

Rodríguez González, E.; Alonso Melero, R.; Carrillo Rodrigo, M.R.; CerrolazaTudanca, S.; Moro Ruano, M.; López Mesa, M.; López Román, A.; Amor Salamanca, M.; González Solís, J. (2022) Lesional Comparative Study in Elite Judocas. Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte vol. 22 (87) pp. 535-549
[Http://cdeporte.rediris.es/revista/revista87/artestudio1394.htm](http://cdeporte.rediris.es/revista/revista87/artestudio1394.htm)
DOI: <https://doi.org/10.15366/rimcafd2022.87.007>

ORIGINAL

COMPARATIVE STUDY OF INJURIES IN ELITE JUDOKAS

ESTUDIO COMPARATIVO LESIONAL EN JUDOCAS DE ÉLITE

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CÓDIGO UNESCO:321315 Traumatología / traumatology; 329915 Medicina Deportiva /Sports Medicine

CLASIFICACIÓN CONSEJO DE EUROPA: 11. Medicina del deporte / Sports Medicine

Recibido 25 de mayo de 2020 **Received** May 25, 2020

Aceptado 13 de febrero de 2021 **Accepted** February 13, 2021

ABSTRACT

Judo is a high static and low dynamic sport, with a high risk of bodily and injury collision. The objective of this work is to determine the incidence of injury and to compare the different risk factors that may be involved. A total of 86 judokas from the Spanish National Judo Team (ENJE) were studied during two Olympic periods: Beijing-Rio. 2028 injuries occurred more frequently in the lower limb, without significant differences according to sex. A higher incidence was observed in tori judoka and during

training. No existing work has examined these parameters. The present study provides data that can be used to reduce the risk of injury in elite judokas.

KEYWORDS: Injuries, high performance, injury mechanism.

RESUMEN

El Judo es un deporte estático alto y dinámico bajo, con alto riesgo de colisión corporal y lesional. El objetivo de este trabajo es determinar la incidencia lesional y comparar los distintos factores de riesgo que pudieran estar implicados. Se estudió a un total de 86 judocas del Equipo Nacional de Judo español (ENJE) durante dos períodos olímpicos: Beijing-Río. Se produjeron 2028 lesiones con mayor frecuencia en miembro inferior, sin diferencias significativas por sexo. Se objetivó mayor incidencia lesional cuando el judoca era tori y durante el momento del entrenamiento. No existen trabajos previos que comparen estos parámetros, por lo que este estudio aporta datos que pueden ser utilizados para prevenir los riesgos de lesión en el judo de alta competición.

PALABRAS CLAVES: Lesiones, alto rendimiento, mecanismo de lesiones.

INTRODUCTION

The word judo (柔道) means the gentle way, no resistance. It was created in 1882 by the master Jigoro Kano as a non-violent method of self-defence for his town and the wider world (Kano, 2013). According to the sport classification of Mitchell, Haskell and Raven, judo is a sport characterised by a high static component (>30%) and low dynamic load (<50%), with risk of bodily collision. Judo is executed as a form of hand to hand combat (Randori) within a Dojo (place dedicated to the teaching of martial art son a tatami). The judoka performing the action takes on the role of tori, whilst the uke is the judoka who receives the action. Judoka clothing consists of a judogi and a belt or obi, whose colour indicated their level of mastery. Judokas are classified into seven weight categories according to their age and gender. Judo is the main sporting fight style currently being practiced around the world (Mitchell, Haskell and Raven, 1994). Of 66 federated sports in Spain, judo is the sixth most popular with 105,206 registered judokas. Of these, 21,229 are females, corresponding to 20% (Ministry of Culture and Sport – Higher Sport Council, 2019). Since 2016, the International Judo Federation (IJF), recognised by the International Olympic Committee (COI), has 203 member national federations which are divided between 5 continental federations and count on 40 million registered members (International Judo Federation, undated).

Judo in Spain emerged in 1962 with 1,950 registered licenses and 115 black belts, reaching 23,600 licences just a few years later (1971). In 1965, the Spanish Royal Judo Federation was created in Madrid. This was shortly followed by the sports first Spanish Olympic representation in Montreal (1976), with two male representatives. Spain first included female representatives in the

Olympic Games in Barcelona (1992), obtaining two gold medals (Cardenal Puente, Carrasco Cantero and Delgado-Corredor Guerra, 2012).

