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Incidence rate of injury and injury sites in European and Swiss karate competitions: a prospective epidemiological study of 2404 fights

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ABSTRACT

Objectives To compare the rates and injury sites among competitors in European and Swiss karate tournaments and to identify differences in these incidence rates by sex and age.

Methods This prospective cohort study collected data from two European and four national tournaments in Switzerland between 2011 and 2019. The on-site medical staff completed an anonymised report sheet with demographic data and injury characteristics in all injuries requiring medical treatment. The incidence rates per 1000 exposed athletes (AoE) and 1000 min of exposition (MoE) were analysed. Furthermore, the relative risk of injury related to sex and age was calculated and compared.

Results In total, 228 injuries were observed in 2404 fights, for an incidence rate of 47.4 per 1000 AoE (95% CI 41.5 to 54.0) or 22.5 injuries per 1000 MoE (95% CI 19.7 to 25.6), respectively. The oldest age group (senior) of both sexes had a 3.6-fold (95% CI 2.7 to 4.8) significantly higher relative risk of injury than younger participants. Furthermore, there was a 2.9-fold (95% CI 1.6 to 5.6) statistically higher risk of injury for males in the senior age group compared with senior females. The most injured body part was the head, followed by the lower extremity, trunk and upper extremity.

Conclusion Senior athletes, especially senior males, had significantly more injuries compared with younger and female senior competitors. Medical staff should be aware of the increased propensity for injury among this age and sex group to facilitate injury prevention and intervention.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Karate results in different types and incidences of injuries.
⇒ These injuries can vary according to competitors' age and sex.

WHAT THIS STUDY ADDS

⇒ This is one of the largest prospective studies of injuries obtained during karate tournaments by adolescents and adult competitors, respectively.
⇒ This study revealed a significantly higher incidence of injuries among the senior age competitors, particularly among male competitors, compared with the younger age group in karate tournaments.
⇒ The head is the most injured body part. However, only minor injuries have been noted. Nonetheless, prevention is key to avoiding head injuries. We suggest good communication between referees and the medical team. Possibly, points should be given faster when directed to the head.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Medical staff should pay greater attention to senior group fights in karate competitions, and the referees should be instructed accordingly.

INTRODUCTION

Karate is one of the most popular traditional combat sports, summarised as 'martial arts'. According to the translation of the word 'karate' (jpn. empty hand), participants use kicks, punches and blocking techniques without any weapons.[1] Modern karate originated in Japan in the early 20th century, and the first worldwide championship was held after the foundation of the World Union of Karate Do Organisation (WUKO) in 1970. In 1993, the WUKO merged with the International Traditional Karate Federation and was renamed the World Karate Federation (WKF). In 2021, karate debuted as an Olympic sport in Tokyo, Japan, but was not considered anymore for the Olympic Games in Paris 2024.[2]

The rules of the WKF define two different styles of competition during a championship.[3] The first is 'kata', which is a shadow fighting style performed without any contact with the opponent; the other is 'kumite', which is a 'free fight' style that requires direct contact with an opponent. Kumite is mostly practised with light contact rules, where hits and kicks must be controlled, and contact to the face or neck is penalised. Injuries occur in both styles, but variable injury patterns occur more often in kumite, depending on external

influences.[4 5] Studies in the past decades have shown the rate and severity of injuries in karate fights. Still, most were focused on specific age groups or did not compare differences between them.[6–10]

This study aimed to compare injury incidence rates and characteristics among men and women in all age groups that competed in the European Championships in 2011, the European U21 Championships in 2015 and the Swiss Karate Championships from 2016 until 2019. We hypothesised that the injury rate would differ according to age and sex, with ages over 21 and male sex suffering more frequent and more severe injuries.

MATERIALS AND METHODS

Population

For this prospective epidemiological study, data were collected from two European and four Swiss National Championships in Switzerland between 2011 and 2019, as stated above. All male and female participants of individual kumite events were matched by age group (U12 to seniors) and sex. The duration of each fight was 3 min for male competitors older than 18 years, while fights for all other age and sex groups were 2 min in duration. For statistical analysis, the different age classifications were divided into three age groups: (senior (>U21), U18 and U21; and U12, U14, and U16, respectively).

Public involvement

The first author of this paper is the deputy chief medical officer of the Swiss Karate Federation. Other medical staff members of the karate tournaments, including medical students and participants, were involved in data collection, and the first author verified all injuries.

