

Injuries in karate: a review

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Abstract

Introduction

Sport injuries usually limit training effects and often ruin athletes' careers. The goal of this study was to review the results obtained in the studies on injuries in karate athletes.

Materials and methods

A comprehensive search in the international databases of MEDLINE, Web of Science, SPORTdiscuss, Academic Search Premiere, Google Scholar was conducted. The study was based on 20 studies from reviewed journals. The particular focus was on the data concerning injury rates. Relative injury risk was computed according to the following formula: injury rate in group 1/injury rate in group 2, where the 1st and 2nd groups represented two different levels in terms of gender, age, competitive level or changes in competitive rules. Types, location and injury patterns in different groups of karate athletes, investigated in both retrospective and prospective studies, were also analysed.

Results

The retrospective studies have documented serious injuries (chiefly fractures), whereas in the prospective studies, conducted exclusively during tournaments, minor injuries were usually recorded, among which contusions were predominant. The results of the majority of the prospective studies have demonstrated higher injury risk in men compared to women. Sports skill level and tournament rank were correlated with elevated risk of injury. Regardless of the study design, injuries were

mostly recorded in the area of head, face and neck. Modifications of the fighting regulations reduced injury risk during championships. However, the risk decline was observed only for minor injuries.

Conclusion

It is important to investigate the factors that reduce injury risk in sport. In karate, injuries are impossible to be entirely eliminated as the impact that exceeds tissue mechanical strength has not been excluded as the main cause of severe injuries. Among children, formal exercise (*kata*) and pre-arranged sparring might represent a safe alternative for karate fights.

Introduction

There are three groups of combat sports, depending on the actions permitted with fighting regulations: Group 1: using weapon as in fencing; Group 2: using punches and/or kicks as in boxing, karate or taekwondo and Group 3: using throws, pinning techniques, strangulation and joint manipulation techniques¹. All the three types of motion actions can be also mixed in ju-jitsu^{2,3}. Undoubtedly, practicing combat sports is risky. Average rates (percentages of injured athletes of 36 Olympic sports) were similar in male (12.1%) and female (13.3%) athletes. The rates of injuries in fencing were 13.1% and 5.6% in males and females, respectively. Opposite patterns were observed in boxing, i.e. 7.3% and 19.4%, in males and females, respectively. The injury risk (IR = #injuries/#athletes) was the highest in males (51.6%) and females (26.6%) taekwondo (which can be regarded as a Korean variant of karate) and was medium in male (10.9%) and female (12.4%) judo athletes. IR in wrestling was

also medium, i.e. 10.5% in males and 13.2% in females⁴. Injury is a factor that causes trouble winning^{5,6}.

Similarly to taekwondo, boxing, judo and wrestling, which are Olympic combat sports, the participants of karate competitions fight in gender, age and weight categories⁷⁻⁹. Karate fighting is considered a high-intensity event¹⁰. Different karate styles are becoming more and more popular because training regimes are oriented at preparation for fighting during competitions. World Karate Federation is the largest international governing body of this sport with over 130 member countries and has more than 10 million members¹¹. With this high number of karate practitioners, it seems very important to prevent injuries. Similar to other sports, identification of the relationship between the causes and the effects of accidents is very important for the activities aimed at reduction in the injury risk¹². It is suggested that in retrospective (R) epidemiological studies analysis is carried out from the effect towards the cause. However, in prospective (P) studies, analysis is typically conducted from the cause towards the effect¹³. There have been the findings of the retrospective studies in institutions providing insurance¹⁴ in hospitals¹⁵ and questionnaire studies among karate athletes who provided information about injuries in a particular time period¹⁶. It is essential to combine activities of an observer of an injury mechanism (karate expert) and a person who diagnoses (medical doctor), which is especially important during P studies^{17,18}. The seriousness of the problem of injuries in karate has been supported by the publications which presented injury rates, injury types and location, and injury

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mechanisms. This was the basis for formulation of prevention-related conclusions. The goal of this study is to review the results obtained in the studies on injuries in karate athletes.

