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## Martial Arts Injuries

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### Abstract

**Objective:** To review the current evidence for the epidemiology of pediatric injuries in martial arts. **Data sources:** The relevant literature was searched using SPORT DISCUS (keywords: martial arts injuries, judo injuries, karate injuries, and taekwondo injuries and ProQuest (keywords: martial arts, taekwondo, karate, and judo), as well as hand searches of the reference lists. **Main results:** In general, the absolute number of injuries in girls is lower than in boys. However, when expressed relative to exposure, the injury rates of girls are higher. Injuries by body region reflect the specific techniques and rules of the martial art. The upper extremities tend to get injured more often in judo, the head and face in karate and the lower extremities in taekwondo. Activities engaged in at the time of injury included performing a kick or being thrown in judo, while punching in karate, and performing a roundhouse kick in taekwondo. Injury type tends to be martial art specific with sprains reported in judo and taekwondo and epistaxis in karate. Injury risk factors in martial arts include age, body weight and exposure. **Conclusions:** Preventive measures should focus on education of coaches, referees, athletes, and tournament directors. Although descriptive research should continue, analytical studies are urgently needed.

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### Introduction

East Asian martial arts have a large following worldwide among children and youth. For instance, in small countries like The Netherlands and Belgium, the number of boys and girls practicing karate and taekwondo varies from 9,000 to more than 23,500 for judo according to the major national governing bodies represented in world championships and Olympic Games [1–3]. The estimated participation in martial arts by children and youth in the USA is around 1 million [4].

With an increase in the number of children and adolescents involved in martial arts, injuries to this population are expected to increase. For instance, between 1983 and 1998, the A and E units of the Cardiff Royal Infirmary, Wales, saw a 45% increase in pediatric martial arts injuries, mostly due to an increase in participation by girls [5].

Studies involving pediatric martial arts injuries have commonly combined two or more martial arts or age groups and did not distinguish between practice and competition injuries [6–9]. The aforementioned studies were retrospective and concerned with time-loss injuries. Prospective studies combining age groups include those by Buckley [10], Poirier [11] and Critchley et al. [12].

The purpose of the present review was to present the distribution of injuries and their determinants in martial arts. In addition, suggestions for injury prevention and further research will be highlighted. The literature search was limited to retrospective and prospective studies due to the inherent methodological weaknesses of numerator-based designs [13]. Data collection covered the period 1980 to present and was accomplished using the following procedures: (1) ancestry approach: retrieval of research cited in published research; and (2) computer searches: the Sport Discus database (key words: martial arts injuries, judo injuries, karate injuries, taekwondo injuries), and ProQuest (key words: martial arts, taekwondo, karate, judo).

### **Incidence of Injury**

What we know about injury rates among pediatric martial arts participants arises primarily from studies of tournament or competition injuries. Some reports from tournaments and competitions were at recreational level; however, most were at national level.

A comparison of injury rates based on prospective studies is summarized in table 1. Included in the table are studies on recreational [14], national [15–20] and international athletes [18, 21]. Perusal of table 1 shows significantly higher injury rates for girls in most studies of the three martial arts [14–17, 19, 21]. However, Pieter and Zemper [18] did not find any significant gender differences in injury rates in taekwondo. Tuominen [20] reported a higher frequency of injuries in boys, but this was not statistically verified.

In a retrospective study, Kujala et al. [22] reported that for boys younger than 15 years, the combined injury rate for practice and competition was 22 injuries/person years of exposure (PYO) in judo and 30/PYO in karate. The values for the girls were 75 and 42/PYO, respectively. In the 15–19-year age group, the boys recorded 90 injuries/PYO in judo and 95/PYO in karate. The girls

