Epidemiology of injuries in Spanish elite throwers

Epidemiología lesional en lanzadores de elite españoles

***Sidorella Braçic*[1]**
***Alfonso Salguero*[2]**
***Fabio García-Heras*[2]**
***José María Yagüe*[2]**
***Olga Molinero*[2]**

[1] Facultad de Ciencias de la Actividad Física y del Deporte, Universidad de León, Spain

[2] Facultad de Ciencias de la Actividad Física y del Deporte, Departamento de Educación Física y Deportiva, Instituto de Biomedicina (IBIOMED), Universidad de León, Spain

Correspondence:
Alfonso Salguero del Valle
asalv@unileon.es

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Abstract

Determining the most relevant injuries in each sport, both in terms of frequency and severity, is essential and represents the initial step in their prevention. The aim of this research was to perform an epidemiological study in athletics throwing, involving 66 Spanish elite throwers. We analyzed the injury rate, the most affected body region, the most frequent injuries, and their relationship with variables such as gender, throwing modality, category, and competitive level. A questionnaire, developed ad hoc from the Injury Surveillance System questionnaire of the National Collegiate Athletic Association (NCAA), was administered. The results showed that, despite a higher number of exposure hours at a higher competitive level, there was a lower injury rate. The lower limb was identified as the most affected body part, with overloads being the most common injury, particularly related to muscle problems.

Keywords: Sport injury, incidence, performance, athletics.

Resumen

Determinar las lesiones más relevantes en cada deporte, frecuencia y gravedad es fundamental, y representa el primer paso para la prevención de las mismas. El objetivo principal de la investigación fue realizar un estudio epidemiológico en la modalidad atlética de lanzamientos. Participaron 66 lanzadores de élite españoles. Se analizó el índice de lesión, región corporal más afectada, lesiones más frecuentes y relación existente entre éstas y el sexo, modalidad de lanzamiento, categoría y nivel competitivo. Se administró un cuestionario desarrollado ad hoc a partir de la herramienta Injury Surveillance System de la National Collegiate Athletic Association (NCAA). Los resultados mostraron que los deportistas de mayor nivel competitivo, a pesar de tener mayor número de horas de exposición, obtuvieron menor índice de lesión. La extremidad inferior fue la más afectada. El tipo de lesión más común fue el de las sobrecargas, concretamente los problemas musculares.

Palabras clave: Lesión deportiva, incidencia, rendimiento, atletas.

Introduction

Competitive sports impose significant physical and psychological demands on athletes, often leading to a high incidence of injuries (Pargman, 2007). Research conducted on 25 Spanish sports modalities confirmed that 78.4% of federated athletes had experienced at least one injury throughout their sports careers. Injury rates ranged from five injuries per 1,000 hours of training to 22 injuries per 1,000 hours of competition, with a global injury rate of 4.1 injuries per 1,000 hours (Pujals et al., 2016).

Injuries can have a profound impact on sports participation, affecting individuals, teams, and communities (Hägglund et al., 2013; Ivarsson et al., 2017). They rank among the most common reasons for sports withdrawal (Crane & Temple, 2015; Pierpoint et al., 2016; Witt & Dangi, 2018). Additionally, these injuries are associated with emotional and cognitive reactions (damage perception, loss, sadness, anger, fear, etc.) which could detrimentally impact the well-being of the athlete and contribute to increased medical expenses resulting from these injuries (Ivarsson et al., 2017; Johnson, 2011).

The initial step in injury prevention is understanding the most significant injuries in each sports modality in terms of both frequency and severity (Edouard et al., 2010; Fuller, 2007). Conducting surveillance on injuries helps in determining the magnitude of the problem, identifying the mechanisms that lead to injuries, and understanding their specific characteristics. This information serves as a valuable source to guide preventive programs and develop new models for treatment, rehabilitation, and functional recovery. It also aids in optimizing sports readaptation processes (Jiménez-Olmedo et al., 2018; Joyce & Lewindon, 2016; Mendiguchia et al., 2012).

Traditionally, research on injury epidemiology has primarily focused on team sports (football, basketball, volleyball, etc.) with relatively limited attention to Athletics, especially in throwing events. A notable exception is the study conducted by Edouard et al. (2010), which involved 121 elite French throwers. This study underscored a moderate to high prevalence of lower limb injuries (59-87%), with a higher incidence during training (60-71%) and often resulting from overuse (43-71%). Additionally, a review by Meron and Saint-Phard (2017) emphasized the importance of technique in injury prevention among these athletes. The authors highlighted the potential risk posed by the necessity to generate high force levels in very short periods, which could stress tendons, muscles, ligaments, and joints.

