

	Probability (%)	
Age/experience	Major injury	Multiple injuries
<18/<3 years	<1	5
<18/⩾3 years	<1	5
⩾18/<3 years	12	22
⩾18/⩾3 years	35	35

For major injuries, univariate analysis showed age and experience each to be predictors (p<0.0001); however, on multivariate analysis, a significant two way interaction between age and experience was detected (p<0.0001). This suggests that it is the combination of age and experience that is an important risk factor. A similar two way interaction was detected for multiple injuries as well. Table 5 shows the estimated probabilities of major or multiple injuries. For multiple injuries, greater frequency of training was associated with a threefold increased risk of injury (p<0.005; OR 2.95; CI 1.60 to 5.24). The risk of multiple injury is higher in tae kwon do than in Shotokan karate (p<0.005; OR 3.70; CI 1.86 to 7.35).

When volume of training (hours/week) was analysed as a continuous variable, the risk of injury in the younger group (<18 years) increased 50% with each additional hour of training. Restated, the risk of injury doubled with each

Table 4 Predictors of multiple injuries

	Univariate	Multivariate		
Variable	p Value	p Value	OR	95% CI
Age	<0.001†			
Sex	0.73	NS		
Experience	0.008†			
Hours/week	<0.0001	0.003	2.95	1.60 to 5.24
Rank	0.14	NS		
Style	<0.001	0.002*	3.70	1.86 to 7.35

*Tae kwon do *v* Shotokan karate only.
†Two way interaction between age and experience (p = 0.003).
Age: ⩾18 years *v* <18 years.
Experience: ⩾3 years *v* <3 years.
Hours/week: >3 hours *v* ⩽3 hours.
Rank: Black belt *v* lower belts.

additional two hours of training a week ($p = 0.03$). The average weekly training in the younger group was 3.3 hours. In the adult group (average weekly training 5.4 hours), analysis suggests a trend ($p = 0.09$) towards increased injury with increased training; however, in this group, the increased risk of injury per additional hour of training was only 7%.

DISCUSSION

In this study, no difference between male and female subjects was detected with respect to rate or severity of injury. Other investigators,[2] on the other hand, have concluded that men are at greater risk of injury than women. The study period for Birrer's investigation was 18 years, beginning in 1976. One possible explanation for this discrepancy is that the participation of women in martial arts has changed dramatically since the mid-seventies, with women participating in tournament sparring more and more. Tournament free sparring is responsible for most injuries in martial arts.[7] Therefore, if men had more opportunities to fight in tournaments while women were restricted from doing the same, the risk of injury not surprisingly would be higher in men.

We found that younger participants, those under 18 years of age, were at much lower risk of injury than adults. The literature to date has been inconsistent with regard to the relative risk of injury among youths versus adults in various martial arts. Zetaruk *et al* concluded that children participating in Uechi-Ryu, a traditional, non-contact karate style, are at very low risk of significant injury.[13] In another study by the same authors, adults in Shotokan karate were at a sixfold greater risk of injury than youths.[14] Oler *et al*[1] assessed injury rates at national tae kwon do championships and found a higher rate of injury among adults than juniors. Conversely, other authors have found that youths are at increased risk of injury in martial arts.[2 15] In our study, because of the interaction between age and experience, it is the combination of these that is a significant risk factor. The lower risk among less experienced youths in our study may be explained on the basis of lower body mass and strength, as well as less technical ability. They are unable to generate the same level of force that older, more experienced martial artists do.[14 16]

The most interesting aspect of this study is the comparison of injuries among different martial art styles. The styles included in the study are: a non-contact style (Shotokan karate); a non-contact style which uses weapons in training (kung fu); a full contact style (tae kwon do) which uses full protective gear; a style consisting primarily of throwing and joint techniques, as opposed to strikes and blocks (aikido); a style that has its origins in combat, but has evolved into a meditative, non-combat type of exercise in its most commonly practiced form (tai chi). Injuries in each martial art were compared with those in the Shotokan karate group, as this was the largest group in the study. The risk of injury in tae kwon do was three times that in Shotokan karate, and the risk of multiple injuries was nearly fourfold. This is probably explained by the difference in contact between these martial arts. The emphasis in tae kwon do is on fast, powerful kicks, which have the potential for causing severe injury.[10 11] The padding worn by tae kwon do athletes may offer some protection, but this may be of greatest benefit to the athlete executing the kick, rather than to the recipient of the technique.[2 10] Shotokan karateka do not wear protective equipment for training, but often wear mouth guards and occasionally lightweight sparring gloves for tournaments. Techniques are theoretically pulled just short of contact to the head, and light contact to the body is permitted.[17–20] In a well controlled match, little force is transmitted to the opponent; therefore, the risk of injury is less.

No difference in injury rates was found between Shotokan karate and kung fu. Shotokan karate finds its origins in kung fu; therefore it is not surprising that there are many similarities between these martial arts. The greatest difference lies in the use of weapons for training in kung fu; however, other authors have noted that there is very little risk of injury from weapons training in martial arts.[2 8] Our data appear to support this contention.