**Table 1.** A comparison of injury rates in young martial arts athletes

Study	Design	Data collection interv/question	Duration injury survival	Injuries		Sample Number of participants	Rate Number of injuries per 100 athletes	Rate, Number of injuries per 1,000 athlete- exposures
				Sex	Number			
<i>Judo</i>								
Pieter and De Créé [21]	P	Q	1 tournament	M	25	111	22.52	77.16
				F	17	62	24.42	104.94
James and Pieter [16]	P	Q	1 tournament	M	54	417	13.0	39.8
				F	45	270	16.7	52.1
<i>Karate</i>								
Tuominen [20]	P	Q		M	33	–	–	133.07
				F	1	–	–	50.00
Pieter [17]	P	Q	1 tournament	M	76	218	34.86	99.74
				F	32	84	38.10	115.11
<i>Taekwondo</i>								
Pieter et al. [14]	P	Q	1 tournament	M	20	139	14.39	78.74
				F	7	43	16.28	97.22
Pieter and Zemper [18]	P	Q	3 tournaments	M	354	3,341	10.60	58.34
				F	87	917	9.49	56.57
Beis et al. [15]	P	Q	1 season	M	76	1,223	6.21	34.23
				F	52	767	6.78	41.27
Pieter and Kazemi [19]	P	Q	1 tournament	M	31	170	18.2	108.4
				F	18	89	20.2	132.4

sustained 145 injuries/PYO in judo and 121/PYO in karate. De Loës [23], also in a retrospective study, reported an incidence rate in judo of 2.3 injuries/10,000 h of exposure for both boys as well as girls aged 14–20 years.

Two prospective studies reported composite rates collapsed over gender and/or age. Oler et al. [24] reported a combined injury rate of 3.4/100 participants based on an estimated 3,000 young male and female taekwondo athletes competing at the national level. Barrault et al. [25] recorded an injury rate of 113.31/ 1,000 athlete-exposures (A-E) in a combined sample of male and female children and adolescent judo athletes. The rate was also collapsed over local, regional and national tournaments.

Zetaruk et al. [26] retrospectively investigated training injuries in karate from one school in the USA. They reported a total of 22 injuries in male and female children of 6–16 years (mean: 10 years), for an injury rate of 32.35/100 participants or 3.7 injuries per 1,000 h of training. The students belonged to a karate club where sparring was not emphasized.

## **Injury Characteristics**

### *Injury Onset*

The vast majority of injuries in martial arts are acute or sudden onset. Only two studies reported gradual onset injuries [17, 18]. In karate, Pieter [17] found 1.9% of all injuries in boys to be of gradual onset. In taekwondo, 1.4 and 3.5% of all injuries in boys and girls, respectively, were of gradual onset [18]. However, no information is available on such factors as the frequency, duration and intensity of training of the competitors investigated, all of which are believed to have a bearing on injury onset [27].

### *Injury Location*

Tables 2 (boys) and 3 (girls) display a percent comparison of injury location in young martial arts athletes [14–21]. In the boys, differences in techniques used and competition rules are clearly reflected in the body regions and body parts injured. In judo, the upper extremities tend to get injured more often (28.0–37.0% of total injuries), whereas the head/face in karate incur most of the injuries (51.3–90.9%). In taekwondo, the lower extremities sustain most of the injuries (36.7–65.0%).

The injury pattern in girls is less clear, probably because of the small sample size in some of the studies [14, 20]. For instance, no head injuries were reported in judo [21] and taekwondo [14]. On the other hand, the spine/trunk was found to be injured most often in one judo study [17] and not at all in karate [20] and taekwondo [14].

**Table 2.** A percent comparison of injury location in young male martial arts athletes based on prospective studies

Injuries	Judo		Karate		Taekwondo			
	Pieter and De Créé [21]	James and Pieter [16]	Tuominen [20]	Pieter [17]	Pieter et al. [14]	Pieter and Zemper [18]	Beis et al. [15]	Pieter and Kazemi [19]
n	25	54	33	76	20	354	76	31
<i>Head</i>	8.0	37.0	90.9	51.3	20.0	34.2	34.2	19.4
Head	4.0	9.3	3.0	–	5.0	10.5	6.6	12.9
Face/teeth	–	27.8	87.9	46.1	10.0	22.9	27.6	6.5
Throat	4.0	–	–	5.3	5.0	0.9	–	–
<i>Spine/trunk</i>	20.0	11.1	6.1	23.7	5.0	12.2	22.4	6.5
Neck	4.0	3.7	–	1.3	–	2.5	–	3.2
Torso	8.0	3.7	6.1	17.1	–	5.7	1.3	–
Back	8.0	1.9	–	1.3	–	–	1.3	3.2
Hip/pelvis	–	–	–	2.6	5.0	1.4	–	–
Groin	–	1.9	–	1.3	–	2.5	19.7	–
<i>Upper extremity</i>	28.0	37.0	3.0	10.5	10.0	14.1	2.6	16.1
Shoulder	12.0	14.8	–	2.6	5.0	1.1	–	–
Arm/elbow	12.0	9.3	–	1.3	–	1.4	–	–
Hand/wrist/fingers	4.0	13.0	3.0	6.6	5.0	11.6	2.6	16.1
<i>Lower extremity</i>	44.0	14.8	–	7.9	65.0	36.7	39.5	54.8
Leg	4.0	–	–	–	5.0	9.0	1.3	12.9
Knee	28.0	11.1	–	2.6	5.0	6.2	2.6	6.5
Ankle	8.0	–	–	–	5.0	5.4	4.0	3.2
Foot/toes	4.0	3.7	–	5.3	50.0	16.1	31.6	32.3
<i>Other</i>	–	–	–	6.6	–	2.8	1.3	3.2

