Epidemiology of injuries in elite taekwondo athletes: two Olympic periods cross-sectional retrospective study

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Table I. OSICS-1: injury type episodes, medical visits and injury seveirity index according to two Olympic periods and sex of the athletes.

Injury Location	Male						Female					
	IE		MV		II (MV/IE)		IE		MV		II (MV/IE)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Ankle	58	35	105	46	1,8	1,3	68	44	110	66	1,6	1,5
Pelvis[1]	8	15	9	15	1,1	1	10	8	14	9	1,4	1,1
Chest[2]	16	4	19	4	1,2	1	1	7	1	9	1	1,3
Shoulder[3]	15	14	31	20	2,1	1,4	7	6	7	8	1	1,3
Foot	104	68	160	91	1,5	1,3	56	57	88	75	1,6	1,3
Hip[4]	19	25	39	60	2,1	2,4	9	10	10	12	1,1	1,2
Head and neck	10	3	10	4	1	1,3	13	13	13	16	1	1,2
Knee	83	101	161	186	1,9	1,8	56	118	71	221	1,3	1,9
Lumbar Spine[5]	23	36	33	49	1,4	1,4	17	35	25	42	1,5	1,2
Lower leg	19	62	25	86	1,3	1,4	27	40	27	57	1	1,4
Thigh	47	55	66	77	1,4	1,4	24	66	36	86	1,5	1,3
Wrist[6]	22	53	26	62	1,2	1,2	17	41	20	48	1,2	1,2
Unspecific	7	10	7	11	1	1,1	6	10	8	10	1,3	1

IE: injury episodes; MV: medical visits; II: injury severity index; 1st: first Olympic period; 2nd: second Olympic period
[1]Pelvis and buttock; [2]Chest, trunk, abdomen and thoracic spine; [3]Shoulder, upper arm, elbow, forearm; [4]Hip and groin; [5]Lumbar spine; [6]Wrist and hand.

Table II. OSICS-2: injury type episodes, medical visits and injury seveirity index according to two Olympic periods and sex of the athletes.

Injury type	Male						Female					
	IE		MV		II (MV/IE)		IE		MV		II (MV/IE)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Cartílage[1]	70	73	107	100	1,5	1,4	66	87	83	136	1,3	1,6
Luxations[2]	78	68	161	137	2,1	2	53	64	98	136	1,8	2,1
Fractures	26	33	66	45	2,5	1,4	6	6	7	7	1,2	1,2
Bruising/Hematoma	129	141	175	182	1,4	1,3	89	133	114	169	1,3	1,3
Laceration/Abrasion	8	2	8	2	1	1	6	2	6	2	1	1
Muscle	44	72	57	100	1,3	1,4	31	74	43	88	1,4	1,2
Nerve	1	5	1	6	1	1,2	1	2	1	2	1	1
Organic	1	1	1	1	1	1	0	1	0	1	0	1
Stress[3]	14	22	37	53	2,6	2,4	11	15	13	33	1,2	2,2
Tendon	41	40	49	49	1,2	1,2	31	34	40	40	1,3	1,2
Non specific[4]	1	2	1	2	1	1	1	2	1	2	1	1
Absence	18	22	28	34	1,6	1,5	16	35	24	43	1,5	1,2

IE: injury episodes; MV: medical visits; II: injury severity index; 1st: first Olympic period; 2nd: second Olympic period
[1]Arthritis, cartilage injuries, synovitis, impingements, bursitis and chronic instability; [2]Joint dislocations and joint sprains;
[3]Stress fractures, other stress and overuse injuries; [4]Whiplash and non-specific injuries.

Table III. Injury episodes, medical visits and injury severity index according to chronological age groups, related to sex and two Olympic periods.

Chronological age	Male						Female					
	IE		MV		II (MV/IE)		IE		MV		II (MV/IE)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
15	3	0	4	0	1,3	0	11	4	17	5	1,5	1,3
16	23	2	29	3	1,3	1,5	38	22	53	28	1,4	1,3
17	25	22	37	30	1,5	1,4	58	30	88	44	1,5	1,5
18	23	38	36	53	1,6	1,4	30	56	40	82	1,3	1,5
19	31	53	42	78	1,4	1,5	17	44	26	56	1,5	1,3
20	43	49	79	75	1,8	1,5	4	62	4	82	1	1,3
21	57	37	81	49	1,4	1,3	18	53	20	104	1,1	2
22	42	24	68	33	1,6	1,4	26	42	34	64	1,3	1,5
23	65	41	98	47	1,5	1,1	35	43	42	52	1,2	1,2
24	44	37	78	66	1,8	1,8	31	28	45	36	1,5	1,3
25	36	50	78	82	2,2	1,6	23	13	30	15	1,3	1,2
26	14	59	28	86	2	1,5	10	16	15	18	1,5	1,1
27	17	37	22	53	1,3	1,4	10	22	16	29	1,6	1,3
28	6	11	9	20	1,5	1,8	0	11	0	33	0	3
29	2	9	2	16	1	1,8	0	7	0	8	0	1,1
30	0	12	0	20	0	1,7	0	0	0	0	0	0
31	0	0	0	0	0	0	0	2	0	3	0	1,5

IE: injury episodes; MV: medical visits; II: injury severity index; 1st: first Olympic period; 2nd: second Olympic period

Table IV. Injury episodes, medical visits and injury severity index according to the weight category when injury occurred, related to sex and two Olympic periods.

Year	Male											
	<58 kg			58-68 kg			68-80 kg			>80 kg		
	IE	MV	II (MV/IE)	IE	MV	II (MV/IE)	IE	MV	II (MV/IE)	IE	MV	II (MV/IE)
1997	48	87	1,8	29	44	1,5	44	64	1,5	20	27	1,4
1998	34	49	1,4	34	43	1,3	38	68	1,8	15	23	1,5
1999	30	55	1,8	13	15	1,2	21	36	1,7	16	26	1,6
2000	35	57	1,6	22	30	1,4	13	39	3	19	28	1,5
2001	33	51	1,5	43	63	1,5	13	25	1,9	24	27	1,1
2002	54	74	1,4	47	83	1,8	12	14	1,2	10	19	1,9
2003	47	71	1,5	55	86	1,6	7	9	1,3	17	24	1,4
2004	44	59	1,3	39	57	1,5	12	16	1,3	24	33	1,4

Year	<49 kg			49-57 kg			57-67 kg			>67 kg		
	IE	MV	II (MV/IE)	IE	MV	II (MV/IE)	IE	MV	II (MV/IE)	IE	MV	II (MV/IE)
1997	12	23	1,9	73	99	1,4	20	31	1,6	0	0	0
1998	13	20	1,5	46	67	1,5	37	47	1,3	3	5	1,7
1999	14	22	1,6	20	25	1,3	17	25	1,5	2	2	1
2000	11	11	1	17	21	1,2	18	24	1,3	8	8	1
2001	34	39	1,1	19	24	1,3	26	27	1	17	24	1,4
2002	49	77	1,6	22	28	1,3	34	58	1,7	8	12	1,5
2003	51	90	1,8	24	31	1,3	49	70	1,4	21	28	1,3
2004	45	68	1,5	16	20	1,3	30	38	1,3	10	25	2,5

IE: injury episodes; MV: medical visits; II: injury severity index

Table V. Injury episodes, medical visits and injury severity index according to the months when injury occurred, related to sex and two Olympic periods.

Months	Male						Female					
	IE		MV		II (MV/IE)		IE		MV		II (MV/IE)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
January	43	47	68	62	1,6	1,3	47	51	75	71	1,6	1,4
February	55	72	106	127	1,9	1,8	26	47	42	78	1,6	1,7
March	59	50	92	66	1,6	1,3	35	47	41	77	1,2	1,6
April	42	50	64	73	1,5	1,5	40	53	54	87	1,4	1,6
May	52	54	71	83	1,4	1,5	48	64	64	85	1,3	1,3
June	29	13	40	19	1,4	1,5	13	20	21	25	1,6	1,3
July	7	30	16	46	2,3	1,5	4	8	4	10	1	1,3
August	18	13	23	14	1,3	1,1	24	23	35	25	1,5	1,1
September	31	40	48	75	1,5	1,9	20	32	28	39	1,4	1,2
October	39	31	63	41	1,6	1,3	28	36	30	65	1,1	1,8
November	42	63	76	86	1,8	1,4	15	48	21	70	1,4	1,5
December	14	18	24	19	1,7	1,1	11	26	15	27	1,4	1

IE: injury episodes; MV: medical visits; II: injury severity index; 1st: first Olympic period; 2nd: second Olympic period

Table VI. Injury episodes, medical visits and injury severity index according to the injury timing when injury occurred, related to two Olympic periods.

Injury timing	IE		MV		II (MV/IE)	
	1st	2nd	1st	2nd	1st	2nd
Training	432	594	612	808	1,4	1,4
Pre-competition	188	203	280	303	1,5	1,5
Competition & Post-competition	122	139	229	259	1,9	1,9

IE: injury episodes; MV: medical visits; II: injury severity index; 1st: first olympic period; 2nd: second olympic period

Table VII. Injury episodes, medical visits and injury severity index according to the competition difficulty level when injury occurred, related to sex and two Olympic periods.

Year			NC		EUC		WC		WCU	
			Male	Female	Male	Female	Male	Female	Male	Female
1997	IE	Pre	15	17	0	0	9	11	15	8
		Post	6	6	0	0	4	3	7	4
	MV	Pre	27	25	0	0	11	17	19	12
		Post	11	8	0	0	25	3	9	5
	II (MV/IE)	Pre	1,8	1,5	0	0	1,2	1,5	1,3	1,5
		Post	1,8	1,3	0	0	6,3	1	1,3	1,3
1998	IE	Pre	11	6	7	6	5	8	4	7
		Post	7	6	8	1	9	5	4	3
	MV	Pre	13	7	7	6	10	14	4	8
		Post	9	10	29	1	10	11	4	5
	II (MV/IE)	Pre	1,2	1,2	1	1	2	1,8	1	1,1
		Post	1,3	1,7	3,6	1	1,1	2,2	1	1,7
1999	IE	Pre	13	7	0	0	5	3	0	0
		Post	6	1	0	0	6	1	0	0
	MV	Pre	17	12	0	0	9	4	0	0
		Post	12	1	0	0	12	3	0	0
	II (MV/IE)	Pre	1,3	1,7	0	0	1,8	1,3	0	0
		Post	2	1	0	0	2	3	0	0
2000	IE	Pre	5	3	1	0	8	1	4	9
		Post	7	1	8	5	9	1	1	3
	MV	Pre	23	4	1	0	16	1	4	9
		Post	19	4	14	6	10	1	1	6
	II (MV/IE)	Pre	4,6	1,3	1	0	2	1	1	1
		Post	2,7	4	1,8	1,2	1,1	1	1	2

2001	IE	Pre	11	4	0	0	3	2	8	12
		Post	9	9	0	0	4	4	0	3
	MV	Pre	11	8	0	0	7	2	9	13
		Post	23	10	0	0	4	5	0	3
	II (MV/IE)	Pre	1	2	0	0	2,3	1	1,1	1,1
		Post	2,6	1,1	0	0	1	1,3	0	1
2002	IE	Pre	16	4	1	10	8	11	4	2
		Post	10	5	11	7	13	5	1	1
	MV	Pre	20	4	1	28	26	15	5	2
		Post	26	23	18	11	16	6	1	2
	II (MV/IE)	Pre	1,3	1	1	2,8	3,3	1,4	1,3	1
		Post	2,6	4,6	1,6	1,6	1,2	1,2	1	2
2003	IE	Pre	13	14	0	0	11	5	0	0
		Post	10	10	0	0	4	10	0	0
	MV	Pre	24	17	0	0	13	5	0	0
		Post	16	14	0	0	18	25	0	0
	II (MV/IE)	Pre	1,8	1,2	0	0	1,2	1	0	0
		Post	1,6	1,4	0	0	4,5	2,5	0	0
2004	IE	Pre	20	16	10	14	1	3	0	0
		Post	6	2	7	7	1	0	0	0
	MV	Pre	29	21	13	24	1	5	0	0
		Post	10	2	14	11	1	0	0	0
	II (MV/IE)	Pre	1,5	1,3	1,3	1,7	1	1,7	0	0
		Post	1,7	1	2	1,6	1	0	0	0

IE: injury episodes; MV: medical visits; II: injury severity index; NC: national championships; EUC: European Championships; WC: World Championships; WCU: World Cups

Epidemiology of injuries in elite taekwondo athletes: two Olympic periods cross-sectional retrospective study

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ABSTRACT

Background: Taekwondo is a popular Korean martial art characterised by its emphasis on dynamic kicking techniques. Taekwondo has been included in the Olympic Games program since 2000 Sydney Olympic Games. Although it is becoming an increasingly popular sport, there is a lack of reliable epidemiologic data on Taekwondo injuries.

Aim: This analytical cross-sectional retrospective cohort study aims to describe reported Taekwondo injuries and to determine the prevalence, characteristics and possible injury risk factors sustained by the Spanish National Team athletes. Additionally, we compared each identified risk factor with it's relation to injury location and type.