Data collection

All athletes requiring medical treatment were included. Demographic data were collected by on-site medical staff, and any interruptions for medical intervention were noted on a standardised and anonymised reporting sheet, which included a record of the injury characteristics (severity, mechanism of injury and injured anatomical structure). The senior author of this study reviewed all injury sheets on-site.

The severity of each injury was categorised according to the WKF Injury Severity Classification, which has been in use since 1990 (online supplemental annex 1).[11]

Athlete exposure was defined as one participant in a bout. Due to the different bout fight times (2 vs 3 min), a time-adjusted exposure was included, defined as one participant fighting for 1 min in a bout. The data were retrieved from the official tournament documentation recorded via the Sportsdata Event Technology programme (Sportradar AG, St. Gall, Switzerland).

Statistical analysis

The proportions of injuries were calculated per 100 athletes. The incidence rates were recorded per 1000 exposures of athletes (AoE) and 1000 min of exposure (MoE). Like Čierna and Lystad, the 95% CI was calculated using a Poisson distribution.[10] The incidence rates of the groups were compared by their relative risk. The exclusion of the null value (ie, 1) in the 95% CI was considered statistically different. A $p<0.05$ based on the χ^2 test or the z-test was considered statistically significant.

RESULTS

Injury incidence rate

A total of 2211 athletes participated in 2404 fights, among which 228 injuries were recorded, resulting in an incidence rate of 10.3 injuries per 100 athletes (95% CI 9.0 to 11.7) or 47.4 injuries per 1000 AoE (95% CI 41.5 to 54.0), and an injury incident rate per 1000 MoE of 22.5 (95% CI 19.7 to 25.6) (table 1).

Relative injury risk

Overall, the injury rate in both sexes was higher in the senior age group compared with that in the combined U12/U16 group, with a relative risk for 1000 exposed AoE (RRAoE) of 4.3 (95% CI 3.0 to 6.0, p<0.0001) and relative risk for 1000 MoE (RRMoE) of 3.3 (95% CI 2.3 to 4.7, p<0.0001), as well as to that of the combined U18/U21 group, with an RRAoE of 3.1 (95% CI 2.2 to 4.3, p<0.0001) and an RRMoE of 2.6 (95% CI 1.9 to 3.6, p<0.0001), respectively. Furthermore, there was a significant difference between the male senior group and males in all other age groups (table 2). No significant difference in age or sex was found between the U12/U16 and U18/U21 age groups. In contrast, we found a statistical significance in sex (males) in the older group, with an RRAoE of 1.6 (95% CI 1.1 to 2.5, p=0.02).

Moreover, there was a statistically significant increased injury rate among senior male competitors compared with that of senior female competitors, with an RRAoE of 2.9 (95% CI 1.6 to 5.6, p<0.0001) and an RRMoE of 2.0 (95% CI 1.1 to 3.7 p=0.02), respectively. We found no difference in injury risk between the sexes in the younger age groups (table 2).

Severity of injury

According to the WKF Injury Severity Classification, most injuries over all age groups were of minor severity (89%). Only 3% of the injuries were severe, occurring in male competitors.

Minor injuries were more common in males than females in the U18/U21 age group. Moderate injuries were significantly more common in female competitors than the male competitors in the U18/U21 group (4% vs 2%, p=0.02).

The rate of severe injuries was significantly higher in male competitors than in female competitors, both in the senior (9% vs 0%, p<0.0001) and U18/U21 (1% vs 0%, p=0.0002) groups. Moreover, in the senior group, moderate injuries were also significantly higher in male competitors compared with female competitors (9% vs 3%, p<0.0001) (table 3).

Table 1 Number of athletes and injuries by age group and sex, including incidence proportions per 100 athletes (A 100) and incidence rates per 1000 athletes of exposure (AoE 1000) and 1000 min of exposure (MoE 1000) with 95% CIs