**Table 3.** A percent comparison of injury location in young female martial arts athletes based on prospective studies

Injuries	Judo		Karate		Taekwondo			
	Pieter and De Créé [21]	James and Pieter [16]	Tuominen [20]	Pieter [17]	Pieter et al. [14]	Pieter and Zemper [18]	Beis et al. [15]	Pieter and Kazemi [19]
n	17	45	1	32	7	87	52	18
<i>Head</i>	–	26.7	100.0	40.6	–	27.6	42.3	5.6
Head	–	13.3	100.0	–	–	8.1	7.7	–
Face/teeth	–	13.3	–	37.5	–	17.2	34.6	5.6
Throat	–	–	–	3.1	–	2.3	–	–
<i>Spine/trunk</i>	47.1	8.9	–	21.9	–	11.5	5.8	27.8
Neck	–	–	–	3.1	–	2.3	–	–
Torso	29.4	6.7	–	18.8	–	5.8	3.9	5.6
Back	17.7	2.2	–	–	–	–	1.9	5.6
Hip/pelvis	–	–	–	–	–	1.2	–	16.7
Groin	–	–	–	–	–	2.3	–	–
<i>Upper extremity</i>	29.4	37.8	–	12.5	14.3	19.5	–	22.2
Shoulder	5.9	4.4	–	3.1	–	1.2	–	–
Arm/elbow	17.7	15.6	–	3.1	–	1.2	–	–
Hand/wrist/fingers	5.9	17.8	–	6.3	14.3	17.2	–	22.2
<i>Lower extremity</i>	17.7	26.7	–	15.6	85.7	41.4	42.3	44.4
Leg	–	4.4	–	–	–	10.3	3.9	–
Knee	17.7	6.7	–	3.1	28.6	6.9	5.8	–
Ankle	–	11.1	–	–	14.3	12.6	7.7	16.7
Foot/toes	–	4.4	–	12.5	42.9	11.5	25.0	27.8
<i>Other</i>	5.9	–	–	9.4	–	–	–	–

For both boys and girls combined, however, the upper extremities in judo, the head in karate and the lower extremities in taekwondo were the most frequently injured body regions. Body parts of particular concern include the shoulder and hand/wrist/fingers in judo, the face in karate and the foot in taekwondo. Head and neck injuries in all three martial arts should be of the greatest concern, especially in taekwondo [28] where it ranks as the second most often injured body region. In one study, the head and neck was the most frequently injured body region at one taekwondo tournament [24].

Zetaruk et al. [26] found that the lower extremities (45% of total injuries) were most often injured in young karate athletes during practice. No information was provided on which body part was the most frequently injured.

#### *Action or Activity*

Our knowledge of situational factors associated with pediatric martial arts injuries is mostly based on acute injuries sustained in competition. Receiving a throw (boys) and groundwork (girls) in judo were activities engaged in when the injury occurred [16, 21], whereas simultaneously executed punches were most often associated with injury in karate [17]. Attacking with a roundhouse kick or receiving it led to most injuries in taekwondo [18, 19].

#### *Chronometry*

Only one study recorded the time during competition when injury occurred. Beis et al. [29] reported that 42.1% of all injuries occurred in the first match in boys, whereas 48.1% of all injuries were sustained in the first match by the girls. Even when exposure time was taken into account, significantly more injuries occurred in the first match. Explanations for this phenomenon may include a larger variety of skill levels in the early rounds of a tournament [30] and athletes less inclined to report an injury as competition nears its end [29].