Methods: This study was a summation of two Olympic periods, eight years, of data of injury reports, which included 1678 injury episodes. The data were collected on standardized injury reports at time of the first medical visit. The data analysis was performed at the High Performance Sports Center in Sant Cugat del Vallés (Barcelona, Spain).

Results: Lower limb injuries are more common than upper limb injuries. Contusions, joint and cartilage injuries are the prevailing types of injury. Chronological age and the weight categories can be considered as risk factors to sustain injuries in male and female elite taekwondist according to their location and type.

Conclusions: The present study provides epidemiological information that will help to inform future injury surveillance studies and the development of prevention strategies and recommendations to reduce the number of injuries in taekwondo competition.

STRENGTHS AND LIMITATIONS

- A large analytical cross-sectional study over a 8-year period and the new findings of different associations between risk factors to sustain an injury and its location and type in elite taekwondo ahtletes were among the main strengths.
- Retrospective nature and unavailability of some relevant data.

INTRODUCTION

Taekwondo is a systematic and scientific Korean age-old martial art that involves multiple physical fighting skills. This fully recognized Olympic sport is regulated by the World Taekwondo Federation and is considered one of the most worldwide popular sports, with a range of 75 to 120 million practitioners in more than 140 countries. Spain is in the top of current medals ranking in the last London 2012 Olympic Games and represent one of the most traditional countries in terms of international sporting success [1].

Taekwondo competitive performance depends on several factors, including physical [2-6], psychological [7, 8], technical [9, 10], and tactical [11-13]. Their practitioners compete according to sex and defined weight categories classification in a full-contact event of two opponents divided in three semi-continuous rounds of two minutes, with one minute's rest between rounds. Taekwondists are equipped with a padded trunk protector, protective padded headgear, protective gloves, and shin guards. Victory is achieved by higher scores given by judges for the specific fighting techniques allowed (kicks and punches), accurately and powerfully, in the legal scoring areas (the abdomen and both sides of the flank; the permitted parts of the face).

Understanding the injury pattern of a particular sport and it's inherent risk factors, is a key area of current sports medicine [14]. As within many other combat sports, there is a high potential for injury associated with elite athletic performance in taekwondo [15-21]. Defining injury as any circumstance for which the athlete sought the assistance of the on-site medical personnel, the latest reviews about competition injuries in taekwondo concluded that total injury rates for elite men ranged from 20.6 to 139.5 per 1000 athlete-exposure (A-E), and for elite women between 25.3 to 105.5 per

1000 A–E. When only time-loss injuries are contemplated, rates for men varied from 6.9 to 33.6 per 1000 A–E and for women from 2.4 to 23.0 per 1000 A–E [20].

The main injury mechanism in taekwondo is the direct contact, especially through the exchange of accurate turning kicks and poorly performed or nonexistent blocking skills [17, 20, 22, 23]. The vast majority of all injuries are localized to the lower extremities, especially in the instep of the foot, and these are contusions, sprains and muscle strains [17, 20, 24, 25]. The head and the neck regions are the next anatomical locations with an increased prevalence in taekwondo competition injuries [17, 20].

Despite the well-documented epidemiology injury profile in taekwondo competition, relatively few studies have evaluated the incidence of injury risk factors related to the training process and long-term preparation in elite level. The main objective of this eight years cross-sectional retrospective cohort study was to determine the prevalence, characteristics (anatomical location and injury type), and possible injury risk factors sustained by male and female Spanish National Team (SNT) taekwondists trained in the High Performance Sports Center (CAR) in Sant Cugat del Vallés (Barcelona, Spain) throughout two different Olympic periods (Sydney 1997 – 2000 and Athens 2001 – 2004).

METHODS

Type of study

This study is a large analytical cross-sectional retrospective cohort study over eight years, divided into two different four years Olympic periods (OP).

Study participants

From the 1st of January 1997 through the 31st of December 2004, a total of 48 taekwondo athletes from the SNT were studied. There were 22 male and 26 female athletes (45.8% and 54.2% of all athletes, respectively). The mean (+SD) age of the athletes in this study was 21.6±1.2 years (minimum=15 years, maximum=31 years). The inclusion criteria were 1) to have trained for the national taekwondo group for a minimum of one sports season, and 2) being a member of the SNT.

Data collection and injury report form

Two data sources were utilized. The first source was a comprehensive database obtained from the CAR, to provide personal and general information about each athlete. The second data source was from an electronic medical data capture system from the CAR sports medical department. This contained the following data fields in an unidentified format: athlete accreditation number, sex, age, date of first registration at CAR, weights category, medical visit date (day/month/year), and injury diagnosis. All injuries were diagnosed by sports medicine doctors, and subsequently recorded by anatomical location (OSICS-1) and injury type (OSICS-2) according to Orchard Sports Injury Classification System, V.10 (OSICS-10) [26]. The system of data entry and storage complied with existing European Union standards for medical data storage [27].

Procedures

The total number of injury episodes (n=1678; males: n=912; females: n=766) were obtained and analysed individually for every elite taekwondist classified by sex and OP. Definition of injury episodes (IE) corresponds to the series of medical visits sustained by an athlete, related to the same injury (same OSICS coding) and occurred no more than two months apart from each other. If the time between them is greater than two months, this is classified as a new episode. We determined this length of time according

to the definition of reinjury proposed by Hagglund [28]: "an injury of the same type and location of a previous injury that occurred within two months of the final rehabilitation day of the previous injury". Additionally, has been included a severity index of injuries, based on the number of medical visits (MV) generated by an IE (more MV, more injury severity). Results related to MV are shown as online supplement data.

Analysed variables used were: chronological age (expressed in years, and three age goups: from 15 to 20 years old, 21 to 25 years old, and 26 to 31 years old); weight category (very light, light, medium, and heavy); annual quarter when injury occurs; injury timing (pre-competition: fifteen days before the beginning of the competition; competition and/or post-competition: all the injuries sustained in competition and/or within the next fifteen days after the last day of competition; out of competition or during training sessions); competition difficulty level (World Championships –WC–, World Cups –WCU–, European Championships –EUC–, National Championships –WC–), which includes as pre-competition injuries all the injuries registered during the fifteen days before the first day of competition and as post-competition injuries all the injuries registered during the days of competition and/or within the next fifteen days after the last day of competition.

Definition of injury

This study adhered to the operational injury definitions recommended by Junge *et al*., [14], thus an injury was defined as new or recurring musculoskeletal complaints or concussions incurred during competition or training receiving medical attention, regardless of time loss from competition or training.

Confidentiality and ethical approval

Research ethics approval was obtained from the Ethics Sports Clinical Investigations Committee of Catalonia (ID-0099S/10308/2011). The investigators obtained the

informed consent from the subjects to access and collect past medical history data and voluntarily participated in the study. All data were stored on highly secured, password-protected files. The investigators signed a confidentiality agreement that states all data gathered during the duration of the study will be utilized solely for the purpose of the investigation.

Statistical analysis

Data are expressed as the number of IE and presented by the standard basic descriptive statistics of mean and standard deviation. The injury classification (OSICS-1: anatomical location; OSICS-2: injury type) and the independent variables (chronological age, weight category, annual quarter, injury timing, competition difficulty level) were analysed in relation to sex and OP. In order to compare the differences between both OP or between sexes, a Student's t-test or analogue non-parametric Mann-Whitney U test were performed, depending on whether the data were normally distributed or not, respectively. In order to analyze the probability of considering a risk factor, or a possible behavior-dependent generator between the injuries (by the criterion of OSICS classification) and each of the independent variables, we used the Pearson Chi-squared test. We regarded two-tailed p values ≤ 0.05 as significant. All statistical modeling was performed using SPSS® 19.0 (SPSS Inc. Chicago, USA).

RESULTS

OSICS-1 classification (anatomical sites)

Independently of sex or OP, the anatomical sites (OSICS-1) with more IE, are (Table 1): knee, foot, thigh, ankle, and lower leg.

Table 1. OSICS 1: injury location episodes according to two Olympic periods and sex of the athletes.

Injury location	Males				Females			
	1st		2nd		1st		2nd	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Ankle	58	13.5	35	7.3	68	21.9	44	9.7
Pelvis[1]	8	1.9	15	3.1	10	3.2	8	1.8
Chest[2]	16	3.7	4	0.8	1	0.3	7	1.5
Shoulder[3]	15	3.5	14	2.9	7	2.3	6	1.3
Foot	104	24.1	68	14.1	56	18.0	57	12.5
Hip[4]	19	4.4	25	5.2	9	2.9	10	2.2
Head and neck	10	2.3	3	0.6	13	4.2	13	2.9
Knee	83	19.3	101	21.0	56	18.0	118	25.9
Lumbar Spine[5]	23	5.3	36	7.5	17	5.5	35	7.7
Lower leg	19	4.4	62	12.9	27	8.7	40	8.8
Thigh	47	10.9	55	11.4	24	7.7	66	14.5
Wrist[6]	22	5.1	53	11.0	17	5.5	41	9.0
Unspecific	7	1.6	10	2.1	6	1.9	10	2.2

n: number of injury episodes; 1st (1997-2000); 2nd (2001-2004); [1]Pelvis and buttock; [2]Chest, trunk, abdomen and thoracic spine; [3]Shoulder, upper arm, elbow, forearm; [4]Hip and groin; [5]Lumbar spine; [6]Wrist and hand.

OSICS-2 classification (injury type)

Independently of sex or OP, the type of injury (OSICS-2) with more IE, are (Table 2): bruising/hematomas (contusions); joint dislocations and joint sprains; arthritis, cartilage injuries, synovitis, impingements, bursitis and chronic instability; muscle injuries; tendon injuries.

Table 2. OSICS-2: injury type episodes according to two Olympic periods and sex of the athletes.

Injury type	Males				Females			
	1st		2nd		1st		2nd	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Cartílage[1]	70	16.2	73	15.2	66	21.2	87	19.1
Luxations[2]	78	18.1	68	14.1	53	17.0	64	14.1
Fractures	26	6.0	33	6.9	6	1.9	6	1.3
Bruising/Hematoma	129	29.9	141	29.3	89	28.6	133	29.2
Laceration/Abrasion	8	1.9	2	0.4	6	1.9	2	0.4
Muscle	44	10.2	72	15.0	31	10.0	74	16.3
Nerve	1	0.2	5	1.0	1	0.3	2	0.4
Organic	1	0.2	1	0.2	0	0.0	1	0.2
Stress[3]	14	3.2	22	4.6	11	3.5	15	3.3
Tendon	41	9.5	40	8.3	31	10.0	34	7.5
Non specific[4]	1	0.2	2	0.4	1	0.3	2	0.4
Absence	18	4.2	22	4.6	16	5.1	35	7.7

n: number of injury episodes; 1st (1997-2000); 2nd (2001-2004); [1]Arthritis, cartilage injuries, synovitis, impingements, bursitis and chronic instability; [2]Joint dislocations and joint sprains; [3]Stress fractures, other stress and overuse injuries; [4]Whiplash and non-specific injuries.

Chronological age

IE significant differences were found between sexes during the first OP, in the chronological age groups of 21 to 25 years old (males: 48.8±11.9 vs females: 26.6±6.7; p=0.03). Independently of the different OP, chronological ages recorded a greater number of IE, are (Table 3): 23-24 years old for males (IE: 20.5%; n=187) and 17-18 years old for females (IE: 22.7% ; n=174). With the numbers available, seems to exist a sufficiently high injury prevalence in anatomical locations (OSICS-1) or injury types (OSICS-2) as for consider a behavior susceptible to be dependent. Therefore, the chronological age seems to condition a specific injury pattern related to determined anatomical locations or injury types (Table 5).

Table 3. Injury episodes according to chronological age groups, related to sex and two Olympic periods.

Chronological age	Males				Females			
	1st		2nd		1st		2nd	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
15	3	0,8	0	0,0	11	3,5	4	0,9
16	23	5,3	2	0,4	38	12,2	22	4,8
17	25	5,8	22	4,6	58	18,6	30	6,6
18	23	5,3	38	7,9	30	9,6	56	12,3
19	31	7,2	53	11,0	17	5,5	44	9,7
20	43	10,0	49	10,2	4	1,3	62	13,6
21	57	13,2	37	7,6	18	5,8	53	11,6
22	42	9,7	24	5,0	26	8,4	42	9,3
23	65	15,1	41	8,5	35	11,3	43	9,5
24	44	10,2	37	7,7	31	10,0	28	6,2
25	36	8,4	50	10,4	23	7,4	13	2,9
26	14	3,2	59	12,3	10	3,2	16	3,5
27	17	3,9	37	7,7	10	3,2	22	4,8
28	6	1,4	11	2,3	0	0,0	11	2,4
29	2	0,5	9	1,9	0	0,0	7	1,5
30	0	0,0	12	2,5	0	0,0	0	0,0
31	0	0,0	0	0,0	0	0,0	2	0,4

n: number of injury episodes; 1st (1997 - 2000); 2nd (2001-2004).