In the present day, the Spanish National Team comprises 84 judokas from different weight categories. Representatives are selected based on the outcomes obtained at national and international competitions (Spanish Royal Federation of Judo and Associated Sports, 2020).

Given its biomechanical characteristics, judo can lead to injuries in different tissues and body parts. In 1988, Noyes, Lindenfeld and Marshall established that specific injuries are inherent to all sports and determined by their implied sporting gestures (Noyes, Lindenfeld and Marshall, 1988).

In its efforts for the prevention and treatment of injuries, the Spanish Royal Federation of Judo and Associated Sports (RFEJYDA) has introduced medical follow-ups into training and competition in order to detect risk factors and injury mechanisms.

AIMS

The present study represents a first ever examination of judokas on the Spanish National Judo Team. The aim of this study is to analyse different incidence rates and the types of injuries suffered in relation to sex, dominance, age and moment (training or competition). Examination is to be conducted in both tori and uke during two Olympic periods, comprising two Olympic Games (Beijing, London and Rio). Once the most common injuries and the mechanisms behind them are identified, the present study will seek to establish appropriate preventative measures.

MATERIAL AND METHODS

Study design: An observational, retrospective and comparative study was conducted. This analysed data collected from the clinical records of all judokas belonging to the ENJE. Data covered a total of 86 judokas from the two Olympic periods: 2007-2011 (from Beijing to London) and 2012-2016 (from London to Rio de Janeiro). Clinical records collected data on judokas' age, sex and dominance, alongside all injury diagnoses and severity, injured tissue and covered anatomical region, and the moment at which the injury occurred and the affected judoka (tori or uke).

Sample: All musculoskeletal injuries suffered by judokas on the ENJE were included, following the classification described by Alonso and the definition of injury made by Brooks (Alonso, 2009; Brooks and Fuller, 2006). All data were collected in situ using relevant reference numbers from participant registration forms stored in the Judo Module of sports facilities ran by the Higher Sports Council of Madrid and developed by the Medical Service of the Spanish Royal Federation of Judo and Associated Sports (RFEJYDA). This service accompanies judokas during competitions and is present during training. It

determines the most appropriate treatment type and length of disruption to sport participation, according to injury severity.

Statistical analysis: A descriptive and comparative analysis was performed of the 2,028 injuries suffered by the 86 judokas included in the present sample during the two considered Olympic periods: Beijing-Rio. Distribution was examined according to age, sex, dominance, moment and action (tori or uke). Injury incidence rates were evaluated attending mainly to the moment and injured body structure, with regards to whether the judoka was acting as tori or uke. Collected data were analysed with the help of the statistical program SPSS in its version 21.0 for Windows. Following a brief descriptive analysis of data, chi-squared analysis was conducted in order to compare associations between the qualitative variables under study. A 95% confidence level was applied, with significance being set at $p < 0.05$

RESULTS

Descriptive and comparative analysis of qualitative variables pertaining to the present sample.

The sample was composed of 43 females and 43 males. With regards to dominance, 54 were right sided and 32 were left sided, with a slight predominance of left handedness amongst females (5%).

Female participants were aged between 19 and 42 years, with an average age of 28 years and a standard deviation of 5.8 years (28 +/- 5.8 years). Male participants were aged between 19 and 40 years, with an average age of 27.4 +/- 5.4 years. Pearson variation coefficients (CV) were 20% and 21% for males and females, respectively, indicating that the participating group was made up of individuals with fairly disperse ages.

Participating females recorded heights of between 150 and 177 centimetres, with an average of 164.8 +/- 7.3 cm (CV = 4%), whilst males were between 158 and 195 cm tall, with an average of 177.9 +/- 8.8 cm (CV = 5%). Less dispersion was therefore seen in relation to height.

Throughout the two Olympic cycles, a total of 2,028 injuries occurred. This related to an average ratio of 2.94, or almost 3 injuries per judoka each year.

Associations between the sex and dominance of judokas

A highly significant association was found between both variables, with a confidence level of 95% (*contingency coefficient [C] = 0.101, p = 0.000*). Table 1 shows that 1,009 injuries were suffered by female judokas, relative to 1,019 injuries suffered by males. Injury percentages are also presented for ENJE judokas, according to sex and dominance.