	U12/U14/U16				U18/U21				Senior				Total			
	Male		Female		Male		Female		Male		Female		Male		Female	
Athletes	577		414		561		387		158		114		1296		915	
AoE	1280		918		1254		840		284		232		2818		1990	
MoE	2560		1836		2738		1680		852		464		6150		3980	
Injuries	36		33		57		33		54		15		147		81	
Incidences	**(95% CI)**		**(95% CI)**		**(95% CI)**		**(95% CI)**		**(95% CI)**		**(95% CI)**		**(95% CI)**		**(95% CI)**	
A 100	6.2	(4.4 to 8.6)	8.0	(5.5 to 11.2)	10.2	(7.7 to 13.2)	8.5	(5.9 to 12.0)	34.2	(25.7 to 44.6)	13.2	(7.4 to 21.7)	11.3	(9.6 to 13.3)	8.6	(7.0 to 11.0)
AoE 1000	28.1	(24.1 to 32.3)	35.9	(24.7 to 50.5)	45.5	(34.3 to 58.9)	39.3	(27.9 to 55.2)	190.1	(142.8 to 248.1)	64.7	(36.2 to 106.6)	52.2	(44.1 to 61.3)	40.7	(32.3 to 50.6)
MoE 1000	14.1	(9.9 to 19.5)	18.0	(12.4 to 25.2)	20.8	(15.8 to 27.0)	19.6	(13.5 to 27.6)	63.4	(47.6 to 82.7)	32.3	(18.1 to 53.3)	23.9	(20.2 to 28.1)	20.4	(16.2 to 25.3)

	Total		
Athletes	2211		
AoE	4808		
MoE	10 130		
Injuries	228		
Incidences		**(95% CI)**	
A 100	10.3	(9.0 to 11.7)	
AoE 1000	47.4	(41.5 to 54.0)	
MoE 1000	22.5	(19.7 to 25.6)	

	U12/U14/U16				U18/U21				Senior				Total			
	Male		Female		Male		Female		Male		Female		Male		Female	
Athletes	577		414		561		387		158		114		1296		915	
AoE	1280		918		1254		840		284		232		2818		1990	
MoE	2560		1836		2738		1680		852		464		6150		3980	
Injuries	36		33		57		33		54		15		147		81	
Incidences	**(95% CI)**		**(95% CI)**		**(95% CI)**		**(95% CI)**		**(95% CI)**		**(95% CI)**		**(95% CI)**		**(95% CI)**	
A 100	6.2	(4.4 to 8.6)	8.0	(5.5 to 11.2)	10.2	(7.7 to 13.2)	8.5	(5.9 to 12.0)	34.2	(25.7 to 44.6)	13.2	(7.4 to 21.7)	11.3	(9.6 to 13.3)	8.6	(7.0 to 11.0)
AoE 1000	28.1	(24.1 to 32.3)	35.9	(24.7 to 50.5)	45.5	(34.3 to 58.9)	39.3	(27.9 to 55.2)	190.1	(142.8 to 248.1)	64.7	(36.2 to 106.6)	52.2	(44.1 to 61.3)	40.7	(32.3 to 50.6)
MoE 1000	14.1	(9.9 to 19.5)	18.0	(12.4 to 25.2)	20.8	(15.8 to 27.0)	19.6	(13.5 to 27.6)	63.4	(47.6 to 82.7)	32.3	(18.1 to 53.3)	23.9	(20.2 to 28.1)	20.4	(16.2 to 25.3)

	Total		
Athletes	2211		
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Incidences		**(95% CI)**	
A 100	10.3	(9.0 to 11.7)	
AoE 1000	47.4	(41.5 to 54.0)	
MoE 1000	22.5	(19.7 to 25.6)	

	Total		
Athletes	272		
AoE	516		
MoE	1316		
Injuries	69		
Incidences		**(95% CI)**	
A 100	25.4	(19.7 to 32.1)	
AoE 1000	133.7	(104.0 to 169.2)	
MoE 1000	52.4	(40.8 to 66.3)	

Injured body part

The head was the most commonly injured body part (66%), followed by the lower extremity (15%), trunk (11%) and upper extremity (6%); 1% of the injuries could not be classified. The head injury rate was lower in older than younger competitors (62% vs 70%, respectively). However, an increased extremity injury rate was observed in older competitors, while the trunk injury rate remained stable (excluding female seniors who had no trunk injuries). Table 4 provides the details of injured body parts.

DISCUSSION

This is one of the largest prospective studies of injuries obtained during karate tournaments by adolescents and adult competitors. We observed significantly higher injury rates in adult participants, especially adult males, compared with those in younger competitors.