Weight category

Independently of the OP analysed, the male weight category group which has more IE, is the under 58 kg (IE: 35.6%; n=325). Then, from 58 to 68 kg (IE: 30.9%; n=282), from 68 to 80 kg (IE: 17.6%; n=160), and more than 80 kg (IE: 15.9%; n=145). In females, is the light weight category from 49 to 57 kg the one with more IE (IE: 30.9%; n=237). The next distribution per weight groups is: from 57 to 67 kg (IE: 30.2%; n=231), under 49 kg (IE: 29.9%; n=229), and more than 67 kg (IE: 9.0%; n=69). Significant differences (p=0.03), were found between sexes in all weight categories (in the very light and heavy weight categories during the first OP, and in the light and medium weight category during the second OP) and between OP in the same sex: females in very light and heavy weight categories and males in light and medium weight categories. Once again, with the available data, seems to exist a sufficiently high injury

prevalence in anatomical locations (OSICS-1) or injury types (OSICS-2) to consider a behavior susceptible to be dependent. Therefore, the weight category should be considered as a risk factor or a possible behavior-dependent generator (Table 5).

Annual quarter

From the total of 912 IE generated by the males (Table 4), 35.7% (n=326) were sustained for the athletes in the first annual quarter, 26.3% (n=240) in the second annual quarter, 15.3% (n=139) in the third annual quarter, and 22.7% (n=207) in the fourth annual quarter. From the total of 766 IE generated by the females (Table 4), 33.0% (n=253) were sustained for the athletes in the first annual quarter, 31.1% (n=238) in the second annual quarter, 14.5% (n=111) in the third annual quarter, and 21.4% (n=164) in the fourth annual quarter.

Table 4. Injury episodes according to the months when injury occurred, related to sex and two Olympic periods.

Months	Males				Females			
	1st		2nd		1st		2nd	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
January	43	10,0	47	9,8	47	15,1	51	11,2
February	55	12,8	72	15,0	26	8,4	47	10,3
March	59	13,7	50	10,4	35	11,3	47	10,3
April	42	9,7	50	10,4	40	12,9	53	11,6
May	52	12,1	54	11,2	48	15,4	64	14,1
June	29	6,7	13	2,7	13	4,2	20	4,4
July	7	1,6	30	6,2	4	1,3	8	1,8
August	18	4,2	13	2,7	24	7,7	23	5,2
September	31	7,2	40	8,3	20	6,4	32	7,0
October	39	9,0	31	6,4	28	9,0	36	7,9
November	42	9,7	63	13,1	15	4,8	48	10,5
December	14	3,3	18	3,8	11	3,5	26	5,7

n: number of injury episodes; 1st (1997-2000); 2nd (2001-2004).

No differences were found between sexes or OP. Excluding the results obtained by male takwondists during the first OP, the annual quarter seems to condition a significant

prevalence of injury anatomical site (OSICS-1) and injury type (OSICS-2), and could be considered as a injury risk factor (Table 5).

Injury timing

From the total of 1678 IE, 61.1% were sustained or during training sessions or out of competition (n=1026), 23.3% in pre-competition period (n=391) and 15.6% in competition or post-competition period (n=261). No differences exist between OP according to the number of IE. In males, there is no significant relationship between injury timing and injury anatomical sites (OSICS-1) or injury types (OSICS-2). Therefore, with the numbers available, only in females this variable should be considered as a injury risk factor (Table 5).

Competition difficulty level

From the total of 367 IE derived from competition in males, 45.2% (n=166) were sustained during NC, 14.4% (n=53) during EUC, 27.2% (n=100) during WC, and 13.1% (n=48) during WCU. From the total of 286 IE derived from competition in females, 38.8% (n=111) were sustained during NC, 17.5% (n=50) during EUC, 25.5% (n=73) during WC, and 18.2% (n=52) during WCU. No differences exist between OP according to the number of IE in relation to the competition difficulty level. There is no significant relationship between competition difficulty level and injury anatomical sites (OSICS-1) or injury types (OSICS-2) . These results are independent of whether the injury has occurred pre or post-competition (Table 5). So, with current data, the competition difficulty level should not be considered as a risk factor or a possible behavior-dependent generator of injuries in elite Taekwondo athletes.

Table 5. Statistical dependency levels of independent variables according to sex and two different Olympic periods.

	Sex		OSICS	Olympic period	IE (n)	*df*	X^2	*p*
Chronological age	Males		1	1st	431	24	43.04	0.005
			2			22	40.99	0.005
			1	2nd	481	24	48.71	0.001
			2			22	49.81	0.001
	Females		1	1st	311	24	128.63	0.001
			2			22	44.26	0.003
			1	2nd	455	24	114.98	0.001
			2			22	78.56	0.001
Weight category	Males		1	1st	431	36	131.56	0.001
			2			33	53.38	0.005
			1	2nd	481	36	348.18	0.001
			2			33	188.11	0.001
	Females		1	1st	311	36	140.39	0.001
			2			33	86.83	0.001
			1	2nd	455	36	170.15	0.001
			2			33	128.78	0.001
Annual quarter	Males		1	1st	431	36	34.57	0.500
			2			33	27.50	0.700
			1	2nd	481	36	245.14	0.001
			2			33	110.42	0.001
	Females		1	1st	311	36	114.17	0.001
			2			33	72.07	0.001
			1	2nd	455	36	83.60	0.001
			2			33	72.89	0.001
Injury timing	Males		1	1st	431	24	29.59	0.150
			2			22	19.09	0.600
			1	2nd	481	24	19.13	0.700
			2			22	25.75	0.250
	Females		1	1st	311	24	82.50	0.001
			2			22	33.43	0.050
			1	2nd	455	24	131.80	0.001
			2			22	69.65	0.010
Competition difficulty level	Males	Pre	1	1st	102	36	41.56	0.200
			2			33	22.01	0.900
			1	2nd	106	36	44.7	0.100
			2			33	27.41	0.700
		Post	1	1st	82	36	27.82	0.850
			2			33	24.29	0.850
			1	2nd	76	36	28.80	0.750
			2			33	33.76	0.400
	Females	Pre	1	1st	86	36	40.83	0.250
			2			33	40.27	0.150
			1	2nd	97	36	42.67	0.200
			2			33	12.53	0.990
		Post	1	1st	40	36	15.46	0.990
			2			33	17.98	0.975
			1	2nd	63	36	22.37	0.950
			2			33	19.62	0.950

OSICS: (1) injury location, (2) injury type; IE: injury episodes; n: number of injury episodes; *df*: degrees of freedom; X^2: chi-square statistic; *p*: significance level; Pre: 1st (1997 - 2000); 2nd (2001-2004).

DISCUSSION

The present study examine the effect of chronological age, weight category, annual quarter, injury timing, and competition difficulty level on injury location and type in elite Taekwondo athletes. The anatomical sites with more injury incidence correspond to the lower limbs (knee, foot, thigh, ankle, and lower leg) for both males and females. These anatomical locations are related to different injury types, prevailing contusions, joint and cartilage injuries and, in smaller proportion, tendon and muscle injuries. Chronological age and weight category are the unique variables that, independently to sex and Olympic period, show a statistically significant relation as possible injury risk factors in elite taekwondo. In the opposite direction, the competition difficulty level does not seem to have any relationship with the injury prevalence in this combat sport. Annual quarter and injury timing show different possible dependent behaviors according to each sex or different Olympic periods.

The present study has some limitations to be considered. First, and perhaps the most important, not correspond to a prospective and/or longitudinal study design (it was not possible, for example, to determine when the injury exactly occurred, or to calculate injury rates with adequate accuracy, or to possess previous injury information, or a training load indicator). Second, despite the high number of IE, there is a low number of taekwondists included that can possibly result in relevant bias.

Injury location (OSICS-1) and injury type (OSICS-2)

Spanish males taekwondists present higher IE than women, however there is no statistically proven difference found. Recent studies reported similar findings [29-35]. Past research cites the most common injury locations as the lower limb [17, 24, 31, 32, 34, 38, 39]. This is not surprising due to the use of the lower limb as the primary striking weapon. There are no significance differences between sexes in knee injuries,

that's a surprising finding because according to many research papers being a female is a risk factor to suffer from more knee injuries [40-42]. It could be possible that this risk factor is minimized because both sexes train and do the same prevention programs, an uncommon aspect in other sports. Foot is the second location with more number of episodes, not rear if we know that the majority of kick techniques use the foot. Some authors affirm that 98 out of 100 hundred kicking techniques are executed with the foot [43, 44]. Chest, thoracic column and abdomen are the locations with less number of episodes, it could be related to the use of protections in these zones during training sessions and competitions. The prevalence of contusions, joint and cartilage injuries, is in accordance with the related literature [26, 30]. It's logical because the practitioners are constantly kicking each other.

Risk factors (depenent variables)

According to sex, the highest injury prevalence occurs at different chronological ages. From 23 to 24 years old in males, from 17 to 18 years old in females. There are many related studies that found a significance correlation between chronological age and injury incidence [16, 22, 24, 35-37]. The data of this study confirm the same results, indicating the chronological age as a potential risk factor for injury incidence in elite taekwondo athletes.

Sex differences according to the weight category is a clear indicator that men suffer more injuries in all weight categories with the exception of intermediate category. This exception is explained by the fact that there are fewer cases of male taekwondo athletes represented. Moreover, independently of sex or Olymnpic period, the weight category emerges as a possible injury risk factor.

Finally, the injury risk factors related to the variables of annual quarters, and especially, injury timing, varies according to sex. Indeed, only in the case of female

taekwondists, the injury timing emerges as an important risk factor to consider in training and competition strategies. These results are relevants because the SNT trains in CAR (men and women) under the same workload and intensity, they share equipment, training systems and prevention methods. This should to minimize the differences between sexes, but this not always happen, as occurs in the case of injury timing.

CONCLUSIONS

The anatomical sites with more injury incidence correspond to the knee, foot, thigh, ankle, and lower leg. In SNT prevailing contusions, joint and cartilage injuries. Chronological age and weight category always show a statistically significant relation as possible injury risk factors. Annual quarter and injury timing show different possible dependent behaviors according to sex or different OP. The present study has some limitations to be considered: not correspond to a prospective and/or longitudinal study design; despite the high number of IE, there is a low number of taekwondists included. This study provide epidemiological information that will help to inform future injury surveillance studies. Further research is needed to achieve a better understanding of elite taekwondo, in relation to sex and competitive categories.

What are the new findings?
- OSICS classification appears to be sensitive to classifying the injury location and type, and to discriminate potential injury risk factors. - Lower limb injuries including knee, foot, thigh, ankle and lower leg, are more common than upper limb injuries. - Contusions, joint and cartilage injuries and, in smaller proportion, tendon and muscle injuries, are the prevailing anatomical types of injury. - Chronological age and the weight categories can be considered as risk factors to sustain injuries in elite taekwondo according to their location and type. - There are some injury risk factors associated with female elite taekwondists and not with their male counterparts (injury timing).

How might it impact on clinical practice in the near future?
- Clinicians taking care of athletes are now aware of different patterns of injuries in Taekwondo practitioners. - It can start the development of prevention strategies and recommendations to reduce the number of injuries in taekwondo. - Training all the subjects together regardless the sex can be a factor to be implemented in other sports to assess whether the differences between them are reduced, or not.

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FOOTNOTES

Contributorship statement: All the authors contributed in a substantial manner to the planning and conduction of the testing, literature review and/or manuscript preparation. Conceived and designed: AAB, FD, AI. Analysed the data: AAB, JBM, AI. Contributed reagents/materials/analysis tools: AAB, LT, JBM, AI. Wrote the paper: AAB, FD, NM, AI. They all gave final approval of the version submitted.

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Competing interests: None.

Ethics approval: The study protocol was approved by the Ethics Sports Clinical Investigations Committee.

Data sharing statement: Extra data is available by emailing AAB.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3, 4
Objectives	3	State specific objectives, including any prespecified hypotheses	3, 4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5, 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5, 6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5, 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5, 6
Bias	9	Describe any efforts to address potential sources of bias	*5, 6*
Study size	10	Explain how the study size was arrived at	5, 6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5, 6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	7
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
Outcome data	15*	Report numbers of outcome events or summary measures	8
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-15
		(*b*) Report category boundaries when continuous variables were categorized	9-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9-15
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-15
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Epidemiology of injuries in elite taekwondo athletes: two Olympic periods cross-sectional retrospective study

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Epidemiology of injuries in elite taekwondo athletes: two Olympic periods cross-sectional retrospective study

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Olympics, Martial Arts, Taekwondo, Sporting injuries, Epidemiology, Injury Prevention

Word count – 2940 words

ABSTRACT

Background: Taekwondo is a popular Korean martial art characterised by its emphasis on dynamic kicking techniques. Taekwondo has been included in the Olympic Games program since 2000 Sydney Olympic Games. Although it is becoming an increasingly popular sport, there is a lack of reliable epidemiologic data on Taekwondo injuries.