The methodology for recording injuries should derive from scientific research findings, aiming for simplicity, clarity, and a universally applicable definition of sports injury. It should be free of ambiguities and designed to efficiently collect data on both the incidence and severity of the issue (Best & Shier, 2007; Hägglund et al., 2010).

Various systems have been employed for injury registration in diverse sports events, including American university leagues (Hootman et al., 2007), the World Athletics Championships 2007 (Junge et al., 2008), the Rugby World Cup 2011 (Fuller et al., 2013), and the London Olympics 2012 (Engebretsen et al., 2013). Nevertheless, the heterogeneity in injury definitions, data collection methods, observation periods, study designs, and sample characteristics poses a challenge for result comparison (Butragueño, 2015). These factors collectively limit the feasibility of implementing these instruments or recording systems on a medium and/or large scale. They are less effective for registering various sports disciplines and/or in different locations.

Numerous organizations have established and implemented their injury registration systems, including The Australian Football League's Injury Survey, The Canadian Intercollegiate Sport Injury, The England Professional Rugby Injury Surveillance Project (PRISP), the Fédération Internationale de Football Association Medical Assessment and Research Centre (F-MARC) in football, The Oslo Sports Trauma Research Center (OSTRC) Questionnaire on Health Problems, and The National College Athletic Association Injury Surveillance System (ISS), among others.

In many of these instances, substantial databases have been created, proving highly valuable for formulating preventive measures and assessing their effectiveness in each discipline (Dick et al., 2007). Sports with greater participation, tradition, or significance often have epidemiological studies covering specific periods, presenting data in terms of the injury rate (number of injuries per 1,000 exposure hours) and the severity of injuries (number of missed competitions and/or training sessions) (Fuller et al., 2006). However, there remains a lack of methodological uniformity that would facilitate result comparison across different research studies.

In Spain, several injury registration systems have been developed. LEFUTPRO (Noya, 2008; 2015) conducted a classification of football injuries using the Orchard Sports Injury Classification System (OSICS) (Till et al., 2007). Ortín (2009) developed a system for collecting injuries in professional footballers based on Buceta (1996) and Olmedilla (2003). García-González et al. (2015) designed a tool based on the Enquête permanente sur les accidents de la vie courante from the Institut de Veille Sanitaire (EPAC), adapted for recreational sports. Another group of authors focused on sports injuries in the school environment (Gutierrez-Castañón, 2008; 2014; Martínez de Quel et al., 2019) or, in the case of strength training, PRONAF (Butragueño, 2015; Butragueño & Benito, 2014). It's worth noting the study by Pujals et al. (2016) using an instrument created from Fuller et al. (2006) and Junge et al. (2008) but without achieving the desired standardization in a sports context and national implementation.

Based on the presented evidence, the main aim of this study was to conduct an epidemiological investigation into injuries suffered by elite Spanish throwers. The study

focused on key variables, including body region, injury rate, time lost, and the moment of injury. Additionally, factors such as gender, throwing modality and category were taken into consideration. To accomplish this, the research utilized the translation and adaptation of a widely recognized international tool, the ISS. This method will facilitate result comparisons across studies, ultimately amplifying the overall significance of the findings.

Method

Participants

The sample comprised 66 elite Spanish throwers, whose distribution based on gender, category, discipline, and competitive level is shown in Table 1. This accounted for 21.2% of the overall sample.

Table 1. Distribution of participants according to category, gender, modality, and competitive level

Variables		*fr*	%
Gender	Male	27	40.9
	Female	39	59.1
Category	U18/U20	19	28.8
	U23 (Promise)	20	30.3
	Senior	27	40.9
Modality	Shot put	20	30.3
	Discus	15	22.7
	Hammer	12	18.2
	Javelin	19	28.8
Competitive Level	National	46	69.7
	International	20	30.3

Note: *fr*: frequency. %: percentage. U18: Under 18. U20: Under 20. U23: Under 23.

The inclusion criterion defining them as elite was being ranked among the top 12 throwers according to the Real Federación Española de Atletismo at the time of data collection. This ranking determined their eligibility for participation in the Spanish Championships.

This research adhered to the Ethical Standards of the University of León (Spain) and followed the guidelines set forth by the World Medical Association and the Declaration of Helsinki (World Medical Association, 2013).