The overall reported incidence rates per 1000 AoE in our study (47.4; 95% CI 41.5 to 54.0) exceed that in the reports by Arriaza *et al*[12] (15; 95% CI 11.4 to 19.2) published in 2016 but are nearly identical to those from Čierna and Lystad[10] (45.3; 95% CI 38.7 to 52.6), while the latter study also noted a higher incidence rate for women aged 12–17 years compared with that in men of the same age and a higher incidence rate of older participants compared with younger participants. However, the other study by Arriaza and Leyes[9] published in 2005 and Macan *et al*[13] reported higher overall incidence rates of 67 injuries per 1000 MoE and 102.8 in 1997 and 98.2 in 2002 per 1000 MoE, respectively.

To the best of our knowledge, there are no comparable data in the literature regarding the injury and incidence rates among different age groups. This difference could be related to the differences in study populations. In our study, all age groups were analysed, whereas Čierna and Lystad *et al* focused only on younger participants aged 6–17 years,[10] and Arriaza and Leyes[9] considered only adult participants. Macan *et al*[13] reported a similar study population by age but focused on national competitions in Croatia with a different research goal from ours; they divided the participants into two age groups (younger or older than 18 years) to determine the change in competition rules between two championships. Similar to previous studies, we observed no significant sex difference in the relative risk of injuries.[9 10 12 14] Two previous studies could not show any significant differences between the injury rates of adult men and women during competitions.[9 15] However, we found a significantly higher incidence rate per 1000 MoE for men in the senior group (>21 years), comparable to the data reported by Kujala *et al*.[16] In the systematic review of Lystad *et al*, the same relative risk of injury was found. Still, when adjusted to exposure time, this difference between females and males was not seen anymore. However, our study still found a difference in relative injury risk even when adjusted to exposure time. We speculate that this increased incidence might be related to an increased willingness of the men to

Table 2 Relative risk of incidence rates per 1000 athletes of exposure (RR AoE) and 1000 min of exposure (RR MoE) with 95% CI and p values by age group and sex

	Category	RR AoE	(95% CI)	P value AoE	RR MoE	(95% CI)	P value MoE
Age							
Male	U18/U21 (ref. U12/U14/U16)	**1.6**	**(1.1 to 2.5)**	**0.02**	**1.5**	**(1.0 to 2.3)**	n.s.
	Sen (ref U12/U14/U16)	**6.8**	**(4.4 to 10.6)**	**<0.0001**	**4.5**	**(2.9 to 7.1)**	**<0.0001**
	Sen (ref U18/U21)	**4.2**	**(2.8 to 6.2)**	**<0.0001**	**3.0**	**(2.1 to 4.5)**	**<0.0001**
Female	U18/U21 (ref. U12/U14/U16)	1.1	(0.7 to 1.8)	n.s.	1.1	(0.7 to 1.8)	n.s.
	Sen (ref U12/U14/U16)	1.8	(0.9 to 3.4)	n.s.	1.8	(0.9 to 3.4)	n.s.
	Sen (ref U18/U21)	1.7	(0.8 to 3.1)	n.s.	1.7	(8.3 to 3.1)	n.s.
Total	U18/U21 (ref. U12/U14/U16)	1.4	(1.0 to 1.9)	**0.049**	1.3	(0.9 to 1.8)	n.s.
	Sen (ref U12/U14/U16)	**4.3**	**(3.0 to 6.0)**	**<0.0001**	**3.3**	**(2.3 to 4.7)**	**<0.0001**
	Sen (ref U18/U21)	**3.1**	**(2.2 to 4.3)**	**<0.0001**	**2.6**	**(1.9 to 3.6)**	**<0.0001**
Sex							
Total	Male (ref. female)	1.3	(1.0 to 1.7)	n.s.	1.2	(0.9 to 1.6)	n.s.
U12/U14/U16	Male (ref. female)	0.8	(0.5 to 1.3)	n.s.	0.8	(0.5 to 1.3)	n.s.
U18/U21	Male (ref. female)	1.2	(0.7 to 1.8)	n.s.	1.1	(0.7 to 1.7)	n.s.
Sen	Male (ref. female)	**2.9**	**(1.6 to 5.6)**	**0.0001**	**2.0**	**(1.1 to 3.7)**	**0.02**

Bold numbers mark significant and highly significant differences.
n.s., not significant.

take risks and the physical condition of adult men. Also, in our study, we were very consistent in data collection because the senior author was always present at all bouts. Lystad *et al* had pooled data from many other studies with different methods, which might explain this marked difference. We also found that age is a significant risk factor for experiencing a more severe injury during a karate competition (senior vs U18/U21 and senior vs U12/U16, p<0.00001).