### **Injury Severity**

#### *Injury Type*

A review of table 4 reveals that contusion is the most common injury type in judo, karate and taekwondo (tables 4 and 5) [14–21]. Sprains were reported in judo [16, 21] and taekwondo [14, 15, 18, 19], but not in karate [17, 20]. The hyperextension seems to be predominantly limited to judo [16, 21].

In girls, the contusion was also reported to be the most frequently occurring injury in all three martial arts [15–21], except in one study on taekwondo, where the sprain was the most often occurring injury [14]. Judo had a larger percentage ‘other’ [16, 21] than karate [17, 20] or taekwondo [14, 15, 18, 19].

**Table 4.** A percent comparison of injury types in young male martial arts athletes based on prospective studies

Study	# inj	Abrasion	Blister	Concussion	Contusion	Dislocation	Epistaxis	Fracture	Hyperextension	Laceration	Tear*	Sprain	Strain	Other
<i>Judo</i>														
Pieter and De Créé [21]	25	8.0	–	4.0	56.0	4.0	–	–	4.0	–	–	12.0	–	12.0
James and Pieter [16]	54	9.3	–	5.6	13.0	1.9	–	1.9	5.6	13.0	5.6	5.6	24.1	13.0
<i>Karate</i>														
Tuominen [20]	33	–	–	–	51.5	–	24.2	3.0	–	15.2	–	–	–	6.1
Pieter [17]	76	2.6	–	–	67.1	–	6.6	2.6	–	4.0	–	–	1.3	15.8
<i>Taekwondo</i>														
Pieter et al. [14]	20	5.0	–	5.0	60.0	–	5.0	–	–	15.0	–	5.0	–	–
Pieter and Zemper [18]	354	1.4	0.3	8.8	39.3	0.9	3.7	5.7	–	5.9	0.6	20.6	4.5	8.5
Beis et al. [15]	76	–	18.4	7.6	38.2	–	11.8	2.6	–	14.5	–	2.6	–	–
Pieter and Kazemi [19]	31	–	–	6.5	38.7	–	3.2	6.5	–	6.5	–	19.4	16.1	3.2

\*Ligament tear.

# inj = Number of injuries.

**Table 5.** A percent comparison of injury types in young female martial arts athletes based on prospective studies

Study	# inj	Abrasion	Blister	Concussion	Contusion	Dislocation	Epistaxis	Fracture	Hyperextension	Laceration	Tear*	Sprain	Strain	Other	
<i>Judo</i>															
Pieter and De Créé [21]	17	11.8	–	–	41.2	–	–	–	5.9	5.9	–	–	–	35.3	
James and Pieter [16]	45	4.4	–	6.7	35.6	2.2	–	–	8.9	2.2	6.7	11.1	13.3	8.9	
<i>Karate</i>															
Tuominen [20]	1	–	–	–	100	–	–	–	–	–	–	–	–	–	
Pieter [17]	32	3.1	6.3	–	71.9	–	–	–	–	3.1	–	–	3.2	12.5	
<i>Taekwondo</i>															
Pieter et al. [14]	7	–	–	–	14.3	–	–	–	–	–	–	85.7	–	–	
Pieter and Zemper [18]	87	1.2	–	8.1	34.5	1.2	1.2	10.4	1.2	2.3	–	27.6	6.9	5.8	
Beis et al. [15]	52	–	11.5	9.6	44.2	1.9	13.5	–	–	15.4	–	–	–	1.9	
Pieter and Kazemi [19]	18	5.6	–	–	44.4	–	–	11.1	–	5.6	–	27.8	–	5.6	

\*Ligament tear.

# inj = Number of injuries.

Epistaxis was found in karate and taekwondo [14, 15, 17–20], but mostly in males. Cerebral concussions were reported in male judo and taekwondo athletes [14–16, 18, 19, 21], but less frequently in their female counterparts [15, 16, 18]. No cerebral concussions were found in the prospective studies on pediatric karate injuries [17, 20]. If exposure time is taken into account, the combined rate collapsed over studies for cerebral concussions in judo would be 2.38/1,000 A-E (boys) and 2.92/1,000 A-E (girls). In taekwondo, the corresponding rates would be 4.53/1,000 A-E (boys) and 3.99/1,000 A-E (girls).