Materials and methods

A comprehensive search in international databases of MEDLINE, Web of Science, SPORTdiscuss, Academic Search Premiere, Google Scholar was conducted to find the results matching the keywords 'karate', 'injury', 'retrospective' and 'prospective'. The analysis excluded the data concerning infrequent cases of injuries. Finally, 20 peer reviewed studies were qualified. They described specific characteristics of injury, such as rates, types, locations, mechanism of injury. Number of injuries reported in different studies ranged from 12 cases¹⁹ to 7431 cases¹⁵. Absolute and relative injury rates (IR) were evaluated in different groups of karatekas. Relative injury risk (IRR) was adopted as a ratio of IR in the Group 1 to IR in the Group 2 used in epidemiology¹³. For the results of retrospective and P studies, the authors calculated IRR risk in consideration of gender, age and sports skill level. Type, location and mechanism of injury percentages were presented and compared.

Results

Injury rate in male and female karate athletes

Table 1 presents incidence of injuries documented in the literature from years 1977 to 2012.

Various indices were used to identify the scale of injury rate in karate. Hence the results and their evaluation seemed to be ambiguous. The findings obtained in the retrospective studies based on institutional documentation (RD) show that the injuries were most frequently observed in men (aged 16–32 years), chiefly during training, while the relative injury rate was 1.95 per 1000 participants

per year¹⁴. In another study, absolute IR in training was also much higher than the rate of injuries occurring in competitions²⁰. A significantly higher IR was also observed in the group of males compared to females. The highest IR was found for the athletes aged 20–24 years (95% CI criterion)²⁰. The youngest karateka in RD record was nearly 14 months¹⁵. In retrospective studies based on questionnaires (RQ) among adult women, contributions of training vs. competition injuries were nearly fifty-fifty²¹. In another RQ study, in a club where sparring and competition were not the main training goal, IR in children (aged 6–16 years) was 3.7 injuries per 1000 h of karate training. IR depended on the experience, training hours and rank rather than on age and gender²². IR during competition for young karatekas (aged 7–15 years) was considerably higher, i.e. 13.3–15.3 injuries/100 minutes of athletic exposure (AE), whereas IR value in girls was higher than in boys¹⁹.

Among the P studies that investigated injury rate during karate competitions, the most popular measure was IR expressed per 1000 AE. The value of #injury/1000 AE in male tournaments ranged from 22.2/1000 AE²³ to 194.0/1000 AE¹⁸. In female athletes, IR was from 66.2/1000 AE²⁴ to 143.2/1000 AE²⁵. The results of observation of karate tournaments recorded by the same authors of P studies provided information about the effect of different factors on the level of IR which was not fully consistent. As a result of application of protective gear in male competition, a four-time reduction in IR was demonstrated (per 100 karate matches)²³. Other observations did not confirm the optimistic prognosis that resulted from these studies^{18,26}. When knuckle padding was used in male tournaments, the IRR was similar as without this type of protective gear²⁶. In an international Oyama's Cup (*Kyokushin* full-contact style), despite the obligatory use of the protective

gear (foot and shin), IR was higher (194.0/1000 AE) compared to the national-level tournaments where this gear was not used (148.6/1000 AE), with IRR being 1.31¹⁸. Elevated IR (192.6/1000 AE) was also observed in the members of the male national team that competed in the selection tournaments in the lead up to Asian Karate Championships 2012²⁷. High sport rank of the Oyama's Cup might have affected the increase in IRR with respect to the national-level competition.

Adult males were characterised usually by higher IR compared to women that presented the same competitive level^{21,24,25,29,30}. A decline in IR during world championships organised by the World Karate Federation as a result of changes in fighting regulations was observed. Consequently, IRR (post-value in relation to pre-value) was 0.64 and 0.46 in males and females, respectively^{24,25}. In another study, before using protective gear, IR in males was slightly different than IR in females, with IRR that reached 1.05. Using protective gear caused a higher IR in female than male athletes (IRR = 0.81)³⁰. Employing an original and more precise index (#injures/100 minutes AE), however, showed that IR was lower in male athletes (0.83)³⁰. With protective gear, IRR (males to females relation) decreased to 0.73³⁰. In the age category under 18 years in general, the competitors fought significantly safer after the changes in rules had been implemented (IRR = 1.55; pre to post-IR's relation)³⁰. Changes in rules caused a significant reduction in IR during male and female tournaments^{24,25,30}, which, however, did not affect the frequency of moderate and severe injuries²⁴.