Aim: This analytical cross-sectional retrospective cohort study aims to describe reported Taekwondo injuries and to determine the prevalence, characteristics and possible injury risk factors sustained by the Spanish National Team athletes. Additionally, we compared each identified risk factor, such as: age, weight category, annual quarter, injury timing and competition difficulty level, with its relation to injury location and type.

Methods: This study was a summation of two Olympic periods, eight years, of data of injury reports, which included 1678 injury episodes. The data were collected on standardized injury reports at time of the first medical visit. The data analysis was performed at the High Performance Sports Center in Sant Cugat del Vallés (Barcelona, Spain).

Results: Independently of sex or Olympic period, the anatomical sites with more injury episodes, are: knee (21.3%), foot (17.0%), ankle (12.2%), thigh (11.4%), and lower leg (8.8%). Contusions (29.3%), cartilage (17.6%), and joint (15.7%) injuries, are the prevailing types of injury. Chronological age, weight categories and the annual quarter can be considered as risk factors to sustain injuries in male and female elite taekwondist according to their location and type ($p \leq 0.001$).

Conclusions: The present study provides epidemiological information that will help to inform future injury surveillance studies and the development of prevention strategies and recommendations to reduce the number of injuries in taekwondo competition.

STRENGTHS AND LIMITATIONS

- A large analytical cross-sectional study over a 8-year period and the new findings of different associations between risk factors to sustain an injury and its location and type in elite taekwondo ahtletes were among the main strengths.
- Retrospective nature and unavailability of some relevant data.

INTRODUCTION

Taekwondo is a systematic and scientific Korean age-old martial art that involves multiple physical fighting skills. This fully recognized Olympic sport is regulated by the World Taekwondo Federation and is considered one of the most worldwide popular sports, with a range of 75 to 120 million practitioners in more than 140 countries. Spain is in the top of current medals ranking in the last London 2012 Olympic Games and represent one of the most traditional countries in terms of international sporting success. [1]

Taekwondo competitive performance depends on several factors, including physical, [2-6] psychological, [7, 8] technical, [9, 10] and tactical. [11-13] Their practitioners compete according to sex and defined weight categories classification in a full-contact event of two opponents divided in three semi-continuous rounds of two minutes, with one minute's rest between rounds. Taekwondists are equipped with a padded trunk protector, protective padded headgear, protective gloves, and shin guards. Victory is achieved by higher scores given by judges for the specific fighting techniques allowed (kicks and punches), accurately and powerfully, in the legal scoring areas (the abdomen and both sides of the flank; the permitted parts of the face).

Understanding the injury pattern of a particular sport and it's inherent risk factors, is a key area of current sports medicine. [14] As within many other combat sports, there is a high potential for injury associated with elite athletic performance in taekwondo. [15-21] Defining injury as any circumstance for which the athlete sought the assistance of the on-site medical personnel, the latest reviews about competition injuries in taekwondo concluded that total injury rates for elite men ranged from 20.6 to 139.5 per 1000 athlete-exposure (A-E), and for elite women between 25.3 to 105.5 per

1000 A–E. When only time-loss injuries are contemplated, rates for men varied from 6.9 to 33.6 per 1000 A–E and for women from 2.4 to 23.0 per 1000 A–E. [20]

The main injury mechanism in taekwondo is the direct contact, especially through the exchange of accurate turning kicks and poorly performed or non existent blocking skills. [17, 20, 22, 23] The vast majority of all injuries are localized to the lower extremities, especially in the instep of the foot, and these are contusions, sprains and muscle strains. [17, 20, 24, 25] The head and the neck regions are the next anatomical locations with an increased prevalence in taekwondo competition injuries. [17, 20]

Despite the well-documented epidemiology injury profile in taekwondo competition, relatively few studies have evaluated the incidence of injury risk factors related to the training process and long-term preparation in elite level. The main objective of this eight years cross-sectional retrospective cohort study was to determine the prevalence, characteristics (anatomical location and injury type), and possible injury risk factors sustained by male and female Spanish National Team (SNT) taekwondists trained in the High Performance Sports Center (CAR) in Sant Cugat del Vallés (Barcelona, Spain) throughout two different Olympic periods (Sydney 1997 – 2000 and Athens 2001 – 2004).

METHODS

Type of study

This study is a large analytical cross-sectional retrospective cohort study over eight years, divided into two different four years Olympic periods (OP).

Study participants

From the 1st of January 1997 through the 31st of December 2004, a total of 48 taekwondo athletes from the SNT were studied. There were 22 male and 26 female athletes (45.8% and 54.2% of all athletes, respectively). The mean (+SD) age of the athletes in this study was 21.6±1.2 years (minimum=15 years, maximum=31 years). The inclusion criteria was: 1) to have trained for the national taekwondo group for a minimum of one sports season, and 2) being a member of the SNT.

Data collection and injury report form

Two data sources were utilized. The first source was a comprehensive database obtained from the CAR, to provide personal and general information about each athlete. The second data source was from an electronic medical data capture system from the CAR sports medical department. This contained the following data fields in an unidentified format: athlete accreditation number, sex, age, date of first registration at CAR, weights category, medical visit date (day/month/year), and injury diagnosis. All injuries were diagnosed by sports medicine doctors, and subsequently recorded by anatomical location (OSICS-1) and injury type (OSICS-2) according to Orchard Sports Injury Classification System, V.10 (OSICS-10). [26] The system of data entry and storage complied with existing European Union standards for medical data storage. [27]

Procedures

The total number of injury episodes (n=1678; males: n=912; females: n=766) were obtained and analysed individually for every elite taekwondist classified by sex and OP. Definition of injury episodes (IE) corresponds to the series of medical visits sustained by an athlete, related to the same injury (same OSICS coding) and occurred no more than two months apart from each other. If the time between them is greater than two months, this is classified as a new episode. We determined this length of time according

to the definition of reinjury proposed by Hagglund: [28] "an injury of the same type and location of a previous injury that occurred within two months of the final rehabilitation day of the previous injury". Additionally, has been included a severity index of injuries, based on the number of medical visits (MV) generated by an IE (more MV, more injury severity). Results related to MV are shown as online supplement data.

Analysed variables used were: chronological age (expressed in years, and three age goups: from 15 to 20 years old, 21 to 25 years old, and 26 to 31 years old); weight category (very light, light, medium, and heavy); annual quarter when injury occurs; injury timing (pre-competition: fifteen days before the beginning of the competition; competition and/or post-competition: all the injuries sustained in competition and/or within the next fifteen days after the last day of competition; out of competition or during training sessions); competition difficulty level (World Championships –WC–, World Cups –WCU–, European Championships –EUC–, National Championships –WC–), which includes as pre-competition injuries all the injuries registered during the fifteen days before the first day of competition and as post-competition injuries all the injuries registered during the days of competition and/or within the next fifteen days after the last day of competition.

Definition of injury

This study adhered to the operational injury definitions recommended by Junge *et al*., [14] thus an injury was defined as new or recurring musculoskeletal complaints or concussions incurred during competition or training receiving medical attention, regardless of time loss from competition or training.

Confidentiality and ethical approval

Research ethics approval was obtained from the Ethics Sports Clinical Investigations Committee of Catalonia (ID-0099S/10308/2011). The investigators obtained the

informed consent from the subjects to access and collect past medical history data and voluntarily participated in the study. All data were stored on highly secured, password-protected files. The investigators signed a confidentiality agreement that states all data gathered during the duration of the study will be utilized solely for the purpose of the investigation.

Statistical analysis

Data are expressed as the number of IE and presented by the standard basic descriptive statistics of mean and standard deviation. The injury classification (OSICS-1: anatomical location; OSICS-2: injury type) and the independent variables (chronological age, weight category, annual quarter, injury timing, competition difficulty level) were analysed in relation to sex and OP. In order to compare the differences between both OP or between sexes, a Student's t-test or analogue non-parametric Mann-Whitney U test were performed, depending on whether the data were normally distributed or not, respectively. In order to analyze the probability of considering a risk factor, or a possible behavior-dependent generator between the injuries (by the criterion of OSICS classification) and each of the independent variables, we used the Pearson Chi-squared test, and adjusted odds ratio (OR). We regarded two-tailed p Bonferroni adjusted values ≤ 0.001 as significant. All statistical modeling was performed using SPSS® 19.0 (SPSS Inc. Chicago, USA).

RESULTS

OSICS-1 classification (anatomical sites)

Independently of sex or OP, the anatomical sites with more IE, are (Figure 1): knee, foot, ankle, thigh, and lower leg.

OSICS-2 classification (injury type)

Independently of sex or OP, the type of injury with more IE, are (Figure 2): bruising/hematomas (contusions); joint dislocations and joint sprains; arthritis, cartilage injuries, synovitis, impingements, bursitis and chronic instability; muscle injuries; tendon injuries.

Chronological age

IE significant differences were found between sexes during the first OP, in the chronological age groups of 21 to 25 years old (males: 48.8±11.9 vs females: 26.6±6.7; p=0.03). Independently of the different OP, chronological ages recorded a greater number of IE, are (Table 1): 23-24 years old for males (IE: 20.5%; n=187) and 17-18 years old for females (IE: 22.7% ; n=174). With the numbers available (Table 3), exclusively during the second OP, seems to exist a sufficiently high injury prevalence in anatomical locations (OSICS-1) or injury types (OSICS-2), as for consider a behavior susceptible to be dependent (males: OR=2.62 / females: OR=3.07).

Table 1. Injury episodes according to chronological age groups, related to sex and two Olympic periods.

Chronological age	Males				Females			
	1st		2nd		1st		2nd	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
15	3	0,8	0	0,0	11	3,5	4	0,9
16	23	5,3	2	0,4	38	12,2	22	4,8
17	25	5,8	22	4,6	58	18,6	30	6,6
18	23	5,3	38	7,9	30	9,6	56	12,3
19	31	7,2	53	11,0	17	5,5	44	9,7
20	43	10,0	49	10,2	4	1,3	62	13,6
21	57	13,2	37	7,6	18	5,8	53	11,6
22	42	9,7	24	5,0	26	8,4	42	9,3
23	65	15,1	41	8,5	35	11,3	43	9,5
24	44	10,2	37	7,7	31	10,0	28	6,2
25	36	8,4	50	10,4	23	7,4	13	2,9
26	14	3,2	59	12,3	10	3,2	16	3,5
27	17	3,9	37	7,7	10	3,2	22	4,8
28	6	1,4	11	2,3	0	0,0	11	2,4

29	2	0,5	9	1,9	0	0,0	7	1,5
30	0	0,0	12	2,5	0	0,0	0	0,0
31	0	0,0	0	0,0	0	0,0	2	0,4

n: number of injury episodes; 1st (1997 - 2000); 2nd (2001-2004).

Weight category

Independently of the OP analysed, the male weight category group which has more IE, is the under 58 kg (IE: 35.6%; n=325). Then, from 58 to 68 kg (IE: 30.9%; n=282), from 68 to 80 kg (IE: 17.6%; n=160), and more than 80 kg (IE: 15.9%; n=145). In females, is the light weight category from 49 to 57 kg the one with more IE (IE: 30.9%; n=237). The next distribution per weight groups is: from 57 to 67 kg (IE: 30.2%; n=231), under 49 kg (IE: 29.9%; n=229), and more than 67 kg (IE: 9.0%; n=69). Significant differences (p=0.01), were found between sexes in all weight categories (in the very light and heavy weight categories during the first OP, and in the light and medium weight category during the second OP) and between OP in the same sex: females in very light and heavy weight categories and males in light and medium weight categories. Except in the first OP, OSICS-2 in males (Table 3), seems to exist a sufficiently high injury prevalence in anatomical locations (OSICS-1) or injury types (OSICS-2) to consider the weight category as a injury risk factor (males: OR=2.02 / females: OR=1.50).

Annual quarter

From the total of 912 IE generated by the males (Table 2), 35.7% (n=326) were sustained for the athletes in the first annual quarter, 26.3% (n=240) in the second annual quarter, 15.3% (n=139) in the third annual quarter, and 22.7% (n=207) in the fourth annual quarter. From the total of 766 IE generated by the females (Table 2), 33.0% (n=253) were sustained for the athletes in the first annual quarter, 31.1% (n=238) in the

second annual quarter, 14.5% (n=111) in the third annual quarter, and 21.4% (n=164) in the fourth annual quarter.

Table 2. Injury episodes according to the months when injury occurred, related to sex and two Olympic periods.

Months	Males				Females			
	1st		2nd		1st		2nd	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
January	43	10,0	47	9,8	47	15,1	51	11,2
February	55	12,8	72	15,0	26	8,4	47	10,3
March	59	13,7	50	10,4	35	11,3	47	10,3
April	42	9,7	50	10,4	40	12,9	53	11,6
May	52	12,1	54	11,2	48	15,4	64	14,1
June	29	6,7	13	2,7	13	4,2	20	4,4
July	7	1,6	30	6,2	4	1,3	8	1,8
August	18	4,2	13	2,7	24	7,7	23	5,2
September	31	7,2	40	8,3	20	6,4	32	7,0
October	39	9,0	31	6,4	28	9,0	36	7,9
November	42	9,7	63	13,1	15	4,8	48	10,5
December	14	3,3	18	3,8	11	3,5	26	5,7

n: number of injury episodes; 1st (1997-2000); 2nd (2001-2004).