### *Catastrophic Injury*

Although Oler et al. [24] using a prospective design and Birrer [8], in a retrospective study, recorded one and six deaths, respectively, it is not clear whether they involved junior, senior, male or female martial arts athletes. Kujala [22] reported permanent disability in judo (0.17% of all judo injuries) and karate (0.17% of all karate injuries), but did not specify the age and gender of the athletes.

### *Time Loss*

Time-loss injury is defined as any injury that will keep the athletes from finishing the present bout and/or continuing with subsequent bouts and that will prevent them from returning to practice or competition for one day or more [31]. Time-loss injuries were reported for karate in boys competing at the national level with rates of 4.03/1,000 A-E [20] and 2.63/1,000 A-E [17]. No time-loss injuries in karate girls were reported in the literature. In taekwondo, the time-loss injury rate for boys ranges from 25.54/1,000 A-E [31] to 6.99/1,000 A-E [19] and 7.66/1,000 A-E [32] in national and international athletes to 3.94/1,000 [33] in recreational participants.

In girls, the rates for national and international taekwondo athletes were 29.91/1,000 A-E [31] and 14.29/1,000 A-E [32], while their recreational counterparts recorded a rate of 13.89/1,000 A-E [33]. Although the girls in Pieter and Kazemi's study [19] sustained time-loss injuries, they decided to continue competing on the day of the injury. There was no follow-up, but their rate would have been 14.71/1,000 A-E. Martin et al. [34] reported time-loss injuries of 8.2 and 8.3/100 participants for boys and girls, respectively, competing at the 1985 Junior Olympics.

Using the same injury definition, one study suggests that recreational female taekwondo athletes <13 years incurred a higher injury rate of more severe injuries ( $\geq 21$  days) than their male counterparts of the same age [33], while time loss per injury in national level boy and girl taekwondo athletes mostly required  $\leq 7$  days away from participation [31]. Most of the time loss

per head and neck injury in young national taekwondo athletes also resulted in  $\leq 7$  days away from participation [28].

### *Clinical Outcome*

Limited data exist on re-injury in pediatric martial arts athletes. Pieter and Kazemi [19] found re-injury rates of 6.99/1,000 A-E in taekwondo boys and 36.76/1,000 A-E in girls. All injuries were sustained in the same season the data were collected for the study. There were no studies that reported the residual effects of injury following retirement from the sport.

## **Injury Risk Factors**

### *Age and Body Weight*

It is hypothesized that injuries would increase with age in taekwondo as the athletes are expected to increase in body weight and strength [18]. However, this assumption was not analyzed for statistical significance. Later prospective studies showed either no statistically different ( $p > 0.05$ ) [14] or a lower injury rate with age ( $p < 0.001$ ) [19] but also a higher one ( $p < 0.001$ ) [15]. Middle school taekwondo athletes were more likely to incur a cerebral concussion in competition compared to high school counterparts (OR = 1.89) [35].

In judo, an increase was reported [25] as well as a decrease [21] in injury rate with age. The latter study confirmed the decrease statistically ( $p < 0.01$ ). Kujala et al. [22] found practice and competition injury rates to increase with age in both male and female judo and karate athletes. However, this was not statistically tested. Zetaruk et al. [26] found no statistical relationship between age and injury in karate practice. One prospective study suggested an increase in injury with increasing weight in young taekwondo athletes [18]. However, this was not confirmed statistically in a later investigation ( $p > 0.05$ ) [15].

### *Exposure*

Experience ( $p < 0.001$ ), training hours/week ( $p = 0.016$ ) and belt rank ( $p = 0.006$ ) were found to be positively related to number of injuries in young karate practitioners [26]. Tuominen [20] confirmed the positive relationship between experience and sustaining an injury in adult males only (OR = 4.9), but not in younger karate athletes.