Table 1. Injury frequency and percentages in males and females

		Sex		Percentage of all injuries	Injury frequency
		FEMALE	MALE		
Dominance right-left	RIGHT	26.6%	31.9%	58.4%	1185
	LEFT	23.2%	18.4%	41.6%	843
Overall injury frequency		1009	1019	100%	2028

Injuries in judokas reporting right-sided dominance were 17% more frequent than in left-sided judokas. Right-sided males suffered almost 5% more injuries than right-sided females. The same percentage difference was seen with regards to injuries in left-sided judokas but in the opposite direction. These strong differences explain the dependence seen between both of these variables. Males and females suffered virtually the same number of injuries.

Associations between body distribution and sex.

A significant association existed between participating athletes' general body distribution and sex ($C = 0.079$ and $p = 0.013$).

Table 2 shows that of the 2,028 injuries studied, those affecting the head presented greater proportional sex differences. Males presented with twice as many head injuries (5.4%) than females, for which this injury type only accounted for 2.7% of all injuries. On the other hand, injuries to the lower limb were the most frequent, accounting for 43.6% of all injuries. In this case, females suffered this type of injury more than males, accounting for 45.8% relative to 41.4%, respectively. The next most common injury location was the upper limb, with 30.3% of injuries affecting this area. In this case, 31.6% of all injuries occurred in the upper limb in males and 29% in females.

Table 2. Distribution of injuries according to affected body part and gender

		Sex		Percentage of all injuries	Injury frequency
		FEMALE	MALE		
General affected body part	LOWER LIMB	45.8%	41.5%	43.6%	885
	UPPER LIMB	29.0%	31.6%	30.3%	615
	TRUNK	20.2%	19.3%	19.8%	401
	HEAD	2.7%	5.4%	4.0%	82
	PELVIS	2.3%	2.2%	2.2%	45
Overall injury frequency		1009	1019	100%	2028

Associations between affected body part and injury moment

A significant association exists between both variables ($C = 0.151$ and $p = 0.000$). Table 3 shows that an imbalance exists between the proportion of injuries suffered according to the two moments considered (training and competition). A total of 1,208 injuries (59.6%) occurred during training, relative to 820 injuries (40.4%) during competition.

The greatest injury differences were found in relation to the following regions of the body.

- Lower limb: In relation to this area, injuries were most notable during competition, with this modality explaining 50.6% of injuries relative to just 38.9% that occurred during training.
- Trunk: In contrast to that seen above, 23.1% of injuries occurred in the trunk during training, relative to 14.9% of injuries occurring in the trunk during competition.
- Pelvis: The percentage of injuries suffered during training broadly exceeded that reported during competition, with 3.1% relative to 1%, respectively.

Table 3. Affected body part and moment at which the injury occurred

		Injury moment		Percentage of all injuries	Injury frequency
		TRAINING	COMPE-TITION		
General affected body part	LOWER LIMB	38.9%	50.6%	43.6%	885
	UPPER LIMB	31.6%	28.4%	30.3%	615
	TRUNK	23.1%	14.9%	19.8%	401
	HEAD	3.3%	5.1%	4%	82
	PELVIS	3.1%	1%	2.2%	45
Overall injury frequency		1208	820	100%	2028

Association between the action performed by the judoka and the location of the injury.

A significant association existed between both attributes ($C = 0.389$ and $p = 0.000$). Table 4, which only presents injuries accounting for 5% or more of all injuries, identifies the body areas found to be differentially affected by injuries in tori and uke judokas. Injuries were found to most frequently occur in the knee, with 15.1% of all injuries occurring here, followed by the hand-wrist, which accounted for 12.2% of all injuries.

Table 4. Affected area of the body and whether the judoka performs (tori) or receives (uke) the action.

		Judoka throwing or being thrown		Percentage of all injuries	Injury frequency
		TORI	UKE		
Affected area of the body	KNEE	13.8%	16.7%	15.1%	306
	HAND-WRIST	9.6%	15.5%	12.2%	248
	SHOULDER	10.1%	9.3%	9.8%	198
	THIGH	11.3%	5.0%	8.5%	172
	ANKLE	4.9%	10.3%	7.3%	149
	LEG	4.5%	9.8%	6.9%	139
	CERVICAL SPINE	9.4%	2.2%	6.2%	125
	ELBOW	3.2%	8.1%	5.4%	110
	LUMBAR SPINE	9.2%	0.7%	5.4%	109
	FOOT	3.9%	6.3%	5.0%	101
	OTHER AREAS	20.1%	17.1%	18.2%	371
Overall injury frequency		1117	911	100%	2028

Association between the action performed by the judoka and anatomic tissue.