Instruments

The instrument employed for data collection was a questionnaire crafted from the Injury Surveillance System (ISS) developed by the National Collegiate Athletic Association (NCAA) (Dick et al., 2007). Comprising 29 closed-type questions, the questionnaire captured sociodemographic details (gender, category, throwing modality, and competitive level), injury-related information (severity, context of the injury, time lost, and modifications in training and/or competition), the athlete's personal circumstances at the time of injury, season period, injury recurrence, as well as training time, weekly training load, competitions, etc., to quantify risk factors.

Following the National Collegiate Athletic Association's guidelines (Dick et al., 2007), injuries were classified as sports-related if they met the following criteria:

a) The injury was considered if it occurred due to participation in organized practice or competition.

b) The injury was deemed if it required medical attention from a coach or sports doctor.

c) The injury was identified if it led to the limitation of the athlete's participation or performance for one or more days after the day of the injury.

Additionally, due to the high level of specificity in the collected data, the injury classification proposed by Gusi and Rodríguez (2002) was used:

1. Traumatic injury (injury to organs or tissues resulting from external mechanical action) was further subdivided into three groups:

- Bone injury: particularly observed in collision-contact sports (football, basketball, handball) or high-risk activities (skiing, mountaineering). It includes fissures, fractures, and dislocations.

- Ligamentous injury: the most common, encompasses sprains or strains from grades I to III grades (tearing).

- Contusion: involving muscles and joints, and minor trauma (associated synovitis).

2. Overuse pathology (all non-traumatic joint problems occurring up to seven days prior to the record) (Marsalli et al., 2017), subdivided into two groups:

- Tendinopathy: highly prevalent, encompasses everything from tendon rupture to tendinitis due to microtraumas, specific modality tendinitis.

- Muscle problems: arising from modality-specific muscle development, including asymmetries, contusions, and muscle tears.

In accordance with the ISS, the injury rate was computed by recording the number of injuries per 1,000 exposure hours. Exposure hours was defined as the duration during which the athlete was exposed to the possibility of injury while engaging in sports practices, including both training and competition.

Procedure

Human observational research was performed to collect information using the administration of a recall questionnaire.

Utilizing data retrieved from the official website of the Real Federación Española de Atletismo (RFEA) (https://www.rfea.es/), which provided access to various rankings spanning different categories and events, a comprehensive list of 394 potential participants was compiled. By cross-referencing and eliminating duplicates from diverse rankings (each athlete included only in the modality where they held the highest position), the potential sample was refined to 284 athletes. Contact was established with each athlete through various ways, wherein they were informed about the study's aims and its voluntary nature. Those who consented to participate subsequently completed an informed consent form along with the ISS questionnaire. Following this, the data were categorized for statistical analysis.

Statistical Analysis

A descriptive analysis of the data was conducted using means, standard deviations for quantitative variables, and frequencies and percentages for categorical variables. Following normality and homoscedasticity tests, a comparative analysis was performed using the independent samples T-Student test and ANOVA based on the independent variables to identify statistically significant differences. The significance level considered for the study was set at $p < .05$*. Data analysis was conducted using the Statistical Package for Social Sciences (SPSS) 26.0. Graphical representation was created using Microsoft Office Excel 2019.

Results

Table 2 shows that 59.1% of the reported injuries were from women. In terms of modalities, the javelin stands out, with 50% of participants reporting experiencing three or more injuries during the studied season.

Table 2. Frequency analysis of injuries during the study season based on gender, modality, category, and competitive level

Variables *fr*		No injury		1 injury		2 injuries		3 or more injuries		Total	
		%	*fr*	*%*	*fr*	*%*	*fr*	*%*	fr	%	
Gender	Male	5	71.4	10	64.3	8	38.1	4	40	27	40.9
	Female	2	28.6	18	35.7	13	61.9	6	60	39	59.1
Modality	Shot put	2	28.6	11	39.3	4	19	3	30	20	30.3
	Discus	1	14.3	7	25	5	23.8	2	20	15	22.7
	Hammer	2	28.6	4	14.3	6	28.6	0	0	12	18.2
	Javelin	2	28.6	6	21.4	6	28.6	5	50	19	28.8
Category	Senior	3	42.9	14	50	6	28.6	4	40	27	40.9
	U23 (Promise)	3	42.9	5	17.9	9	42.9	3	30	20	30.3
	U18/U20	1	14.3	9	32.1	6	28.6	3	30	19	28.8
Competitive Level	National	5	71.4	19	67.9	14	66.7	8	80	46	69.7
	International	2	28.6	9	32.1	7	33.3	2	20	20	30.3

Note: *fr*: frequency. %: percentage. U18: Under 18. U20: Under 20. U23: Under 23.