Injury types

Distribution of the frequency of typical injuries depended on the study design (Table 2). Percentage comparison of the injury types showed much

Table 1 Injury rates in karate										
Study	Competition/ championship	Study design	N athletes/ N matches	N injuries	Injury risk/ 1000 AE	Injury risk/100 matches	Injury risk/100 minutes	Injury/exposure	Remark	
Sterkowicz 1986 ⁴⁴	Males, 1977–1980	RD	39/	42	.	.	.	1.95/1000 participants per year	Age 21.6 (14–32) years. Training/ competition 95%/5%	
Kujala et al. 1995 ²⁰	Males and females 1990–1991	RD	572/	141	.	.	.	247/1000 person years of exposure	Training/competi- tion 70%/30%	
Kujala et al. 1995 ²⁰	Males and females 1990–1991	RD	417/	123	.	.	.	295/1000 person years of exposure	Age 20–24 years	
Kujala et al. 1995 ²⁰	Males and females 1990–1991	RD	155/	18	.	.	.	166/1000 person years of exposure	Age 25–34 years	
Yard et al. 2007 ¹⁵	Males and Females 1990–2003	RD	/	7431	.	.	.	Absolute IR = 79.5%	Age 11.9 years (14 months–17 years). Males 72.6%	
Zetaruk et al. 2000 ²²	One past year	RQ	68/	22	.	.	.	3.7/1000 h; 32.3/100 training participants	Age 10 (6–16) years. Training 100%	
Peeri et al. 2011 ¹⁶	Male Elite Turkey National Team Camp 2010, last year	RQ	40/	151	.	.	.	82.5/100 respond- ents	Age 24.7 years	
Shotorbani et al. 2012 ²¹	Female, athletes career until questionnaire	RQ	97/	526	.	.	.	57.7/year	Age 24.3 (18–30) years. Training 55.3%/Competi- tion 44.7%	
McLatchie 1977 ¹⁷	Male, eight tournaments in 1974–1975	P	/744	147	98.8	19.8	.	.	Competition 100%, without protective gear	
McLatchie 1977 ¹⁷	Male, four tournaments 1975–1976	P	/1102	49	22.2	4.5	.	.	Competition 100%, with protective gear	
Sterkowicz 1984 ¹⁸	Male, three national and one international Kyokushin Tournaments 1980–1982	P	/323	96	148.6	28.7	.	.	Without protec- tive gear	
Sterkowicz 1984 ¹⁸	Male International Oyama Cup 1983	P	/57	22	194.0	38.6	.	.	With protective gear (foot and shin)	
Johannsen & Noerregaard 1988 ²⁵	Male Danish International and Team Championships 1984–1986	P	403/620	153	123.4	24.7	.	.	Knuckle padding was not used	
Johannsen and Noerregaard 1988 ²⁵	Male, 1983–1986	P	270/290	74	127.6	25.5	.	.	Knuckle padding was used	