A significant association exists between both attributes ($C = 0.431$ and $p = 0.000$). Table 5 shows that of the 11 examined anatomical tissues pertaining to the 2,028 injuries suffered, the most affected tissue in tori judokas was muscle (23.2% of all injuries), whilst the joint was most affected in uke judokas (15.3%).

Table 5. Anatomical tissue and the action performed by the judoka (tori or uke).

		Judoka throwing or being thrown		Percentage of all injuries	Injury frequency
		TORI	UKE		
Anatomic tissue	MUSCLE	23.2%	4.6%	27.9%	565
	JOINT	9.6%	15.3%	24.9%	505
	LIGAMENT	3.8%	8.1%	11.9%	242
	EPIPHYSIS-BONE-PERIOSTEUM	3.1%	8.0%	11.1%	225
	ENTHESIS-TENDON	7.6%	1.7%	9.4%	190
	CARTILLAGES	1.3%	3.4%	4.7%	95
	CAPSULE	2.1%	1.5%	3.6%	72
	NERVE	2.2%	0.4%	2.7%	54
	MENISCUS	1.1%	0.8%	2.0%	40
	BURSA-CYST	0.6%	0.7%	1.3%	27
	OTHER	0.4%	0.2%	0.6%	13
Overall injury frequency		1117	911	100%	2028

The present epidemiological study also identified a highly significant association ($C = 0.439$ and $p = 0.000$) with regards to whether the judoka was performing a throw or being thrown at the time of the injury. This finding is hugely important when it comes to putting preventative measures into place.

Association between the action being performed by the judoka (tori or uke) and whether the injury requires rest from sport

A significant association existed between both attributes ($C = 0.220$ and $p = 0.000$). Table 6 shows that more than half of the injuries suffered did not require

rest from sport, with 52.6% not requiring rest and 47.4% demanding it. With regards to the action being performed, injuries suffered whilst acting as uke largely required rest, with almost 60% of injuries demanding concomitant rest relative to 40% that did not. The opposite occurred in relation to injuries suffered whilst acting as tori, with 62.8% of injuries not requiring rest and the remaining 37.2% leading to a break from the sport.

Table 6. Whether the judoka was throwing or being thrown and rest from sport

		Rest from sport		Percentage of all injuries	Injury frequency
		NO	YES		
Whether judoka was throwing or being thrown	TORI	65.8%	43.2%	55.1%	1117
	UKE	34.2%	56.8%	44.9%	911
Overall injury frequency		1066	962	100%	2028

In contrast, no significant association was found between the variable describing whether a judoka was throwing or being thrown and the need for physiotherapeutic treatment. Injuries suffered whilst performing a throw (tori) demanded such treatment in 84% of cases, whilst 76% of those being thrown (uke) led to treatment ($C = 0.034$ and $p = 0.269$).

Association between general diagnosis and whether the judoka was throwing or being thrown

A significant association existed between both of these attributes ($C = 0.507$ and $p = 0.000$). Table 7, which only includes injuries accounting for 3% or more of all injuries, shows the main differences between these variables regarding injury percentage.

Table 7. General diagnosis and whether the judoka was throwing or being thrown.

		Judoka throwing or being thrown		Percentage of all injuries	Injury frequency
		TORI	UKE		
General diagnosis	CONTRACTURE	27.8%	3.2%	16.8%	340
	SPRAIN	4.8%	17.7%	14.7%	215
	ARTHRITIS	3.9%	10.9%	7.1%	143
	CONTUSION-HEMATOMA	2.3%	11.5%	6.5%	131
	TENDINOPATHY-TENOSYNOVITIS	9.8%	1.4%	6.0%	122
	ARTHROSIS	5.3%	2.6%	4.1%	83
	LUMBALGIA-LUMBOCIÁTICA	6.6%	0.5%	3.9%	79
	LUXATION-SUBLUXATION	1.2%	7.1%	3.8%	78
	DISTENSION	3.0%	3.7%	3.4%	68
	TRAUMA	1.0%	5.6%	3.1%	62
	OTHER	37.3%	39.5%	30.6%	707
Overall injury frequency		1117	911	100%	2028

Association between general diagnosis and moment of the injury

A significant association existed between both of these attributes ($C = 0.528$ and $p = 0.000$). Table 8 shows differences in injury occurrence according to these variables. In all cases, percentages pertaining to the most frequent injury parameters more than doubled those pertaining to the less frequent counterpart.