Table 3 illustrates a profile of throwers with a higher predisposition to injuries. This profile is characterized by being male, participating in the discus modality, belonging to the U18/U20 category, and competing at the national level.

Table 4 presents the frequency of injuries based on the modality, considering the moment of the injury. It is evident that the highest frequency of injuries occurred during training. Specifically, a more in-depth analysis reveals that the highest frequency was observed during practice sessions related to specific technique training (33.3%) and strength training (32.2%).

Table 3. Injuries, exposure hours (training and competition), and injury rate (injuries/1,000 exposure hours) during the study season

Variables M (Sd)		Number of injuries	Training time	Competition time	Exposure hours	Injury Rate
		M (Sd)	*M (Sd)*	*M (Sd)*	*M (Sd)*	
Gender	Male	1.56 (1.31)	471.93 (176.13)	14.85 (5.87)	486.78 (177.70)	3.38 (2.75)
	Female	1.59 (0.08)	445.85 (147.80)	18.85 (8.15)	464.69 (150.51)	3.31 (2.27)
	p	n.s.	n.s.	.033*	n.s.	n.s.
Modality	Shot put	1.40 (0.88)	487.60 (156.10)	19.50 (6.05)	507.10 (155.22)	2.73 (2.46)
	Discus	1.53 (0.83)	432.40 (187.90)	19.67 (9.90)	452.07 (192.85)	3.83 (2.56)
	Hammer	1.33 (0.78)	417.83 (135.12)	15.50 (7.34)	433.33 (139.93)	3.13 (2.50)
	Javelin	1.95 (1.39)	467.26 (156.57)	13.95 (5.67)	481.21 (157.37)	3.71 (2.41)
	p	n.s.	n.s.	n.s.	n.s.	n.s.
Category	Senior	1.48 (1.09)	478.74 (125.82)	16.48 (7.18)	495.22 (129.95)	2.99 (2.27)
	U23 (Promise)	1.70 (1.17)	473.80 (179.78)	19.30 (8.66)	493.10 (181.99)	2.44 (2.71)
	U18/U20	1.58 (0.84)	406.74 (175.67)	16.05 (6.58)	422.79 (175.12)	3.72 (2.51)
	p	n.s.	n.s.	n.s.	n.s.	n.s.
Competitive Level	National	1.63 (1.12)	415.00 (146.56)	15.57 (6.29)	430.57 (147.36)	3.78 (2.53)
	International	1.45 (0.83)	552.00 (148.50)	21.00 (8.83)	573.00 (150.38)	2.33 (2.00)
	p	n.s.	.001**	.006**	.001**	.027*
Total		1.58 (1.04)	456.52 (159.21)	17.21 (7.52)	473.73 (161.23)	3.34 (2.46)

Note: *M: Mean. Sd: Standard Deviation*. U18: Under 18. U20: Under 20. U23: Under 23. *p: Significance*. n.s.: *Not significant.* *: $p < .05$. **: $p < .01$.

Table 4. Moment of the injury, modality, and frequency of the injury

Moment of injury	Shot put		Discus		Hammer		Javelin		Total	
	fr	%	*fr*	%	*fr*	%	*fr*	%	*fr*	%
TRAINING	28	30.77	20	21.98	13	14.29	30	32.97	91	100
Before training	0	0.00	1	5.00	0	0,00	0	0.00	1	1.10
During training	28	100	19	95.00	13	100	30	100	90	98.90
Warm-up	1	3.57	0	0.00	1	7.69	0	0.00	2	2.22
Specific Technique Training	8	28.57	3	15.79	4	30.77	15	50.00	30	33.33
Strength Training	14	50.00	8	42.11	3	23.08	4	13.33	29	32.22
Plyometric	1	3.57	3	15.79	0	0.00	3	10.00	7	7.78
Running	3	10.71	4	21.05	2	15.38	4	13.33	13	14.44
Others	1	3.57	1	5.26	3	23.08	4	13.33	9	10.00
After training	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
COMPITING	4	30.77	4	30.77	2	15.38	3	23.08	13	100
Before competition	0	0.00	0	0.00	1	50.00	0	0.00	1	7.69
During competition	4	100	4	100	1	50.00	2	66.67	11	84.62
After competition	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
OTHERS	0	0.00	0	0.00	0	0.00	1	33.33	1	7.69
Total	32		24		15		33		104	

Note: *fr:* frequency. %: percentage.