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Study	Competition/ championship	Study design	N athletes/ N matches	N injuries	Injury risk/ 1000 AE	Injury risk/100 matches	Injury risk/100 minutes	Injury/exposure	Remark
Critchley et al. 1999 ²⁸	Male and female national championships 1996–1998	P	1273/1770	160	45.2	9.0	.	IR = 13/100 adult male competitors, IR = 10/100 adult females, Under 16 years old IR = 11/100 participants	Age 22 years, with protective gear
Ariaza and Leyer 2005 ²⁵	Male, World championships 1996, 1998, 2000	P	/1957	617	157.6	31.5	.		
Ariaza and Leyer 2005 ²⁵	Female, World championships 1996, 1998, 2000	P	/880	252	143.2	28.6	.		
Macan et al. 2006 ³⁰	Male Zagreb Region competition 1997	P	/600	/143	119.2	23.8	9.7		Protective gloves and gum shields
Macan et al. 2006 ³⁰	Male Zagreb Region competition Female 1997	P	/287	/65	113.2	22.6	11.7		Protective gloves and gum shields
Macan et al. 2006 ³⁰	Male 2002	P	/1106	/163	73.7	14.7	8.9		Standardised gloves. Changed rules
Macan et al. 2006 ³⁰	Female 2002	P	/498	/91	91.4	18.3	12.1		Standardised gloves. Changed rules
Pieter 2007 ³²	Male two open karate tournaments	P	489/530	12	11.32	2.26	2.5		Time loss injuries only
Halabchi et al. 2007 ²⁹	Female Iranian championships 2004–2005, six tournaments	P	1019/1139	186	81.6	16.3			
Ariaza et al. 2009 ²⁴	Male World Karate championships 2002, 2004, 2006	P	/1901	383	100.7	20.0	6.7		Changed rules
Ariaza et al. 2009 ²⁴	Female World Karate championships 2002, 2004, 2006	P	/861	114	66.2	13.0	6.6		Changed rules
Pieter 2010 ¹⁹	Male Dutch National Youth Karate championship	P	218/381	76	99.7	19.9	13.3		Age 7–15 years
Pieter 2010 ¹⁹	Female Dutch National Youth Karate championship	P	84/139	32	115.1	23.0	15.3		Age 7–15 years
Boostani et al. 2012 ²⁷	Male Iran karate national team selective tournaments	P	/462	178	192.6	38.5			

P, prospective; RD, retrospective based on documentation; RQ, retrospective based on questionnaire. If possible, injury rates were recalculated from authors' data and showed as #injuries/1000 AE.

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Table 2 Types of injuries in karate practitioners

Study	Period or competition	Study design	N of injuries	Concussion (%)	Contusion (%)	Fracture (%)	Luxation (%)	Sprain (%)	Strain (%)	Other/unspecified (remark)
Sterkowicz 1986 ¹⁴	Poland 1977–1980	RD	42	4.8	.	71.4	.	9.5	2.4	11.9 ^a , training (95%)/competition (5%)
Kujala et al. 1995 ²⁰	Finland 1987–1991	RD	1150	-	35.1	16.9	1.1	44.7 ^b	.	2.2
Yard et al. 2007 ¹⁵	United States 1990–2003	RD	7431*	0.7	24.7 ^c	26.8	2.0	29.8 ^b	.	16.0 ^d
McPherson and Pickett 2010 ³¹	Canada 1993–2006	RD	181	5.5	6.1	39.8	25.4	23.2 ^b	.	.
Zetarak et al. 2000 ²²	One past year	RQ	22	.	36.4	.	.	9.1	13.6	13.6 ^e
Peeri et al. 2011 ¹⁶	Male Elite Turkey National Team Camp 2010, last year	RQ	159	.	19.5	6.3	7.5	13.3 ^f	11.9 ^g	41.5 ^h
Shotorbani et al. 2012 ²¹	Female, athletes career until questionnaire	RQ	526 ⁱ							Training (55.3%)/competition (44.7%)
Sterkowicz 1984 ¹⁸	Male three national and one international Kyokushin Tournaments 1980–1982	P	96	4.1	66.8	.	1.0	8.3		Other (19.8%) ^j
Sterkowicz 1984 ¹⁸	Male three national and one international Kyokushin Tournaments 1980–1982	P	53	0.0	81.1	.	1.9	11.3	.	/Competitions (100%), Other(5.7%) ^k , without protective gear, attacking person
Sterkowicz 1984 ¹⁸	Male three national and one international Kyokushin Tournaments 1980–1982	P	43	9.3	48.7	.	0.0	4.7	.	Other(37.3%) ^l , without protective gear, attacked person
Johansen and Noerregaard 1988 ²⁶	Male Danish International and Team Championships 1984–1985	P	120 (head)	44.0	9.0	.	.	.		Other(47.0%) ^m , without protective pads,
Johansen & Noerregaard 1988 ²⁶	Male Danish International and Team Championships 1983–1986	P	68 (head)	66.0	1.4	.	.	.		Other(32.6%) ⁿ , with protective pads,
Critchley et al. 1999 ²⁸	Male and female National Championships 1996–1998	P	160	7.5	85.6 ⁺	6.3 ⁺⁺	.	.		Other (0.6%)