## **Suggestions for Injury Prevention**

The purpose of this overview was to present epidemiological data pertaining to injuries in pediatric martial arts athletes with a view to facilitate understanding

of how, where and why injuries occur in judo, karate and taekwondo, so that they may be prevented in the future. The review of the literature revealed the following injury patterns: (1) a higher injury rate per 1,000 A-E was reported for girls in some studies [14–17, 19, 21]; (2) the most often injured body regions/parts: upper extremities (hand/wrist/fingers), lower extremities (knee), spine/trunk in judo; head (face), spine/trunk, upper extremities, lower extremities in karate; lower extremities (foot/toes), head, upper extremities in taekwondo [14–21]; (3) in boys, contusion is the most frequently occurring injury type in all three martial arts, followed by strain in judo, epistaxis in karate, and sprain in taekwondo; in girls, contusion is also the most often occurring injury type, followed by abrasion in judo, blister in karate, and sprain in taekwondo; a small number of catastrophic injuries (<1% of all injuries) occur in all three martial arts; time-loss injuries were reported for karate (only boys) and taekwondo [14–21]; (4) performing a throw (boys) and being thrown (girls) were actions most often associated with injury in judo [16, 21]; in karate, punching was most frequently associated with injury [17, 20], while in taekwondo, it was executing the roundhouse kick [14, 15, 19]; (5) age and body weight were identified as risk factors in all three martial arts in some studies [15, 19, 21, 25], but not in others [14, 26], while exposure to injury was found to be related to karate injuries [26].

Suggestions for preventive measures are summarized in table 6. The recommendations are based on descriptive data and await further research evaluating some or all of the suggestions included in the table. McLatchie et al. [40] have conducted the only study to date investigating the effect of preventive measures on competition injuries in karate. In adult karate athletes, the total injury rate decreased from 0.25 to 0.05 injuries per bout after implementation of preventive measures involving coaches, athletes, referees and protective equipment. No such studies have been done with pediatric martial arts athletes.

### **Challenges for Further Research**

Future research should adopt a definition of injury that is not restricted to time-loss injuries only so as to arrive at a more complete pediatric injury profile in martial arts [36]. More studies are needed to assess training injuries and compare them to those sustained in competition. These investigations should be done based on a multifactorial model and also include potential risk factors. Very little is known about injury risk factors in judo, karate and taekwondo and identifying them should be emphasized in future research. Analytical studies are also needed to evaluate suggested preventive measures based on risk factors that have been statistically verified for their predictive value.

**Table 6.** Suggestions for injury prevention (adapted from Pieter [36])

Preventive measures	Type of evidence	
	Retrospective	Prospective
<i>Education</i>		
Coaches, referees, athletes, and tournament directors should be educated relative to injuries, their mechanisms and prevention		Oler et al. [24]; Pieter and Zemper [18]; Koh and Watkinson [37]
Coaches and referees should be required to meet minimum standards of qualification	Birrer [8]	Oler et al. [24]; Critchley et al. [12]
<i>Coaching – training</i>		
Children and youth in martial arts should be taught not to enter competition prematurely		Oler et al. [24]; Pieter and Zemper [28]
More appropriate advice regarding the use of the roundhouse kick in taekwondo as well as more adequate game planning and blocking skills		Pieter and Bercades [33]; Pieter et al. [14]; Pieter and Zemper [28]; Koh and Cassidy [35]
<i>The sport</i>		
Re-evaluation of current competition rules that allow blows to the head/face to help reduce injuries	Birrer [8]	Oler et al. [24]; Tuominen [20]; Pieter and Zemper [28]
It is suggested to compete with closed fists instead of open hands in karate and taekwondo to help reduce fractures to the hands and fingers		Pieter and Zemper [31]
<i>Equipment</i>		
It is recommended to allow padding for the foot in taekwondo athletes to help reduce injuries to this body part		Beis et al. [15]; Pieter and Zemper [38]
Mouthguards should be mandatory at all competitions to help prevent dental and orofacial injuries as well as reduce the incidence and severity of brain injuries		Nowjack-Raymer and Gift [4]; Tuominen [20]; Biasca et al. [39]
<i>Referee</i>		
The referee should have competition experience, preferably at the national level as a minimum requirement, to better assess the activities in the ring in terms of the nature of the blows and other aspects of the match		McLatchie et al. [40]

The psychological profile of the pediatric martial arts athlete should also be considered as a potential risk factor for injury [28]. For instance, Filaire et al. [41] showed cognitive and somatic state anxiety to be positively related to the level of judo competition: the higher the level of competition, the higher the state of anxiety. Psychological stress was found to be related to injuries in high school basketball, wrestling and gymnastics [42] but has not yet been studied in martial arts.

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