Figure 1 illustrates the body parts affected by the recorded injuries, categorized by gender, category, discipline, and competitive level. Detailed information is provided regarding the affected body regions, including head/neck, upper limb, trunk/back, and lower limb.

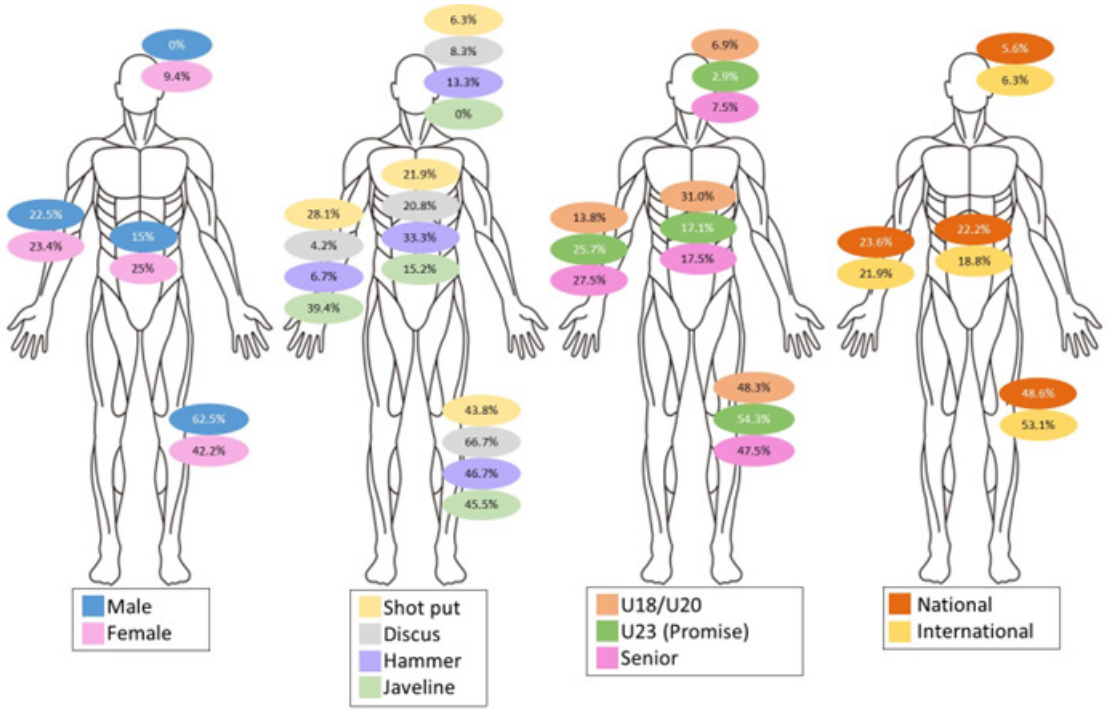

Figure 1. Anatomical location of injuries based on gender, modality, category, and competitive level

It is notable that the lower limb was the most affected across all the analysed independent variables. However, the substantial percentage of upper limb injuries, especially among javelin throwers (39.4%), should not be overlooked. An exception was observed among athletes in the U18/U20 category, where there was a higher percentage of injuries in the trunk/back region (30.0%).

When examining each of the throwing modalities, out of the total 104 recorded injuries, 31.7% were classified as traumatic, while 68.3% were attributed to overload. Hammer throwers exhibited a higher incidence of both ligamentous (23.1%) and muscle (40.4%) injuries (Figure 2).