No differences were found between sexes or OP. Excluding the results obtained by male takwondists during the first OP (Table 3), the annual quarter seems to condition a significant prevalence of injury anatomical site (OSICS-1) and injury type (OSICS-2), and could be considered as a injury risk factor (males: OR=2.04 / females: OR=1.71).

Injury timing

From the total of 1678 IE, 61.1% were sustained or during training sessions or out of competition (n=1026), 23.3% in pre-competition period (n=391) and 15.6% in competition or post-competition period (n=261). No differences exist between OP according to the number of IE. There is no significant relationship between injury timing and injury anatomical sites (OSICS-1) or injury types (OSICS-2). Therefore,

with the numbers available, injury timing should not be considered as a risk factor or a possible behavior-dependent generator of injuries in elite Taekwondo athletes (Table 3).

Competition difficulty level

From the total of 367 IE derived from competition in males, 45.2% (n=166) were sustained during NC, 14.4% (n=53) during EUC, 27.2% (n=100) during WC, and 13.1% (n=48) during WCU. From the total of 286 IE derived from competition in females, 38.8% (n=111) were sustained during NC, 17.5% (n=50) during EUC, 25.5% (n=73) during WC, and 18.2% (n=52) during WCU. No differences exist between OP according to the number of IE in relation to the competition difficulty level. There is no significant relationship between competition difficulty level and injury anatomical sites (OSICS-1) or injury types (OSICS-2) . These results are independent of whether the injury has occurred pre or post-competition (Table 3). So, with current data, the competition difficulty level should not be considered as a risk factor or a possible behavior-dependent generator of injuries in elite Taekwondo athletes.

Table 3. Statistical dependency levels of independent variables according to sex and two different Olympic periods.

	Sex	OSICS	Olympic period	IE (n)	*df*	X^2	$p_{adjusted}$
Chronological age	Males	1	1st	431	24	43.04	0.005
		2			22	40.99	0.005
		1	2nd	481	24	48.71	0.001 *
		2			22	49.81	0.001 *
	Females	1	1st	311	24	128.63	0.002
		2			22	44.26	0.003
		1	2nd	455	24	114.98	0.001 *
		2			22	78.56	0.001 *
Weight category	Males	1	1st	431	36	131.56	0.001 *
		2			33	53.38	0.005
		1	2nd	481	36	348.18	0.001 *
		2			33	188.11	0.001 *
	Females	1	1st	311	36	140.39	0.001 *
		2			33	86.83	0.001 *
		1	2nd	455	36	170.15	0.001 *
		2			33	128.78	0.001 *
Annual	Males	1	1st	431	36	34.57	0.500

quarter			2			33	27.50	0.700
			1	2nd	481	36	245.14	0.001 *
			2			33	110.42	0.001 *
	Females		1	1st	311	36	114.17	0.001 *
			2			33	72.07	0.001 *
			1	2nd	455	36	83.60	0.001 *
			2			33	72.89	0.001 *
Injury timing	Males		1	1st	431	24	29.59	0.150
			2			22	19.09	0.600
			1	2nd	481	24	19.13	0.700
			2			22	25.75	0.250
	Females		1	1st	311	24	82.50	0.002
			2			22	33.43	0.050
			1	2nd	455	24	131.80	0.002
			2			22	69.65	0.010
Competition difficulty level	Males	Pre	1	1st	102	36	41.56	0.200
			2			33	22.01	0.900
			1	2nd	106	36	44.7	0.100
			2			33	27.41	0.700
		Post	1	1st	82	36	27.82	0.850
			2			33	24.29	0.850
			1	2nd	76	36	28.80	0.750
			2			33	33.76	0.400
	Females	Pre	1	1st	86	36	40.83	0.250
			2			33	40.27	0.150
			1	2nd	97	36	42.67	0.200
			2			33	12.53	0.990
		Post	1	1st	40	36	15.46	0.990
			2			33	17.98	0.975
			1	2nd	63	36	22.37	0.950
			2			33	19.62	0.950

OSICS: (1) injury location, (2) injury type; IE: injury episodes; n: number of injury episodes; *df*: degrees of freedom; X^2: chi-square statistic; * $p_{adjusted}$: significance level ≤0.001; Pre: 1st (1997 - 2000); 2nd (2001-2004).

DISCUSSION

The present study examine the effect of chronological age, weight category, annual quarter, injury timing, and competition difficulty level on injury location and type in elite Taekwondo athletes. The anatomical sites with more injury incidence correspond to the lower limbs (knee, foot, ankle, thigh and lower leg) for both males and females. These anatomical locations are related to different injury types, prevailing contusions, joint and cartilage injuries and, in smaller proportion, tendon and muscle injuries. Chronological age, weight category and annual quarter, are the variables that show a statistically significant relation as possible injury risk factors in elite taekwondo. In the opposite direction, the injury timing and competition difficulty level does not seem to have any relationship with the injury prevalence in this combat sport.

The present study has some limitations to be considered. First, and perhaps the most important, not correspond to a prospective and/or longitudinal study design (it was not possible, for example, to determine when the injury exactly occurred, or to calculate injury rates with adequate accuracy, or to possess previous injury information, or a training load indicator). Second, despite the high number of IE, there is a low number of elite taekwondists included that can possibly result in relevant bias.

Injury location (OSICS-1) and injury type (OSICS-2)

Spanish males taekwondists present higher IE than women, however there is no statistically proven difference found. Recent studies reported similar findings. [29-35] Past research cites the most common injury locations as the lower limb. [17, 24, 31, 32, 34, 36-39] This is not surprising due to the use of the lower limb as the primary striking weapon. There are no significance differences between sexes in knee injuries, that's a surprising finding because according to many research papers being a female is a risk factor to suffer from more knee injuries. [40-42] It could be possible that this risk factor

is minimized because both sexes train and do the same prevention programs, an uncommon aspect in other sports. Foot is the second location with more number of episodes, not rear if we know that the majority of kick techniques use the foot. Some authors affirm that 98 out of 100 hundred kicking techniques are executed with the foot. [43, 44] Chest, thoracic column and abdomen are the locations with less number of episodes, it could be related to the use of protections in these zones during training sessions and competitions. The prevalence of contusions, joint and cartilage injuries, is in accordance with the related literature. [26, 30] It's logical because the practitioners are constantly kicking each other.

Risk factors (depenent variables)

According to sex, the highest injury prevalence occurs at different chronological ages. From 23 to 24 years old in males, from 17 to 18 years old in females. There are many related studies that found a significance correlation between chronological age and injury incidence. [16, 22, 24, 35-37] (I=The data of this study confirm the same results, indicating the chronological age as a potential risk factor for injury incidence in elite taekwondo athletes.

Sex differences according to the weight category is a clear indicator that men suffer more injuries in all weight categories with the exception of intermediate category. This exception is explained by the fact that there are fewer cases of male taekwondo athletes represented. Moreover, the weight category emerges as a possible injury risk factor.

All sports planning training system varies depending on the competitive calendar and, consequently, on the season annual periods. In the present study, this fact seems to condition the injury pattern of taekwondo athletes, and it can be considered as a risk factor by coaches and sports medicine specialists.

Finally, in all the variables that could be considered as risk factors were recorded some differences according to sex and/or different OP. The first OP, regarding to chronological age (males and famales, and OSICS-1 and OSICS-2) , the weight category (males OSICS-2), and specially in the annual period (males OSICS-1 and OSICS-2), seems to record a different behavior as a risk factor injuries causes. Although the retrospective nature of this study the training load was not recorded, it is known that the Spanish responsible coaches were different during the two analyzed OP. Different training systems, applied in a certain way for both genders, could be on of the reasons for these results. Therefore, each sporting context should be specifically analyzed to assess the full dimension of the elite injury epidemiology in taekwondo.

CONCLUSIONS

The anatomical sites with more injury incidence correspond to the knee, foot, ankle, thigh, and lower leg. In SNT prevailing contusions, joint and cartilage injuries. Chronological age, weight category, and annual quarter, show a statistically significant relation as possible injury risk factors according to sex or different OP. The present study has some limitations to be considered: not correspond to a prospective and/or longitudinal study design; despite the high number of IE, there is a low number of elite taekwondists included. This study provide epidemiological information that will help to inform future injury surveillance studies. Further research is needed to achieve a better understanding of elite taekwondo, in relation to sex and different training systems.

What are the new findings?
- OSICS classification appears to be sensitive to classifying the injury location and type, and to discriminate potential injury risk factors. - Lower limb injuries including knee, foot, ankle, thigh, and lower leg, are more common than upper limb injuries. - Contusions, joint and cartilage injuries and, in smaller proportion, tendon and muscle injuries, are the prevailing anatomical types of injury.

- Chronological age, weight category and the annual quarter can be considered as risk factors to sustain injuries in elite taekwondo according to their location and type. - All recorded risk factors are likely to have a greater or lesser dependence according to gender or different OP registered.

How might it impact on clinical practice in the near future?
- Clinicians taking care of athletes are now aware of different patterns of injuries in Taekwondo practitioners. - It can start the development of prevention strategies and recommendations to reduce the number of injuries in taekwondo. - Although the results described here and that we can use as a guide, each sporting context, adjusted to each training system must be analysed specifically.

Figure 1: Injury location episodes according to two Olympic periods and sex of the athletes. 1Pelvis and buttock; 2Chest, trunk, abdomen and thoracic spine; 3Shoulder, upper arm, elbow, forearm; 4Hip and groin; 5Lumbar spine; 6Wrist and hand; M: males; F: females.

Figure 2: Injury type episodes according to two Olympic periods and sex of the athletes.1Arthritis, cartilage injuries, synovitis, impingements, bursitis and chronic instability; 2Joint dislocations and joint sprains; 3Stress fractures, other stress and overuse injuries; 4Whiplash and non-specific injuries; M: males; F: females.

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FOOTNOTES

Contributorship statement: All the authors contributed in a substantial manner to the planning and conduction of the testing, literature review and/or manuscript preparation. Conceived and designed: AAB, FD, AI. Analysed the data: AAB, JBM, AI. Contributed

reagents/materials/analysis tools: AAB, LT, JBM, AI. Wrote the paper: AAB, FD, NM, AI. They all gave final approval of the version submitted.

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Competing interests: None.

Ethics approval: The study protocol was approved by the Ethics Sports Clinical Investigations Committee.

Data sharing statement: Extra data is available by emailing AAB.

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Epidemiology of injuries in elite taekwondo athletes: two Olympic periods cross-sectional retrospective study

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Olympics, Martial Arts, Taekwondo, Sporting injuries, Epidemiology, Injury Prevention

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ABSTRACT

Background: Taekwondo is a popular Korean martial art characterised by its emphasis on dynamic kicking techniques. Taekwondo has been included in the Olympic Games program since 2000 Sydney Olympic Games. Although it is becoming an increasingly popular sport, there is a lack of reliable epidemiologic data on Taekwondo injuries.

Aim: This analytical cross-sectional retrospective cohort study aims to describe reported Taekwondo injuries and to determine the prevalence, characteristics and possible injury risk factors sustained by the Spanish National Team athletes. Additionally, we compared each identified risk factor, such as: age, weight category, annual quarter, injury timing and competition difficulty level, with ~~it's~~its relation to injury location and type.

Methods: This study was a summation of two Olympic periods, eight years, of data of injury reports, which included 1678 injury episodes. The data were collected on standardized injury reports at time of the first medical visit. The data analysis was performed at the High Performance Sports Center in Sant Cugat del Vallés (Barcelona, Spain).

Results: ~~Lower limb injuries are~~Independently of sex or Olympic period, the anatomical sites with more ~~common than upper limb injuries.~~injury episodes, are: knee (21.3%), foot (17.0%), ankle (12.2%), thigh (11.4%), and lower leg (8.8%). Contusions~~, joint and~~ (29.3%), cartilage (17.6%), and joint (15.7%) injuries, are the prevailing types of injury. Chronological age ~~and the~~, weight categories and the annual quarter can be considered as risk factors to sustain injuries in male and female elite taekwondist according to their location and type~~.~~ ($p \leq 0.001$).

Conclusions: The present study provides epidemiological information that will help to inform future injury surveillance studies and the development of prevention strategies

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and recommendations to reduce the number of injuries in taekwondo competition.

STRENGTHS AND LIMITATIONS

- A large analytical cross-sectional study over a 8-year period and the new findings of different associations between risk factors to sustain an injury and its location and type in elite taekwondo ahtletes were among the main strengths.
- Retrospective nature and unavailability of some relevant data.