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Table 2 Continued

Study	Period or competition	Study design	N of injuries	Concussion (%)	Contusion (%)	Fracture (%)	Luxation (%)	Sprain (%)	Strain (%)	Other/unspecified (remark)
Ariaza and Leyes 2005 ²⁵	Male and female World Championships 1996, 1998, 2000	P	891	3.8	52.8	2.8	.	.	.	Other (40.6%) ^a
Pieter 2007 ³²	Male two open karate tournaments	P	12	8.3	.	58.3	.	.	.	Other (33.4%) ^p , time loss injuries only
Halabchi et al. 2007 ²⁹	Female Iranian Championships 2004–2005, 6 tournaments	P	186	7.0	43.6 ⁺⁺⁺	1.6	1.6	.	.	Other (46.2%) ^r
Ariaza et al. 2009 ²⁴	Male and female World Karate Championships 2002, 2004, 2006	P	64	28.1	3.1	31.3	9.4	4.7	.	Other (23.4%) ^s , moderate plus severe injuries contribution was 12.9% of all injuries (n = 497)
Pieter 2010 ¹⁹	Male Dutch National Youth Karate Championship	P	76	.	67.1	2.6	.	.	1.3	Other (29.0%) ^t , age 7–15 years
Pieter 2010 ¹⁹	Female Dutch National Youth Karate Championship	P	32	.	71.9	.	.	.	3.1	Other (25%) ^u , age 7–15 years

^a, included testicular rupture (2.4%), abdominal trauma (2.4%); ^b, counted together with sprains; ^c, summed up with abrasion; ^d, included laceration (5.1%); ^e, wind knocked; ^f, included meniscus (7.0%); ^g, included muscle tear (4.4%); ^h, summed up trauma (38.4) and ulcer 3.1; ⁱ, author's classification: bone (4.4%), skin (14.4%), joint (36.5%), muscle tendon (44.7%); ^j, including laceration (8.3%), epistaxis (7.3%), wind knocked out (4.2%); ^k, including lacerations (3.7%), epistaxis (1.9%); ^l, including epistaxis (14.0%), laceration (14%), wind knocked out (9.3%); ^m, including lacerations (24%), epistaxis (12.0%), TKO/groggy (11.0%); ⁿ, including laceration (12.0%), epistaxis (10%), TKO/groggy (1.4%); ^o, including epistaxis (16.2%), laceration (13.7%), abrasion (4.7%); ^p, including laceration (16.0%), ligament torn (8.3%); ^q, including abrasion (15.1%), epistaxis and hematoma (26.3%); ^r, laceration requiring sutures (17.2%), knee joint ligament rupture 6.2%); ^s, epistaxis (6.6%), laceration (3.9%), abrasion (2.6%), nerve injury (1.3%), haemorrhage (1.3%); ^t, blister (6.3%), abrasion (3.1%); *Including men and women (72.6% males, 27.4% females); ⁺, with laceration, ⁺⁺, with luxation; ⁺⁺⁺, contusion and muscle strain; P, prospective; RD, retrospective based on institutional documentation; RQ, retrospective based on questionnaire.

more frequent fractures observed in RD studies, i.e. from 16.9%²⁰ to 71.4%¹⁴. However, the contribution of sprains and strains ranged from 11.9%¹⁴ to 44.7%²⁰. They were also in contrast to the rate of contusion (from 0.0%¹⁴ to 35.1%²⁰) and luxation (from 0.0%¹⁴ to 25.4%³⁰). It was found in RD studies that 17.9% of the patients necessitated hospitalisation that took from 2 to 21 days. In 60.0% of the people, bodily injuries were evaluated (according to Polish regulations) as 1%–9% whereas in 20%, medical board evaluated injuries as

10%–15%. Twenty percent of the injured karatekas were evaluated as returned to entirely healthy status¹⁴. The documentation analysed in RD studies confirmed the fact that it is severe injuries which are reported to hospitals and insurance institutions. The RQ studies did not find concussions, which were rather rare in RD and P studies of karate practitioners. In RQ studies, diagnoses might have been inaccurate since they originated from the injured people rather than from competent doctors.