Table 8. General diagnosis and injury percentage at the moment of training or competition

		Injury moment		Percentage of all injuries	Injury frequency
		TRAINING	COMPE-TITION		
General diagnosis	CONTRACTURE	26.8%	2.0%	16.8%	340
	SPRAIN	7.0%	26.1%	14.7%	299
	ARTHRITIS	4.6%	10.7%	7.1%	143
	CONTUSION-HEMATOMA	2.6%	12.2%	6.5%	131
	TENDINOPATHY-TENOSYNOVITIS	9.7%	0.6%	6.0%	122
	ARTHROSIS	6.6%	0.4%	4.1%	83
	LUMBALGIA-LUMBOCIÁTICA	5.8%	1.1%	3.9%	79
	LUXATION-SUBLUXATION	1.5%	7.3%	3.8%	78
	DISTENSION	1.5%	6.1%	3.4%	68
	TRAUMA	1.2%	5.7%	3.1%	62
	OTHER	32.7%	27.8%	30.6%	623
Overall injury frequency		1208	820	100%	2028

Outcomes pertaining to the associations between whether the judoka was throwing or being thrown at the time of injury and relapse reveal a significant association between both of these aspects ($C = 0.125$ and $p = 0.000$). A total of 52.9% of injuries suffers whilst performing as tori lead to relapse, relative to 40.3% of those suffered whilst performing as uke.

DISCUSSION

Given that the risk of type 1 and 2 error was considered to be the same, it is important to highlight that alpha was set at 95% for all comparative analyses conducted, the outcomes of which drive the conclusions of the present study. Further, the conclusions reached in this report are highly reliable as they relate to longitudinal and populational data, covering two Olympic periods.

This retrospective and epidemiological study is the first to examine all of the injuries suffered by elite level judokas on the Spanish National Judo Team (ENJE) over the duration of two Olympic periods. A previous study conducted by Frey et al., studied the injuries suffered by French judokas over the course of 21 years of competition. However, this prior work did not establish the moment of injury (training or competition), nor did it examine whether the judoka was performing a throw or being thrown (tori or uke) at the time of injury. These aspects were examined in the present study and, according to the outcomes reported, appear to be fundamental considerations for the multi-disciplinary team attending to elite judokas when putting preventative measures in place (Frey et al., 2019).

Results obtained in the present study with regards to variables pertaining to the body part affected by injury and gender, show a significant association between

these aspects. These findings are highly similar to those obtained in research conducted by Paup and Finley. These authors carried out a study in which the incidence of injuries suffered by males and females in martial arts training was compared. Their analysis found that, generally speaking, a higher percentage of injuries is found amongst females, however, they concluded that different types of martial arts are characterised by significantly different injury types and distributions (Paup and Finley, 1994).

In the present study, analysis of general diagnosis in relation to the moment of the injury (training and competition) reveals that the most commonly suffered injuries during competition are sprains, whilst contractures are most common during training. This coincides with outcomes reported in a study conducted by Frey et al. (2019) which identifies knee sprain injuries to be the most frequent injury type amongst high-level judokas during competition. In this same sense, findings uncovered in a literature review performed by Pocceco et al. (2013) are highly similar to ours, with the most prevalent injuries in both articles being sprain, followed by contracture, traumatic arthritis and contusion.

On the other hand, disparity exists in relation to work carried out by Okada et al. (2007), who evaluated lumbar spine injuries through administration of a questionnaire to 82 male judo practitioners. This prior study reported a highly significant prevalence of lower back pain, with prevalence varying lightly according to weight category; 34.5% in the light-weight category; 32.3% in the middle-weight category, and; 40.9% in the heavy-weight category. Nonetheless, the present study did not unveil a notable percentage of symptomology relating to lower back pain in the general diagnosis made of injuries. Indeed, such symptoms were only reported for 5.8% of all injuries suffered during training and 1.1% of injuries suffered during competition.