INTRODUCTION

Taekwondo is a systematic and scientific Korean age-old martial art that involves multiple physical fighting skills. This fully recognized Olympic sport is regulated by the World Taekwondo Federation and is considered one of the most worldwide popular sports, with a range of 75 to 120 million practitioners in more than 140 countries. Spain is in the top of current medals ranking in the last London 2012 Olympic Games and represent one of the most traditional countries in terms of international sporting success [1].

Taekwondo competitive performance depends on several factors, including physical [2-6], psychological [7, 8], technical [9, 10], and tactical [11-13]. Their practitioners compete according to sex and defined weight categories classification in a full-contact event of two opponents divided in three semi-continuous rounds of two minutes, with one minute's rest between rounds. Taekwondists are equipped with a padded trunk protector, protective padded headgear, protective gloves, and shin guards. Victory is achieved by higher scores given by judges for the specific fighting techniques allowed (kicks and punches), accurately and powerfully, in the legal scoring areas (the abdomen and both sides of the flank; the permitted parts of the face).

Understanding the injury pattern of a particular sport and it's inherent risk factors, is a key area of current sports medicine [14]. As within many other combat sports, there is a high potential for injury associated with elite athletic performance in taekwondo [15-21]. Defining injury as any circumstance for which the athlete sought the assistance of the on-site medical personnel, the latest reviews about competition

injuries in taekwondo concluded that total injury rates for elite men ranged from 20.6 to 139.5 per 1000 athlete-exposure (A-E), and for elite women between 25.3 to 105.5 per 1000 A–E. When only time-loss injuries are contemplated, rates for men varied from 6.9 to 33.6 per 1000 A–E and for women from 2.4 to 23.0 per 1000 A–E [20].

The main injury mechanism in taekwondo is the direct contact, especially through the exchange of accurate turning kicks and poorly performed or nonexistent blocking skills [17, 20, 22, 23]. The vast majority of all injuries are localized to the lower extremities, especially in the instep of the foot, and these are contusions, sprains and muscle strains [17, 20, 24, 25]. The head and the neck regions are the next anatomical locations with an increased prevalence in taekwondo competition injuries [17, 20].

Despite the well-documented epidemiology injury profile in taekwondo competition, relatively few studies have evaluated the incidence of injury risk factors related to the training process and long-term preparation in elite level. The main objective of this eight years cross-sectional retrospective cohort study was to determine the prevalence, characteristics (anatomical location and injury type), and possible injury risk factors sustained by male and female Spanish National Team (SNT) taekwondists trained in the High Performance Sports Center (CAR) in Sant Cugat del Vallés (Barcelona, Spain) throughout two different Olympic periods (Sydney 1997 – 2000 and Athens 2001 – 2004).

METHODS

Type of study

This study is a large analytical cross-sectional retrospective cohort study over eight years, divided into two different four years Olympic periods (OP).

Study participants

From the 1st of January 1997 through the 31st of December 2004, a total of 48 taekwondo athletes from the SNT were studied. There were 22 male and 26 female athletes (45.8% and 54.2% of all athletes, respectively). The mean (+SD) age of the athletes in this study was 21.6±1.2 years (minimum=15 years, maximum=31 years). The inclusion criteria were 1) to have trained for the national taekwondo group for a minimum of one sports season, and 2) being a member of the SNT.

Data collection and injury report form

Two data sources were utilized. The first source was a comprehensive database obtained from the CAR, to provide personal and general information about each athlete. The second data source was from an electronic medical data capture system from the CAR sports medical department. This contained the following data fields in an unidentified format: athlete accreditation number, sex, age, date of first registration at CAR, weights category, medical visit date (day/month/year), and injury diagnosis. All injuries were diagnosed by sports medicine doctors, and subsequently recorded by anatomical location (OSICS-1) and injury type (OSICS-2) according to Orchard Sports Injury Classification System, V.10 (OSICS-10) [26]. The system of data entry and storage complied with existing European Union standards for medical data storage [27].

Procedures

The total number of injury episodes (n=1678; males: n=912; females: n=766) were obtained and analysed individually for every elite taekwondist classified by sex and OP. Definition of injury episodes (IE) corresponds to the series of medical visits sustained by an athlete, related to the same injury (same OSICS coding) and occurred no more

than two months apart from each other. If the time between them is greater than two months, this is classified as a new episode. We determined this length of time according to the definition of reinjury proposed by Hagglund [28]: "an injury of the same type and location of a previous injury that occurred within two months of the final rehabilitation day of the previous injury". Additionally, has been included a severity index of injuries, based on the number of medical visits (MV) generated by an IE (more MV, more injury severity). Results related to MV are shown as online supplement data.

Analysed variables used were: chronological age (expressed in years, and three age goups: from 15 to 20 years old, 21 to 25 years old, and 26 to 31 years old); weight category (very light, light, medium, and heavy); annual quarter when injury occurs; injury timing (pre-competition: fifteen days before the beginning of the competition; competition and/or post-competition: all the injuries sustained in competition and/or within the next fifteen days after the last day of competition; out of competition or during training sessions); competition difficulty level (World Championships –WC–, World Cups –WCU–, European Championships –EUC–, National Championships –WC–), which includes as pre-competition injuries all the injuries registered during the fifteen days before the first day of competition and as post-competition injuries all the injuries registered during the days of competition and/or within the next fifteen days after the last day of competition.

Definition of injury

This study adhered to the operational injury definitions recommended by Junge *et al*., [14], thus an injury was defined as new or recurring musculoskeletal complaints or concussions incurred during competition or training receiving medical attention, regardless of time loss from competition or training.

Confidentiality and ethical approval

Research ethics approval was obtained from the Ethics Sports Clinical Investigations Committee of Catalonia (ID-0099S/10308/2011). The investigators obtained the informed consent from the subjects to access and collect past medical history data and voluntarily participated in the study. All data were stored on highly secured, password-protected files. The investigators signed a confidentiality agreement that states all data gathered during the duration of the study will be utilized solely for the purpose of the investigation.

Statistical analysis

Data are expressed as the number of IE and presented by the standard basic descriptive statistics of mean and standard deviation. The injury classification (OSICS-1: anatomical location; OSICS-2: injury type) and the independent variables (chronological age, weight category, annual quarter, injury timing, competition difficulty level) were analysed in relation to sex and OP. In order to compare the differences between both OP or between sexes, a Student's t-test or analogue non-parametric Mann-Whitney U test were performed, depending on whether the data were normally distributed or not, respectively. In order to analyze the probability of considering a risk factor, or a possible behavior-dependent generator between the injuries (by the criterion of OSICS classification) and each of the independent variables, we used the Pearson Chi-squared test~~.~~, and adjusted odds ratio (OR). We regarded two-tailed p Bonferroni adjusted values ≤0.~~05~~001 as significant. All statistical modeling was performed using SPSS® 19.0 (SPSS Inc. Chicago, USA).

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RESULTS

OSICS-1 classification (anatomical sites)

Independently of sex or OP, the anatomical sites ~~(OSICS 1)~~ with more IE, are (~~Table~~Figure 1): knee, foot, ankle, thigh~~, ankle~~, and lower leg.

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~~Table 1. OSICS 1: injury location episodes according to two Olympic periods and sex of the athletes.~~

~~Injury location~~	~~Males~~				~~Females~~			
	~~1st~~		~~2nd~~		~~1st~~		~~2nd~~	
	~~(n)~~	~~(%)~~	~~(n)~~	~~(%)~~	~~(n)~~	~~(%)~~	~~(n)~~	~~(%)~~
~~Ankle~~	~~58~~	~~13.5~~	~~35~~	~~7.3~~	~~68~~	~~21.9~~	~~44~~	~~9.7~~
~~Pelvis[1]~~	~~8~~	~~1.9~~	~~15~~	~~3.1~~	~~10~~	~~3.2~~	~~8~~	~~1.8~~
~~Chest[2]~~	~~16~~	~~3.7~~	~~4~~	~~0.8~~	~~1~~	~~0.3~~	~~7~~	~~1.5~~
~~Shoulder[3]~~	~~15~~	~~3.5~~	~~14~~	~~2.9~~	~~7~~	~~2.3~~	~~6~~	~~1.3~~
~~Foot~~	~~104~~	~~24.1~~	~~68~~	~~14.1~~	~~56~~	~~18.0~~	~~57~~	~~12.5~~
~~Hip[4]~~	~~19~~	~~4.4~~	~~25~~	~~5.2~~	~~9~~	~~2.9~~	~~10~~	~~2.2~~
~~Head and neck~~	~~10~~	~~2.3~~	~~3~~	~~0.6~~	~~13~~	~~4.2~~	~~13~~	~~2.9~~
~~Knee~~	~~83~~	~~19.3~~	~~101~~	~~21.0~~	~~56~~	~~18.0~~	~~118~~	~~25.9~~
~~Lumbar Spine[5]~~	~~23~~	~~5.3~~	~~36~~	~~7.5~~	~~17~~	~~5.5~~	~~35~~	~~7.7~~
~~Lower leg~~	~~19~~	~~4.4~~	~~62~~	~~12.9~~	~~27~~	~~8.7~~	~~40~~	~~8.8~~
~~Thigh~~	~~47~~	~~10.9~~	~~55~~	~~11.4~~	~~24~~	~~7.7~~	~~66~~	~~14.5~~
~~Wrist[6]~~	~~22~~	~~5.1~~	~~53~~	~~11.0~~	~~17~~	~~5.5~~	~~41~~	~~9.0~~
~~Unspecific~~	~~7~~	~~1.6~~	~~10~~	~~2.1~~	~~6~~	~~1.9~~	~~10~~	~~2.2~~

~~n: number of injury episodes; 1st (1997-2000); 2nd (2001-2004); [1]Pelvis and buttock; [2]Chest, trunk, abdomen and thoracic spine; [3]Shoulder, upper arm, elbow, forearm; [4]Hip and groin; [5]Lumbar spine; [6]Wrist and hand.~~

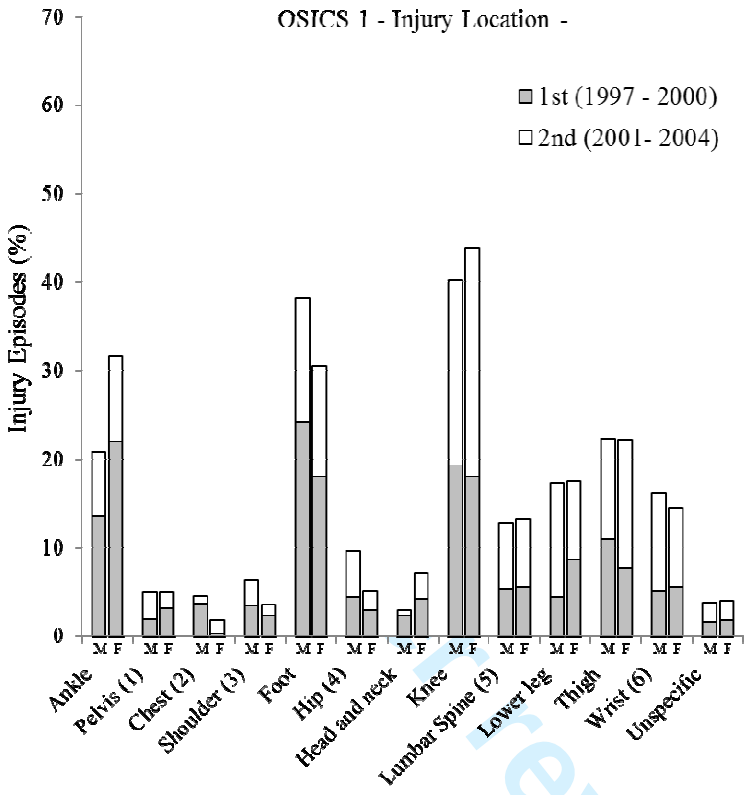

Figure 1: Injury location episodes according to two Olympic periods and sex of the athletes. [1]Pelvis and buttock; [2]Chest, trunk, abdomen and thoracic spine; [3]Shoulder, upper arm, elbow, forearm; [4]Hip and groin; [5]Lumbar spine; [6]Wrist and hand; M: males; F: females.

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OSICS-2 classification (injury type)

Independently of sex or OP, the type of injury ~~(OSICS 2)~~ with more IE, are (~~Table~~Figure 2): bruising/hematomas (contusions); joint dislocations and joint sprains; arthritis, cartilage injuries, synovitis, impingements, bursitis and chronic instability; muscle injuries; tendon injuries.

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Table 2. OSICS-2: injury type episodes according to two Olympic periods and sex of the athletes.