P studies recorded a higher variety in the classification of sustained injuries than R studies. In P studies, the vast majority of injuries were contusions, except for the studies where authors were focused on severe injuries. The most frequent among time-loss injuries were fractures (58.3%) and, also frequent, concussions (8.3%)³². Moderate and severe injuries contribution was only 12.9% of all 497 injuries recorded among elite competitors. In the area of head injuries (n = 64), the highest percentage was found for fractures (31.3%) and concussions

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(28.1%)²⁴. Frequency of typical injuries depended on the tactical situation, for example, contusions were more frequent in the attacking (81.1%) compared to the attacked athlete (48.7%). The specific injuries, which occurred exclusively in the attacked athletes included concussion (9.3%) and wind knocked out (9.3%)¹⁸.

Injury location

Karate injuries reported in RD studies concerned mainly head, face and neck¹⁴ as well as upper and lower limbs^{15,20} (Table 3). In RQ studies, the percentage of head, face and neck injuries ranged from 5% in children²² to 32.4% in adults¹⁶. Adult men were more often injured in the head, face and neck compared to women (32.4% vs. 9.2%), among which the most frequent were lower limbs injuries (28.5% vs. 53.7%)^{16,21}. In P studies, head, face and neck injuries accounted for 22.9%¹⁸ to 92%²⁶. Contribution of injuries of trunk, upper limbs and lower limbs ranged from 4%²⁶ to 31.8%¹⁸, 10.1%²⁷ to 17.2%²⁴ and 3.4%²⁷ to 55.2%¹⁸, respectively. During the Oyama Cup, where protective gear for feet and shin, the contribution of injuries in the head, face, neck and trunk was increased compared to the injuries reported in the national-level competition where protective gear was not used¹⁸. Similar patterns were observed in a Danish research, but they concerned an increase in the frequency of head, face and neck injuries²⁶. During karate tournaments, both for women and men, predominant injuries were head, face and neck injuries (55.4% vs. 57.9%)^{27,29}. Moreover, 15-year-old girl and boy karate athletes had also considerable risk of head injury, i.e. 43.8% vs. 52.6%, respectively¹⁹.

Causes and mechanisms of karate injuries

The circumstances in which injuries occurred were frequently identified

as punches, kicks, blocks and falling on the ground. In general, it can be concluded that the impact that exceeded tissue strength led to body damage among karatekas. The most frequent mechanism in RD studies was the impact that occurred during kicks (33.3%) in the head, in the lower limb, groin, stomach and punchbag, falling on the ground (25.6%), hitting with the upper extremity (20.5%) against the head, upper limb, a wall or a board¹⁴. Mechanism of the injury during kicking was formed through being kicked (26.9%), falling (20.8%) and kicking (18.0%)¹⁵. In another study, the cause of the body injuries in karatekas were: kick/foot strike (38.0%), fall/throw/jump (26.0%), block (9.0%), weapon (5.0%) and others (12%)³¹. In RQ studies, the most frequent injury mechanism occurred with kicks (47.0%) and punches (43.2%), whereas it was observed less often for falling on the ground (9.8%)¹⁶. The predominant causes of injuries in P studies were punches (from 48.4%²⁸ to 82.7%)²⁵. Therefore, kicks were less frequently recognised as an injury mechanism, i.e. from 7.3%²⁵ to 29.2%²⁷. Some authors reported injuries during blocking the attack with the frequency of 5.1%²⁷–18.8%¹⁹.