With regards to the area affected by injury, a systematic review performed by Pocceco et al. (2013) with judokas participating in the 2008 and 2012 Olympic Games showed identical results to those presented in the present article. In this sense, the three most commonly injured areas of the body were the knee, shoulder and hand (explaining around 11-12% of injuries on average). An interesting observation in this respect has been made by Pocceco E. et al. who concluded that psychological factors may increase injury risk in judo (Pocceco et al., 2013).

A study performed by Burks and Satterfield using surveys of martial arts practitioners found 186 ankle and foot injuries. These authors concluded that the practice of martial arts was associated with different types of injuries in the lower limb (Burks and Satterfield, 1998). Although it is difficult to compare these prior data with our data given that Burks and Satterfield did not focus exclusively on Judo, they do indicate some agreement with regards to the most commonly injured areas of the body. Specifically, the lower limb was the most affected area in both research works.

A novel aspect of the present work that should be highlighted pertains to its examination of injury incidence in relation to tori and uke (judoka performing a throw or being thrown) and the moment at which the injury took place (training

or competition). These aspects are entirely novel as this is the first study the associate these variables. Outcomes of this associative analysis reveal that, regardless of whether the judoka was performing a throw or being thrown when injured, the lower limb is the most affected area of the body (43.6%), followed by the upper limb (30.3%) and the trunk (19%). Further, 11 types of anatomical tissue were studied, revealing that musculoskeletal tissue is the most frequently injured (27.9%), mainly in the thigh (8.5%) and leg (6.6%). This is followed by joint tissue (24.9%), in relation to which the knee (15.1%) and hand-wrist (12.2%) are most often affected. Results also conclude that uke judokas are more affected than their counterparts, with joint tissue (34.1%) and ligament (18.1%) being the most influenced tissue types. These outcomes differ to those obtained by Čierna et al., (2019) in their epidemiological study of injuries suffered by elite European athletes engaged in Judo. In this alternative instance, the most affected anatomical region was the head/neck, accounting for 41% of injuries. This disparity in results is due to the fact that Čierna et al. only considered injuries produced during competition, whereas the present study covered injuries suffered by tori and uke in both competition and in training (Čierna et al., 2019).

A finding of notable interest and great relevance to the present study comes in the shape of the analysis of the relationship between tori/uke and the moment of injury. This analysis found that uke suffered more injuries than tori and that these injuries occurred more frequently during training than during competition, with this outcome being reflected through a proportion of 7/5. With regards to this final outcome, a valuable observation is made which, a priori, appears to contradict other obtained findings. However, this outcome can be explained when the time dedicated to each activity, training and competition is considered. An elite judoka dedicates between 500 and 700 hours a year to training fights, relative to just 4 to 10 hours a year on combats during competitions. These 4 to 10 hours are shared between 10 to 12 competitions that are spread throughout the year. Each competition tends to involve an average of 5 combats, which last for between 5 and 10 minutes. Considering all of these data together leads to a surprising conclusion. The risk of suffering an injury is between 50 and 90 times greater during combat fought out in competition that during training bouts, despite the fact that far fewer hours are spent engaged in this type of fight. This implies an average of 60 injuries during each hour of competition, relative to just one injury for each hour of training. These outcomes are compatible with those reported in studies conducted by Schmidt (1975) and Nishime (2007) in Karate, with these prior studies also recording more injuries during competition. However, these authors did not consider injuries suffered during training which, although shown by the present study to be less frequent, are relevant because they also lead to a period of rest from the sport (Schmidt, 1975; Nishime, 2007).

In incorporating the novel comparison of tori/uke and moment of injury variable, final results of the present work contribute crucial information to inform the application of preventative measures. Results demonstrate that a relationship exists between the affected body part and the moment at which the injury occurred. This point is of supreme importance when it comes to interpreting outcomes as the incorporation of these variables within studies examining injuries in elite judokas enables analysis of the causes that impact upon the

source of injury during Judo practice. All of the specialised literature consulted to inform the present research examined these variables separately, in isolation, without establishing a connection between them. For this reason, results obtained in the present study are highly reliable when it comes to demonstrating the potential reasons behind injury occurrence.

These last data are of extremely high interest to the RFEJYDA given that they provide incredibly valuable information in relation to the adoption of preventative measures, with the aim of reducing the number of injuries suffered by judokas during different phases of Judo practice.

According to the present results, we can be 95% confident that a highly significant association exists between the area of the body affected by injury and the moment at which this injury is produced. This is evidenced by the emergence of a relationship between trunk and pelvis injuries and training, and between lower limb injuries and competition.