Injury type	Males				Females			
	1st		2nd		1st		2nd	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
Cartilage[1]	70	16.2	73	15.2	66	21.2	87	19.1
Luxations[2]	78	18.1	68	14.1	53	17.0	64	14.1
Fractures	26	6.0	33	6.9	6	1.9	6	1.3
Bruising/Hematoma	129	29.9	141	29.3	89	28.6	133	29.2
Laceration/Abrasion	8	1.9	2	0.4	6	1.9	2	0.4
Muscle	44	10.2	72	15.0	31	10.0	74	16.3
Nerve	1	0.2	5	1.0	1	0.3	2	0.4
Organic	1	0.2	1	0.2	0	0.0	1	0.2
Stress[3]	14	3.2	22	4.6	11	3.5	15	3.3
Tendon	41	9.5	40	8.3	31	10.0	34	7.5
Non-specific[4]	1	0.2	2	0.4	1	0.3	2	0.4
Absence	18	4.2	22	4.6	16	5.1	35	7.7

n: number of injury episodes; 1st (1997-2000); 2nd (2001-2004); [1]Arthritis, cartilage injuries, synovitis, impingements, bursitis and chronic instability; [2]Joint dislocations and joint sprains; [3]Stress fractures, other stress and overuse injuries; [4]Whiplash and non-specific injuries.

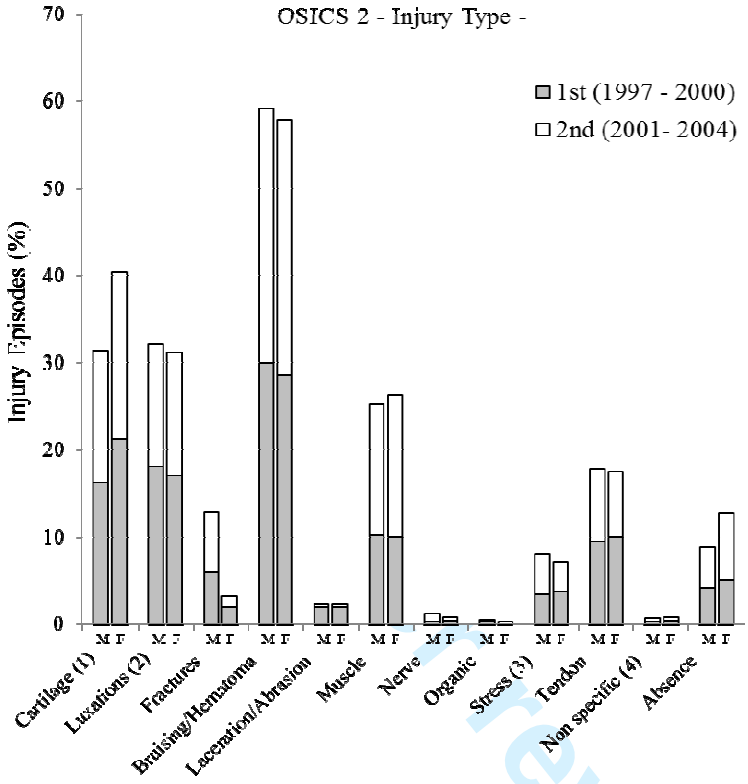

Figure 2: Injury type episodes according to two Olympic periods and sex of the athletes.[1]Arthritis, cartilage injuries, synovitis, impingements, bursitis and chronic instability; [2]Joint dislocations and joint sprains; [3]Stress fractures, other stress and overuse injuries; [4]Whiplash and non-specific injuries; M: males; F: females.

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Chronological age

IE significant differences were found between sexes during the first OP, in the chronological age groups of 21 to 25 years old (males: 48.8±11.9 vs females: 26.6±6.7; p=0.03). Independently of the different OP, chronological ages recorded a greater number of IE, are (Table ~~3~~1): 23-24 years old for males (IE: 20.5%; n=187) and 17-18 years old for females (IE: 22.7% ; n=174). With the numbers available (Table 3), exclusively during the second OP, seems to exist a sufficiently high injury prevalence in anatomical locations (OSICS-1) or injury types (OSICS-2~~)~~), as for consider a behavior susceptible to be dependent~~. Therefore, the chronological age seems to condition a~~

~~specific injury pattern related to determined anatomical locations or injury types (Table 5~~ (males: OR=2.62 / females: OR=3.07).

Table ~~3.~~ 1. Injury episodes according to chronological age groups, related to sex and two Olympic periods.

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Chronological age	Males				Females			
	1st		2nd		1st		2nd	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
15	3	0,8	0	0,0	11	3,5	4	0,9
16	23	5,3	2	0,4	38	12,2	22	4,8
17	25	5,8	22	4,6	58	18,6	30	6,6
18	23	5,3	38	7,9	30	9,6	56	12,3
19	31	7,2	53	11,0	17	5,5	44	9,7
20	43	10,0	49	10,2	4	1,3	62	13,6
21	57	13,2	37	7,6	18	5,8	53	11,6
22	42	9,7	24	5,0	26	8,4	42	9,3
23	65	15,1	41	8,5	35	11,3	43	9,5
24	44	10,2	37	7,7	31	10,0	28	6,2
25	36	8,4	50	10,4	23	7,4	13	2,9
26	14	3,2	59	12,3	10	3,2	16	3,5
27	17	3,9	37	7,7	10	3,2	22	4,8
28	6	1,4	11	2,3	0	0,0	11	2,4
29	2	0,5	9	1,9	0	0,0	7	1,5
30	0	0,0	12	2,5	0	0,0	0	0,0
31	0	0,0	0	0,0	0	0,0	2	0,4

n: number of injury episodes; 1st (1997 - 2000); 2nd (2001-2004).

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Weight category

Independently of the OP analysed, the male weight category group which has more IE, is the under 58 kg (IE: 35.6%; n=325). Then, from 58 to 68 kg (IE: 30.9%; n=282), from 68 to 80 kg (IE: 17.6%; n=160), and more than 80 kg (IE: 15.9%; n=145). In females, is the light weight category from 49 to 57 kg the one with more IE (IE: 30.9%; n=237). The next distribution per weight groups is: from 57 to 67 kg (IE: 30.2%; n=231), under 49 kg (IE: 29.9%; n=229), and more than 67 kg (IE: 9.0%; n=69). Significant differences (p=0.~~03~~01), were found between sexes in all weight categories (in the very light and heavy weight categories during the first OP, and in the light and

medium weight category during the second OP) and between OP in the same sex: females in very light and heavy weight categories and males in light and medium weight categories. ~~Once again, with the available data,~~Except in the first OP, OSICS-2 in males (Table 3), seems to exist a sufficiently high injury prevalence in anatomical locations (OSICS-1) or injury types (OSICS-2) to consider ~~a behavior susceptible to be dependent. Therefore,~~ the weight category ~~should be considered~~ as a injury risk factor ~~or a possible behavior dependent generator (Table 5~~(males: OR=2.02 / females: OR=1.50).

Annual quarter

From the total of 912 IE generated by the males (Table 42), 35.7% (n=326) were sustained for the athletes in the first annual quarter, 26.3% (n=240) in the second annual quarter, 15.3% (n=139) in the third annual quarter, and 22.7% (n=207) in the fourth annual quarter. From the total of 766 IE generated by the females (Table 42), 33.0% (n=253) were sustained for the athletes in the first annual quarter, 31.1% (n=238) in the second annual quarter, 14.5% (n=111) in the third annual quarter, and 21.4% (n=164) in the fourth annual quarter.

Table ~~4~~2. Injury episodes according to the months when injury occurred, related to sex and two Olympic periods.

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Months	Males				Females			
	1st		2nd		1st		2nd	
	(n)	(%)	(n)	(%)	(n)	(%)	(n)	(%)
January	43	10,0	47	9,8	47	15,1	51	11,2
February	55	12,8	72	15,0	26	8,4	47	10,3
March	59	13,7	50	10,4	35	11,3	47	10,3
April	42	9,7	50	10,4	40	12,9	53	11,6
May	52	12,1	54	11,2	48	15,4	64	14,1
June	29	6,7	13	2,7	13	4,2	20	4,4
July	7	1,6	30	6,2	4	1,3	8	1,8
August	18	4,2	13	2,7	24	7,7	23	5,2

September	31	7,2	40	8,3	20	6,4	32	7,0
October	39	9,0	31	6,4	28	9,0	36	7,9
November	42	9,7	63	13,1	15	4,8	48	10,5
December	14	3,3	18	3,8	11	3,5	26	5,7

n: number of injury episodes; 1st (1997-2000); 2nd (2001-2004).

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No differences were found between sexes or OP. Excluding the results obtained by male takwondists during the first OP~~,~~ (Table 3), the annual quarter seems to condition a significant prevalence of injury anatomical site (OSICS-1) and injury type (OSICS-2), and could be considered as a injury risk factor (~~Table 5~~males: OR=2.04 / females: OR=1.71).

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Injury timing

From the total of 1678 IE, 61.1% were sustained or during training sessions or out of competition (n=1026), 23.3% in pre-competition period (n=391) and 15.6% in competition or post-competition period (n=261). No differences exist between OP according to the number of IE. ~~In males, there~~There is no significant relationship between injury timing and injury anatomical sites (OSICS-1) or injury types (OSICS-2). Therefore, with the numbers available, ~~only in females this variable~~injury timing should not be considered as a ~~injury~~ risk factor or a possible behavior-dependent generator of injuries in elite Taekwondo athletes (Table ~~5~~3).

Competition difficulty level

From the total of 367 IE derived from competition in males, 45.2% (n=166) were sustained during NC, 14.4% (n=53) during EUC, 27.2% (n=100) during WC, and 13.1% (n=48) during WCU. From the total of 286 IE derived from competition in females, 38.8% (n=111) were sustained during NC, 17.5% (n=50) during EUC, 25.5% (n=73) during WC, and 18.2% (n=52) during WCU. No differences exist between OP

according to the number of IE in relation to the competition difficulty level. There is no significant relationship between competition difficulty level and injury anatomical sites (OSICS-1) or injury types (OSICS-2) . These results are independent of whether the injury has occurred pre or post-competition (Table ~~5~~3). So, with current data, the competition difficulty level should not be considered as a risk factor or a possible behavior-dependent generator of injuries in elite Taekwondo athletes.

Table ~~5~~3. Statistical dependency levels of independent variables according to sex and two different Olympic periods.

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	Sex	OSICS	Olympic period	IE (n)	*df*	X^2	~~*p*~~ $p_{adjusted}$
Chronological age	Males	1	1st	431	24	43.04	0.005
		2			22	40.99	0.005
		1	2nd	481	24	48.71	0.001*
		2			22	49.81	0.001*
	Females	1	1st	311	24	128.63	0.~~001~~002
		2			22	44.26	0.003
		1	2nd	455	24	114.98	0.001*
		2			22	78.56	0.001*
Weight category	Males	1	1st	431	36	131.56	0.001*
		2			33	53.38	0.005
		1	2nd	481	36	348.18	0.001*
		2			33	188.11	0.001*
	Females	1	1st	311	36	140.39	0.001*
		2			33	86.83	0.001*
		1	2nd	455	36	170.15	0.001*
		2			33	128.78	0.001*
Annual quarter	Males	1	1st	431	36	34.57	0.500
		2			33	27.50	0.700
		1	2nd	481	36	245.14	0.001*
		2			33	110.42	0.001*
	Females	1	1st	311	36	114.17	0.001*
		2			33	72.07	0.001*
		1	2nd	455	36	83.60	0.001*
		2			33	72.89	0.001*
Injury timing	Males	1	1st	431	24	29.59	0.150
		2			22	19.09	0.600
		1	2nd	481	24	19.13	0.700
		2			22	25.75	0.250
	Females	1	1st	311	24	82.50	0.~~001~~002
		2			22	33.43	0.050
		1	2nd	455	24	131.80	

								0.~~001~~002
			2			22	69.65	0.010
Competition difficulty level	Males	Pre	1	1st	102	36	41.56	0.200
			2			33	22.01	0.900
			1	2nd	106	36	44.7	0.100
			2			33	27.41	0.700
		Post	1	1st	82	36	27.82	0.850
			2			33	24.29	0.850
			1	2nd	76	36	28.80	0.750
			2			33	33.76	0.400
	Females	Pre	1	1st	86	36	40.83	0.250
			2			33	40.27	0.150
			1	2nd	97	36	42.67	0.200
			2			33	12.53	0.990
		Post	1	1st	40	36	15.46	0.990
			2			33	17.98	0.975
			1	2nd	63	36	22.37	0.950
			2			33	19.62	0.950

OSICS: (1) injury location, (2) injury type; IE: injury episodes; n: number of injury episodes; *df*: degrees of freedom; X^2: chi-square statistic; ~~*p*~~* $p_{adjusted}$: significance level ≤0.001; Pre: 1st (1997 - 2000); 2nd (2001-2004).

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DISCUSSION

The present study examine the effect of chronological age, weight category, annual quarter, injury timing, and competition difficulty level on injury location and type in elite Taekwondo athletes. The anatomical sites with more injury incidence correspond to the lower limbs (knee, foot, ~~thigh,~~ ankle, thigh and lower leg) for both males and females. These anatomical locations are related to different injury types, prevailing contusions, joint and cartilage injuries and, in smaller proportion, tendon and muscle injuries. Chronological age ~~and~~ , weight category and annual quarter, are the ~~unique~~ variables that~~, independently to sex and Olympic period,~~ show a statistically significant relation as possible injury risk factors in elite taekwondo. In the opposite direction, the injury timing and competition difficulty level does not seem to have any relationship with the injury prevalence in this combat sport. ~~Annual quarter and injury timing show different possible dependent behaviors according to each sex or different Olympic periods.~~

The present study has some limitations to be considered. First, and perhaps the most important, not correspond to a prospective and/or longitudinal study design (it was not possible, for example, to determine when the injury exactly occurred, or to calculate injury rates with adequate accuracy, or to possess previous injury information, or a training load indicator). Second, despite the high number of IE, there is a low number of elite taekwondists included that can possibly result in relevant bias.