Regarding types of injuries, the higher rate of bruising in full-contact tae kwon do versus non-contact Shotokan karate seems intuitive, although protective equipment may be expected to reduce the incidence of bruising to some extent[20] in the former group. Hand and foot padding has not been shown to reduce peak acceleration to the head,[21] although headgear may provide some protection.[20 22]

The emphasis on joint techniques, which place the joints in extremes of range of motion, as well as throws in aikido,[23] may explain the higher rate of injuries to muscle-tendon units and ligaments in this martial art when compared to Shotokan karate.

Finally, the results of this study suggest that three hours of training a week may be a reasonable limit for athletes under 18 years of age, as none of the time loss injuries or multiple injuries occurred in younger athletes who trained less than three hours a week. With injury risk doubling with each additional two hours of training, younger martial artists should exercise caution in exceeding this limit. It could be argued, however, that those who trained more than the average three hours a week may have been a more enthusiastic or motivated subgroup. These individuals might have been at increased risk of injury, even if training had been limited to three hours. Even among the younger martial artists who trained more than three hours a week, however, no major injuries were reported. This suggests that martial arts training in general appears to be a relatively safe form of physical activity for youths.

Limitations of the study

Although a number of significant associations between the variables and the main outcome measures were detected, the cross sectional design of this study carries with it certain limitations. As the data on weekly training and injury outcomes were collected for the same time period, a true causal relation cannot be concluded, as the injury experience could have affected the weekly training. The investigators attempted to address this by asking for average weekly training throughout the year, rather than specifically requesting weekly training at the time the survey was completed. It is likely that if the injury experience affected the average weekly training, this change would probably be a decrease in training, thereby creating an association between increased injury and decreased weekly training. Our analysis detected a significant relation between increased weekly training and increased injury; therefore, a causal relation between weekly training and injury outcome is likely.

Although reasonable for analysis, the 84% response rate may have a certain bias, depending on the characteristics of the 16% who did not participate in the study. Although it was explained that even those who had not been injured during the preceding year were eligible to participate in the study, it is possible that this injury-free population was less likely to return the surveys. Conversely, athletes who had sustained multiple injuries may have been reluctant to fill out the surveys, despite the anonymity of the questionnaire. As such, the effect of the non-responder group on the study results is unknown. The possibility of sampling error due to the relatively small number of participants in each martial art also exists.

Recall bias is a concern in this type of cross sectional survey, with remote injuries being more likely to be forgotten. If Birrer's assessment is correct, that 60% of martial arts injuries are not reported,[24] our injury incidence data may

What is already known on this topic

Injury rates for martial arts vary greatly, depending on the style. No studies have compared the risk of injury in different martial arts. Although many martial artists do not compete, most studies assess risk exclusively in tournaments. There is a paucity of data on the risks of martial arts outside of the tournament setting.

What this study adds

This study compares the risk of injury in five popular martial arts styles. The risk is assessed for a period of regular training, with tournaments comprising only a small proportion of the total exposure time. The rates determined in this study more accurately reflect the risk of injury per year to most participants in these five martial arts.

underestimate the true incidence of injury in martial arts. Recall would not be affected by rank, experience, or weekly training, but could potentially be affected by age. Younger martial artists may have more difficulty in remembering injuries, which could have affected our results on age and injury outcomes. This was addressed by having the parents of the younger participants assist in completing the surveys. Although the parents may not have been aware of all minor injuries that did not result in time off from training, they would certainly have been aware of any significant injuries that did require time off, as parents would have been involved in transporting the child to and from training.

Some authors suggest that female martial artists may be more inclined to report injury than their male counterparts.[24 25] Style may also affect the likelihood of athletes to report injuries. Aikido and tai chi do not involve participation in tournaments; therefore, these martial artists may be more likely to report injuries. Conversely, martial artists involved in a highly competitive sport such as Olympic-style tae kwon do may be reluctant to admit to injuries for fear of not making a competition team, or they may be less likely to take time off for an injury. The former was addressed by reassuring participants of the confidentiality of their responses. The impact of the latter is unknown, but it is possible that our study may have underestimated injuries among highly competitive martial artists in Shotokan karate, tae kwon do, and kung fu. A prospective study with assessment of injuries made by sport medicine physicians or other appropriately trained allied health professionals would eliminate this potential recall bias. To truly determine a causal relation between the variables and outcome measures, we have identified in this study that a prospective study is required.

Finally, even within a particular martial art, there may be differences in injury risk, depending on whether or not rules of safety are closely adhered to. Burke *et al*[26] found a much lower risk of injury in tae kwon do tournaments than had previously been reported. They concluded that the lower risk was due to implementation of protective measures including strictly enforced rules of engagement that did not permit blows to the face, and only light contact to the other target areas.