An examination conducted by Engebretsen et al., (2013) of medical records, identified 47 injuries in 383 Olympic judokas (12.3%) during the Olympic Games competition held in London in 2012 (153 females and 230 males). Further, another study of 392 judokas conducted by Green et al., (2007) recorded an injury rate of 13% during competition. Both of these works contribute findings in relation to the injuries suffered by judokas during competitions, however, they did not evaluate the injuries suffered during training sessions.

With regards to rest from sport, we can conclude that 47% of the 2,028 injuries examined forced the athlete to take a break from the sport and that all of these cases were related with a later relapse. Further, 80% of these injuries required treatment with physiotherapy, although only 4% needed surgery.

Finally, it is interesting to comment that notable injuries inherent to Judo are Heberden's nodules. These injuries affect the joints in the hands due to the athlete gripping the kimono and cause perichondritis, or "cauliflower ear", which affects ear cartilage and results from friction with the tatami during randori. Nonetheless, these injuries were not included within the set of injuries studied given that they do not incapacitate the judoka or inhibit them from continuing the activity (González et al., 2007).

Results obtained from the present epidemiological study provide valuable information for the RFEJYDA and, especially, to the medical and technical team. It is particularly useful as it will be very helpful for the prevention of future injuries in judokas, considering whether they are tori or uke, or whether they are competing or training. Based on outcomes of the present study, it is possible to identify the most frequent injuries suffered by tori, these being contractures, tendinopathy and lower back pain, and the most common injuries suffered by uke, these being sprains, contusions and dislocation. Knowledge of these data is of Paramount importance for the multidisciplinary team (physical trainer, coach and medical team) of the RFEJYDA. It equips this team to be able to put into action a prevention program that is adapted to each judoka and, in this way, drive a reduction in injury frequency.

Future research should be directed towards the prevention of sports injuries. Although a variety of research is needed, a focus should be placed on the relationship between the judoka's specific technique (tokui-waza) and the injuries they suffer. Our data reinforces calls to work in an individualised way with each judoka, with the aim of modifying specific sporting gestures which may lead to an injury and affect performance. Thus, the incorporation of a system that follows-up on and monitors injuries in Judo is of great importance.

Implementation of a strategic injury prevention plan in Judo must also consider effective training programs. This has been suggested by Ríos Azuara, Pérez Flores and Ríos Alcolea (2014) who have urged the importance of a good warm-up routine, alongside the establishment of comprehensive biomechanical analysis. In addition to this, Medina and Lorente (2016) have reminded of the need to maintain a good focus on good eccentric development, body core control, balance and proprioception.

CONCLUSIONS

- 2028 injuries were suffered by 86 judokas included on the Spanish National Judo Team (ENJE) during the Olympic periods running from Beijing 2008 to Río 2016. This implies a rate of 2.94, or almost 3 injuries per judoka each year. Incidence was similar between females and males, with judokas with right-sided dominance suffering injuries relatively more frequently.
- Joint injuries and those experienced in the lower limb were more frequent. Injuries occurred more often during competition and when the judoka was acting as uke. Muscular injuries and those affecting the tendons were more commonly suffered in the upper limb, during training and when the judoka was acting as tori.
- Most frequently suffered injuries in the lower limb affected the knee joint. Such injuries were seen more often in males, occurring more commonly during competition and when the judoka was acting as uke. Most frequently suffered injuries in the upper limb affected the hand-wrist. Such injuries were seen more often in males, occurring more commonly during training and when the judoka was acting as uke. Trunk and cervical spine injuries mainly occurred during training, in females and when the judoka was acting as tori.
- The greatest differences were found in relation to the affected region of the body and whether the judoka was performing a throw or being thrown. Injuries suffered by tori judokas exceeded in number those suffered by uke judokas in the thigh, cervical spine and lumbar spine. In contrast, uke judokas suffered more injuries than tori judokas to the hand-wrist, ankles, leg and elbow.
- Based on the results of the present study, prevention strategies are recommended that are individualised to each judoka. Such work should target more closely preventative muscular and joint training, especially in tori judokas.

- Comprehensive knowledge about injury risk in both tori and uke judoka, the moment of training or competition, and potential risk factors related with high-level Judo performance is crucial for the development of effective strategies for the prevention of injuries. The introduction of an injury surveillance system is of paramount importance in Judo.

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