Death cases

Death cases should be analysed if they are typical of a particular sport or, if not, when they occurred during competition or athletic training³³. In Japan, only one death case was reported. It occurred as a result of a karate punch at the Ritsumeikan University³⁴. Three deaths were reported in the USA as a result of blunt injury of the chest. The first death occurred during taekwondo fighting caused by a kick performed by a coach to the lateral part of the chest, the doctors found rib fracture (5th rib on the left), pulmonary oedema, congestion and hepatic exudate. The suffocation was caused by the ingested

matter sucked into the trachea. In the second case, a Kempo practitioner received a series of punches on the chest during his tournament fight. It was in the late evening when he was taken to the hospital because of the serious pain and vomiting, and the doctors diagnosed ruptured spleen and infectious mononucleosis. The latter illness might have caused the spleen oedema, making it extremely susceptible to injuries. The patient died one hour after a surgical intervention. The third case occurred during the fight with an advanced fighter. The patient received a light roundhouse kick into the solar plexus. Although resuscitation was performed in the ambulance, the death was recorded after the arrival to the hospital. Stimulation of the vagus nerve, which caused cardiac dysrhythmia, eventually led to cardiac arrest and was found to be the cause of the death. The doctors found the effusion to the soft tissue surrounding the vagus nerve, numerous petechiae in the liver, numerous haematomas in the lung lobes and emphysema of both lungs. All the three cases concerned young men with training experience below one year³⁵.

In Poland, a death accident was reported for a 17-year-old participant of a training unit. He had one-year training experience and low level of advancement in *Kyokushin* karate (8th kyu). Practice fights were performed during the training session under supervision of a coach and according to the regulations which exclude attack to the face. The students were wearing boxing helmets and shin guards. When choosing the partners, the coaches divided students according to the age and body height. At the end of the classes, the patient was fighting with an opponent aged 18 years, with training experience of over two years and 6th kyu rank. The dangerous accident took place when this person was in the corner

Table 3 Injury location in karate practitioners

Study	Period or competition	Study design	N of injuries	Head, face neck (%)	Trunk (%)	Upper limbs (%)	Lower limbs (%)	Other/unspecified, remark
Sterkowicz 1986 ¹⁴	Poland 1977–1980	RD	42	50.0	11.9	9.5	28.6	.
Kujala et al. 1995 ²⁰	Finland 1987–1991	RD	1150	19.4	15.9	26.3	37.3	1.1%
Yard et al. 2007 ¹⁵	United States 1990–2003	RD	7431*	15.8	7.4	36.7	39.2	0.9%
Zetaruk et al. 2000 ²²	One past year	RQ	22	5.0.	14.4	36.0	45.0.	.
Peeri et al. 2011 ¹⁶	Male Elite Turkey National Team Camp 2010, last year	RQ	151	32.4.	12.6	26.5	28.5	.
Shotorbani et al. 2012 ²¹	Female, athletes career until questionnaire	RQ	526	9.2	11.4	25.7	53.7	.
Sterkowicz 1984 ¹⁸	Male three national and one international Kyokushin Tournaments 1980–1982	P	96	22.9	6.3	15.6.	55.2	.
Sterkowicz 1984 ¹⁸	Male International Oyama Cup 1983	P	22	36.3	31.8	31.8	Summed up with upper limbs	Shin and foot protectors used
Johannsen and Noerregaard 1988 ²⁶	Male Danish International and Team Championships 1984–1985	P	153	78.0	4.0	18.0	Summed up with upper limbs	Knuckle padding was not used
Johannsen and Noerregaard 1988 ²⁶	Male Danish International and Team Championships 1983–1986	P	74	92.0	4.0	4.0	Summed up with upper limbs	Knuckle padding was used
Critchley et al. 1999 ²⁸	Male and Female national championships 1996–1998	P	160	57.0	5.6	14.3	23.1	
Pieter 2007 ³²	Male two open karate tournaments	P	12	50.0	8.3	16.7	16.7	8.3%, time-loss injuries
Halabchi et al. 2007 ²⁹	Female Iranian Championships 2004–2005, six tournaments	P	186	55.4	10.8	33.9	Summed up with upper limbs	
Ariaza et al. 2009 ²⁴	Male and Female World Karate Championships 2002, 2004, 2006	P	64	62.5	3.1	17.2	17.2	After rules were changed, severe and moderate injuries
Pieter 2010 ¹⁹	Male Dutch National Youth Karate Championship	P	76	52.6	22.4	10.5	7.9	
Pieter 2010 ¹⁹	Female Dutch National Youth Karate Championship	P	32	43.8	18.8	12.5	15.6	
Boostani et al. 2012 ²⁷	Male Iran karate national team selective tournaments	P	178	57.9	28.6	10.1	3.4	