Regarding injury severity, a direct comparison with the severity found in previous studies was not possible because of differences in the grouping and classification systems. We, thus, advocate for a consistent injury severity grading system and support the recommendations from Lystad *et al* and the IOC (International Olympic Committee) consensus statement.[11 17] Similar to this study, Macan *et al* documented higher grades of severity in male participants using a different classification system.[13] In addition,

Table 3 Severity of injuries as total and percentage by age group and sex

		U12-U16		U18-U21		Senior		Total	
Severity			%		%		%		%
3	Male	33	48	54	60	42	61	129	57
	Female	31	45	29	32	13	19	73	32
	Total	64	93	83	92	55	80	202	89
2	Male	3	4	2	2***	6	9****	11	5
	Female	2	3	4	4***	2	3****	8	4
	Total	5	7	6	7	8	12	19	8
1	Male	0	0	1	1*	6	9**	7	3
	Female	0	0	0	0*	0	0**	0	0
	Total	0	0	1	1	6	9	7	3
Total		69	100	90	100	69	100	228	100

P values by χ^2 test: *p=0.0002; **p<0.0001; ***p=0.02; ****p<0.0001.

Table 4 Injured body part in percentage by age group and sex

		U12 (%)	U18 (%)	Senior (%)	Total (%)
Head	Male	67	58	56	59
	Female	73	82	87	80
	Total	70	67	62	66
Upper extremity	Male	6	7	11	8
	Female	0	6	0	2
	Total	3	7	9	6
Trunk	Male	14	14	13	14
	Female	9	9	0	7
	Total	12	12	10	11
Lower extremity	Male	14	16	20	17
	Female	18	3	13	11
	Total	16	11	19	15

a similar study by Arriaza and Leyes that used the same severity classification severity did not separate the age groups, and they demonstrated only marginal sex differences in grades of severity.[9] Although we revealed a higher incidence rate of injury in male adults, we do not have a convincing explanation for their higher grades of injury severity and can only speculate the reasons.

We found that the head was the most injured body part (affecting 66% of all injuries); Arriaza and Leyes[9] and Critchley *et al*[14] reported nearly identical rates of head injury in karate tournaments at 62.5% and 57.0%, respectively. However, Arriaza and Leyes[9] and Critchley *et al*[14] found the trunk to be the rarest injured body part, while the upper extremity was the least injured in this study. We observed that in the younger age groups, the head is injured overproportionately more often than in the older age group. This probably depends on older participants' increased experience in blocking techniques, but this study cannot prove this explanation. During the study period, three marked WKF rules might influence injury rates: first, no blow to the head was allowed. Second, a face mask was compulsory for competitors under the age of 14 years old (U14) and third, since January first 2012, a face mask was not compulsory for cadets and juniors anymore. From 1 January 2023, a protective face mask or helmet was mandatory. From 1 January 2024, onwards, only a protective WKF helmet will be compulsory. Regarding the first point, according to current WKF rules, registered blows to the head were punished during the study period. The authors know that changes to the WKF rules regarding the impact and protective equipment might be important to the injury rates. Still, these confounders, in combination with the small injury rate, might not lead to exact conclusions.

Limitation

The main limitation of our study was that we studied only European and Swiss Karate Championships carried out in Switzerland, as the senior author is the deputy chief medical officer of the Swiss Karate Federation. Thus, our results cannot represent the general injury risks of karate tournaments. However, international tournaments were also included in the analysis, and the results do not consider Swiss karate tournaments alone. Another limitation is the documentation of fight times. It is unclear whether a fight had to be completely stopped due to injury on the combat recording system, implying an error in fighting times. The injury rate per fight minute might thus be higher.

Clinical implications

The results of our study can inform physicians in charge of karate tournaments about the actual type and frequency of injuries encountered during a karate competition. Moreover, greater attention must be paid during senior group fights to be able to offer immediate medical support. We also suggest informing referees of the age, sex and body locations most at risk for injury.

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Contributors Conceptualisation: CR, RFA and KG. Data collection. CR and KG, Students methodology: CR, RFA, KG and AD. Statistical analysis: CR, RFA and AD. Writing and original draft: CR, RFA, KG and AD. Writing, review and editing: CR, RFA and KG. Guarantor: Claudio Rosso, RFA

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