CONCLUSIONS

(1) There is a threefold greater risk of injury in tae kwon do than in Shotokan karate.
(2) Injury rates and types of injury in Shotokan karate and kung fu are similar.
(3) Different martial arts have different distributions of injury by body region.
(4) There are no significant differences in injuries between sexes.
(5) Martial artists under 18 years of age are at significantly lower risk of injury than older athletes.
(6) Athletes ≥18 years with at least three years of experience are at greatest risk of sustaining major injuries (35%) and multiple injuries (35%).
(7) Athletes <18 years old with <3 years of experience have a low risk of multiple injuries (5%) and an extremely low risk of major injuries (<1%).

Authors' affiliations
M N Zetaruk, Children's Hospital, University of Manitoba, Canada
M A Violán, University of Barcelona, Spain
D Zurakowski, L J Micheli, Children's Hospital, Harvard Medical School, Cambridge, MA, USA

Conflict of interests: none declared

REFERENCES

1 **Oler M**, Tomson W, Pepe H, *et al*. Morbidity and mortality in the martial arts: a warning. *J Trauma* 1991;**31**:251–3.
2 **Birrer RB**. Trauma epidemiology in the martial arts. The results of an eighteen-year survey. *Am J Sports Med* 1996;**24**:S72–9.
3 **Violán MA**, Small EW, Zetaruk MN, *et al*. The effect of karate training on flexibility, muscle strength, and balance in 8 to 13-year-old boys. *Pediatr Exerc Sci* 1997;**9**:55–64.
4 **Fetto JF**. Judo and karate-do. In: Fu FH, Stone DA, eds. *Sports injuries: mechanisms, prevention, treatment*. Baltimore: Williams and Wilkins, 1994:455–68.
5 **Stricevic MV**, Patel MR, Okazaki T, *et al*. Karate: historical perspective and injuries sustained in national and international tournament competitions. *Am J Sports Med* 1983;**11**:320–4.
6 **McLatchie G**, Morris EW. Prevention of karate injuries. *Br J Sports Med* 1977;**11**:78–82.
7 **Jaffe L**, Minkoff J. Martial arts: a perspective on their evolution, injuries, and training formats. *Orthop Rev* 1988;**17**:208–21.
8 **Birrer RB**, Halbrook SP. Martial arts injuries: the results of a five year national survey. *Am J Sports Med* 1988;**16**:408–10.
9 **Birrer RB**, Birrer CD, Son DS, *et al*. Injuries in taekwondo. *Phys Sportsmed* 1981;**9**:97–103.
10 **Zemper ED**, Pieter W. Injury rates during the 1988 US Olympic team trials for taekwondo. *Br J Sports Med* 1989;**23**:161–4.
11 **Serina ER**, Lieu DK. Thoracic injury potential of basic competition taekwondo kicks. *J Biomech* 1991;**24**:951–60.
12 **Cantu RC**. Neurologic athletic head and neck injuries: return to play guidelines after a head injury. *Clin Sports Med* 1998;**17**:45–60.
13 **Zetaruk MN**, Violán MA, Zurakowski D, *et al*. Karate injuries in children and adolescents. *Accid Anal Prev* 2000;**32**:421–5.
14 **Zetaruk MN**. Safety recommendations in Shotokan karate. *Clin J Sport Med* 2000;**10**:117–22.
15 **Patel DR**, Stier B, Luckstead EF. Major international sport profiles. *Pediatr Clin North Am* 2002;**49**:769–92.
16 **O'Neill DB**, Micheli LJ. Overuse injuries in the young athlete. *Clin Sports Med* 1988;**7**:591–610.
17 **Corcoran J**, Farkus E, Karate. In: Cororan J, Farkus E, Sobel S, eds. *The original martial arts encyclopedia: tradition- history- pioneers*. Los Angeles: Pro-Action Publishing, 1993:46–80.
18 **Kurland HL**. Injuries in karate. *Phys Sportsmed* 1980;**8**:80–5.
19 **Funakoshi G**. *Karate-do Kyohan: the master text*. Tokyo: Kodansho International, Ltd, 1973:212.
20 **Critchley GR**, Mannion S, Meredith C. Injury rates in Shotokan karate. *Br J Sports Med* 1999;**33**:174–7.
21 **Schwartz M**, Hudson A, Fernie G, *et al*. Biomechanical study of full-contact karate contrasted with boxing. *J Neurosurg* 1986;**64**:248–52.
22 **Schmid L**, Hajek E, Votipka F, *et al*. Experience with headgear in boxing. *J Sport Med Phys Fitness* 1969;**8**:171–6.
23 **Corcoran J**, Farkus E. Aikido. In: Corcoran J, Farkus E, Sobel S, eds. *The original martial arts encyclopedia: tradition- history- pioneers*. Los Angeles: Pro-Action Publishing, 1993:6–11.
24 **Birrer RB**, Birrer CD. Unreported injuries in the martial arts. *Br J Sports Med* 1983;**17**:131–3.
25 **Pieter W**, Zemper ED. Time-loss injuries in junior olympic taekwondo athletes. *Sport Exercise and Injury* 1997;**3**:37–42.
26 **Burke DT**, Barfoot K, Bryant S, *et al*. Effect of implementation of safety measures in tae kwon do competition. *Br J Sports Med* 2003;**37**:401–4.