Injury location (OSICS-1) and injury type (OSICS-2)

Spanish males taekwondists present higher IE than women, however there is no statistically proven difference found. Recent studies reported similar findings [29-35]. Past research cites the most common injury locations as the lower limb [17, 24, 31, 32, 34, 38, 39]. This is not surprising due to the use of the lower limb as the primary

striking weapon. There are no significance differences between sexes in knee injuries, that's a surprising finding because according to many research papers being a female is a risk factor to suffer from more knee injuries [40-42]. It could be possible that this risk factor is minimized because both sexes train and do the same prevention programs, an uncommon aspect in other sports. Foot is the second location with more number of episodes, not rear if we know that the majority of kick techniques use the foot. Some authors affirm that 98 out of 100 hundred kicking techniques are executed with the foot [43, 44]. Chest, thoracic column and abdomen are the locations with less number of episodes, it could be related to the use of protections in these zones during training sessions and competitions. The prevalence of contusions, joint and cartilage injuries, is in accordance with the related literature [26, 30]. It's logical because the practitioners are constantly kicking each other.

Risk factors (depenent variables)

According to sex, the highest injury prevalence occurs at different chronological ages. From 23 to 24 years old in males, from 17 to 18 years old in females. There are many related studies that found a significance correlation between chronological age and injury incidence [16, 22, 24, 35-37]. The data of this study confirm the same results, indicating the chronological age as a potential risk factor for injury incidence in elite taekwondo athletes.

Sex differences according to the weight category is a clear indicator that men suffer more injuries in all weight categories with the exception of intermediate category. This exception is explained by the fact that there are fewer cases of male taekwondo athletes represented. Moreover~~, independently of sex or Olymnpic period~~, the weight category emerges as a possible injury risk factor.

~~Finally, the injury risk factors related to the variables of annual quarters, and especially, injury timing, varies according to sex. Indeed, only in the case of female taekwondists, the injury timing emerges as an important risk factor to consider in training and competition strategies. These results are relevants because the SNT trains in CAR (men and women) under the same workload and intensity, they share equipment, training systems and prevention methods. This should to minimize the differences between sexes, but this not always happen, as occurs in the case of injury timing.~~

All sports planning training system varies depending on the competitive calendar and, consequently, on the season annual periods. In the present study, this fact seems to condition the injury pattern of taekwondo athletes, and it can be considered as a risk factor by coaches and sports medicine specialists.

Finally, in all the variables that could be considered as risk factors were recorded some differences according to sex and/or different OP. The first OP, regarding to chronological age (males and famales, and OSICS-1 and OSICS-2) , the weight category (males OSICS-2), and specially in the annual period (males OSICS-1 and OSICS-2), seems to record a different behavior as a risk factor injuries causes. Although the retrospective nature of this study the training load was not recorded, it is known that the Spanish responsible coaches were different during the two analyzed OP. Different training systems, applied in a certain way for both genders, could be on of the reasons for these results. Therefore, each sporting context should be specifically analyzed to assess the full dimension of the elite injury epidemiology in taekwondo.

CONCLUSIONS

The anatomical sites with more injury incidence correspond to the knee, foot, ankle, thigh, ~~ankle,~~ and lower leg. In SNT prevailing contusions, joint and cartilage injuries.

Chronological age ~~and ,~~ weight category ~~always~~, and annual quarter, show a statistically significant relation as possible injury risk factors~~. Annual quarter and injury timing show different possible dependent behaviors~~ according to sex or different OP. The present study has some limitations to be considered: not correspond to a prospective and/or longitudinal study design; despite the high number of IE, there is a low number of elite taekwondists included. This study provide epidemiological information that will help to inform future injury surveillance studies. Further research is needed to achieve a better understanding of elite taekwondo, in relation to sex and ~~competitive categories~~different training systems.

What are the new findings?
- OSICS classification appears to be sensitive to classifying the injury location and type, and to discriminate potential injury risk factors. - Lower limb injuries including knee, foot, ankle, thigh, ~~ankle~~ and lower leg, are more common than upper limb injuries. - Contusions, joint and cartilage injuries and, in smaller proportion, tendon and muscle injuries, are the prevailing anatomical types of injury. - Chronological age, weight category and the ~~weight categories~~annual quarter can be considered as risk factors to sustain injuries in elite taekwondo according to their location and type. - ~~There are some injury risk factors associated with female elite taekwondists and not with their male counterparts (injury timing).~~ All recorded risk factors are likely to have a greater or lesser dependence according to gender or different OP registered.

How might it impact on clinical practice in the near future?
- Clinicians taking care of athletes are now aware of different patterns of injuries in Taekwondo practitioners. - It can start the development of prevention strategies and recommendations to reduce the number of injuries in taekwondo. - ~~Training all the subjects together regardless the sex can be a factor to be implemented in other sports to assess whether the differences between them are reduced, or not.~~Although the results described here and that we can use as a guide, each sporting context, adjusted to each training system must be analysed specifically.

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FOOTNOTES

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Contributorship statement: All the authors contributed in a substantial manner to the planning and conduction of the testing, literature review and/or manuscript preparation. Conceived and designed: AAB, FD, AI. Analysed the data: AAB, JBM, AI. Contributed reagents/materials/analysis tools: AAB, LT, JBM, AI. Wrote the paper: AAB, FD, NM, AI. They all gave final approval of the version submitted.

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Competing interests: None.

Ethics approval: The study protocol was approved by the Ethics Sports Clinical Investigations Committee.

Data sharing statement: Extra data is available by emailing AAB.

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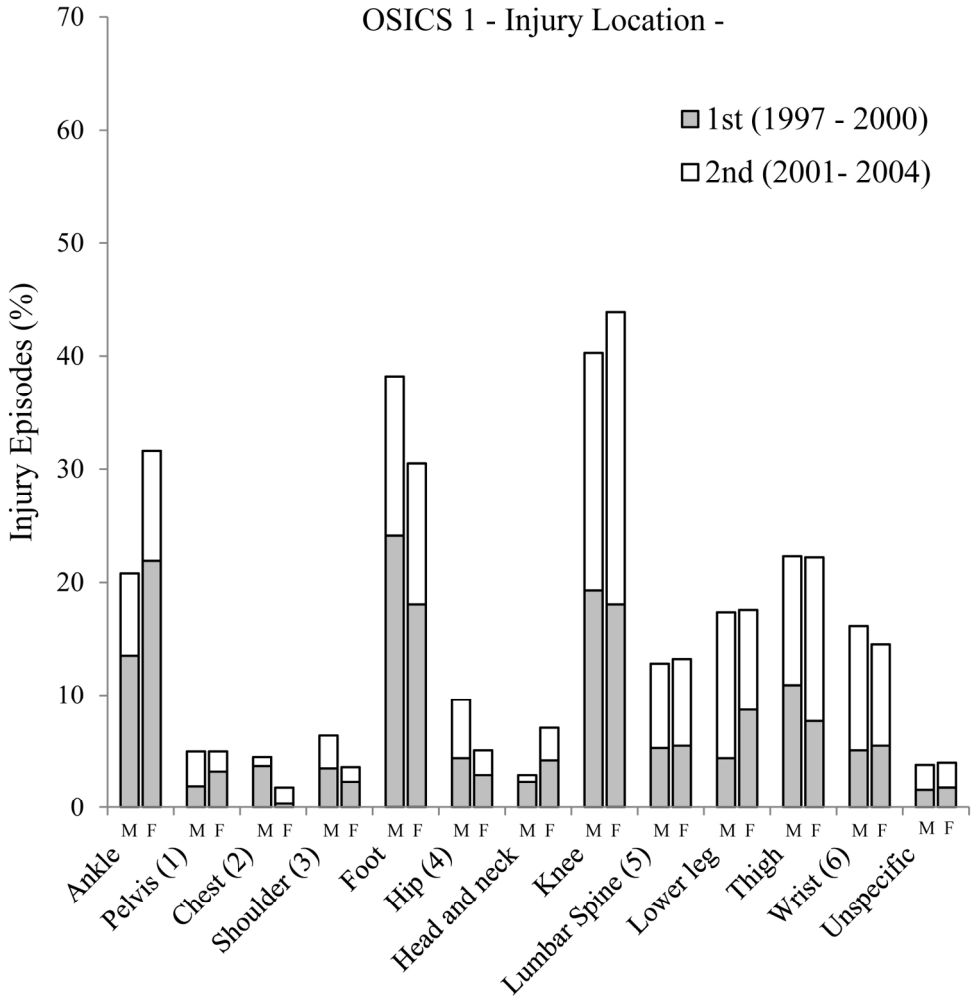

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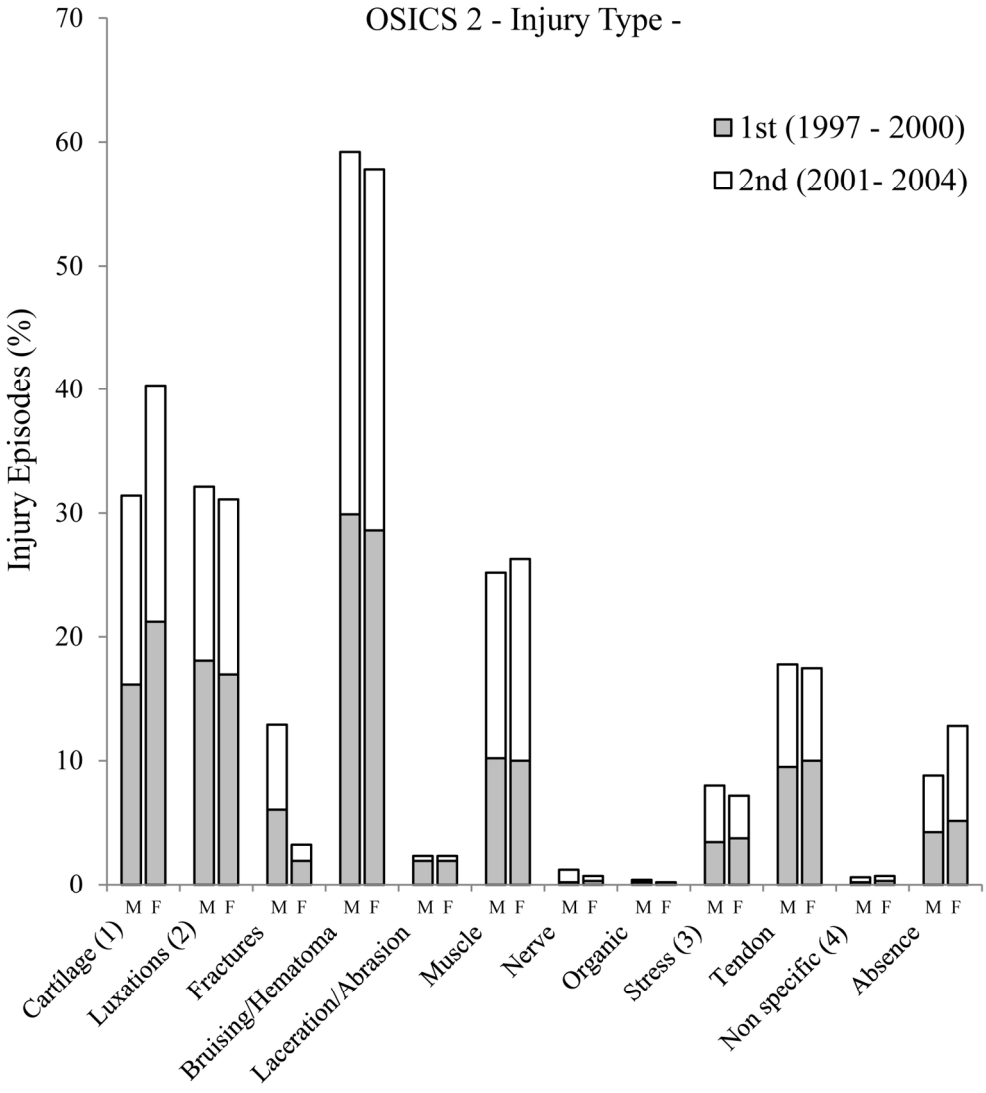

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3, 4
Objectives	3	State specific objectives, including any prespecified hypotheses	3, 4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5, 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5, 6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5, 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5, 6
Bias	9	Describe any efforts to address potential sources of bias	*5, 6*
Study size	10	Explain how the study size was arrived at	5, 6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5, 6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	7
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	8
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
Outcome data	15*	Report numbers of outcome events or summary measures	8
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-15
		(*b*) Report category boundaries when continuous variables were categorized	9-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9-15
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-15
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.