P, prospective; RD, retrospective based on institutional documentation; RQ, retrospective based on questionnaire.

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of the fighting field and moved to the right, turning a little backward to the movement direction. At this moment, he received a roundhouse kick to the back of the head. After making a few steps, he staggered but was supported. Then, he lost consciousness for ca. 3 minutes. After the doctor arrived, he was immediately transferred to the local hospital, where he was diagnosed with head contusion and concussion. RTG images did not show changes. The opinion of the surgeon after opening the skull was that the thickness of occipital bone was 3–4 mm while the muscles of the nape of the neck were too weak with respect to the age and overall body build. This might have been conducive to craniocerebral trauma. The patient died on the 5th day after the accident. Its cause was contusion and cerebellar tear¹⁴. Physical modifications after head injuries caused by accelerations usually result in elastic deformation of the skull, rapid acceleration of the head motion and the relative motion of the brain with respect to the skull bones³⁶. A specific characteristic of the above accidents was that they occurred during the fight and concerned beginner karatekas. The ability to control the fight remains the basic criterion of the exams for individual ranks.

Discussion

The authors have referenced some of their own studies in this review. These referenced studies have been conducted in accordance with the Declaration of Helsinki (1964) and the protocols of these studies have been approved by the relevant ethics committees related to the institution in which they were performed. All human subjects, in these referenced studies, gave informed consent to participate in these studies.

In karate, the attacked targets are termed with Japanese word *Kyusho*, which means the places in the human

body, where a punch might cause disturbances in function of organs important to health, loss of consciousness and even death. Knowing these places is of much importance in martial arts^{37,38}. The frequency of attacks to the vital points in the opponent's body depended on the fighting regulations. During the World Open Karate Tournament in Tokyo (full-contact *Kyokushin* style), kicks represented the principal method of attack (83% of all the techniques that scored points)⁵, whereas punches were predominant during the World Championships in Madrid and Monte Ray (93.7%)³⁹. Severe injuries have been documented primarily in RD studies, where the principle way for determination of IR was the number of injuries with respect to the number of participants. In P studies, IR was understood to mean #injuries per 100 participants, per 100 fights, per 1000 AE or per 100 minutes of fighting (see Table 1). In other P studies, the authors used original IR index, with the divisor represented by the number of attacks. IR was 6.3 injuries per 1000 kicks and 2.2 injuries per 1000 punches¹⁸. The previously postulated prevention activities concerned prevention by control of kicks and strikes, prevention by protective clothing and pre-fight medical examination²³. Changes in fighting regulations have produced a positive effect of a reduction in the number of minor injuries^{24,30}. The striking fact in this review of the results of epidemiological research studies was the young age of the injured people (e.g. 14 months, 6 years, 7–15 years)^{15,19,22}. In contemporary opinion of doctors, minimal age for participation in karate should be older than 14 years⁴⁰.

Conclusion

It is important to investigate the factors that reduce IR in sport. In karate, injuries are impossible to be entirely eliminated as the impact

that exceeds tissue mechanical strength has not been excluded as the main cause of severe injuries yet.

- Since the target of the attack in karate is vital points in the opponents body, modifications of fighting regulations carried out by sports federation can be only partially effective in reduction of the injury risk.
- Among children, formal exercise (kata) and pre-arranged sparring might represent a safe alternative for karate fights.

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