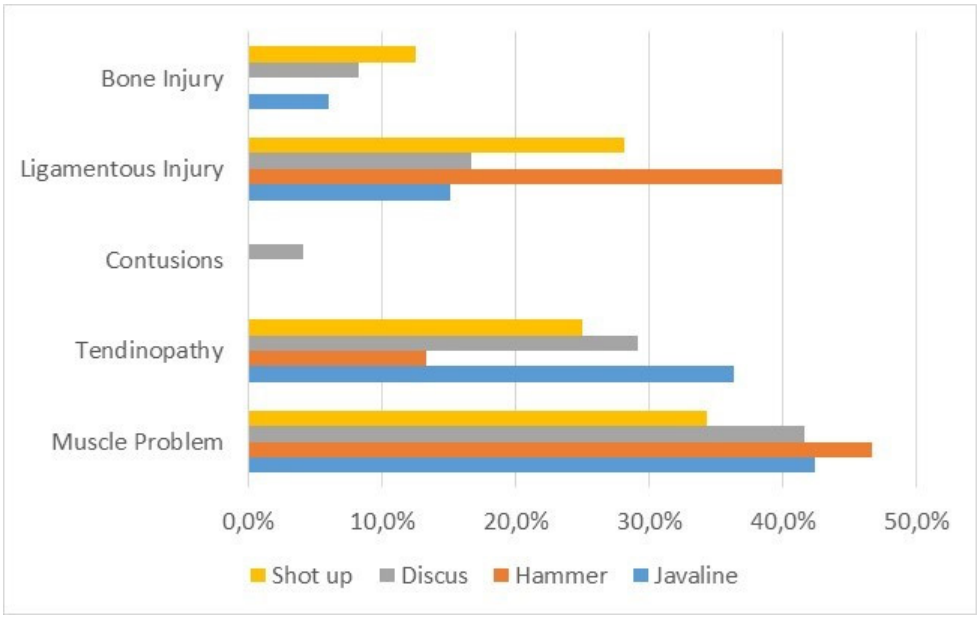

Figure 2. Type of injury based on modality

Lastly, Table 5 compiles the recorded injuries categorized by training sessions. It is noteworthy that the highest number of injuries (n = 45) occurred among those who trained between three and six sessions per week.

Table 5. Injuries based on weekly training sessions

Injuries	From 3 to 6 sessions/ week		From 7 to 9 sessions/ week		More than 9 sessions/ week		TOTAL	
	fr	%	*fr*	%	*fr*	%	*fr*	%
No injury	5	10.0	2	15.4	0	0	7	10.6
1 injury	24	48.0	2	15.4	2	66.7	28	42.4
2 injuries	14	28.0	6	46.2	1	33.3	21	31.8
3 injuries	5	10.0	3	23.1	0	0	8	12.1
5 injuries or more	2	4.0	0	0	0	0	2	3.0
TOTAL	50	100	13	100	3	100	66	100

Note: *fr:* frequency. %: percentage.

Discussion

The present study contributes valuable insights into the epidemiology of sports-related injuries among Spanish elite throwers. The results provide novel and noteworthy data, particularly as the study focuses on a specific discipline within athletics, addressing a gap in scientific publications. Notably, the study goes beyond considering only competitive category (age) and gender; it also differentiates among various events within throwing competitions and their respective competitive levels. This comprehensive approach aligns with recommendations from authors such as Meron and Saint-Phard (2017).

Women exhibit a higher injury frequency at 59.1%, compared to 40.9% in men. These percentages closely align with those reported by specialists in throwing events studied by Edouard et al. (2010), where women accounted for 60% of injuries compared to 40% in men. In terms of the number of training hours per year, men trained significantly more than women (p = .024*). However, women engaged in more competitions, resulting in similar total exposure hours.

The data obtained do not provide statistical evidence to assert that a particular throwing modality is significantly more injurious. However, it is notable that both discus and javelin exhibit a higher injury rate. These findings differ from those reported by Edouard et al. (2010), where hammer throwers were identified as the most injured.

Concerning the category of athletes, senior and U23 (Promise) throwers exhibit the same frequency of injuries, even though the former, albeit not significantly, accumulate a greater number of exposure hours (frequency and training sessions, number of competitions, etc.). This phenomenon could be attributed to the protective effect of training, as well as a more effective transfer of specific strength training and technique, particularly in the case of higher-category athletes (Meron & Saint-Phard, 2017; Romero & Tous, 2010).

The injury frequency among throwers is considerable, with 59 out of 66 participants experiencing at least one injury during the studied season. Additionally, it is noteworthy that international athletes tend to have lower injury rates than national athletes, despite having a greater number of exposure hours. This trend is observed in other sports modalities such as beach volleyball (Jiménez-Olmedo et al., 2018). Various studies suggest that international athletes invest more time in training and potentially focus more exclusively on sports preparation, enhancing their physical condition and refining their technique, two fundamental aspects in injury prevention (Meron & Saint-Phard, 2017; Romero & Tous, 2010).

Concerning the moment of injury, many injuries occur during training. Javelin throwers experience the highest number of injuries during specific technique training, while shot put athletes are more prone to injuries during strength training. This differs from the findings of Morgan and Oberlander (2001), who observed the highest number of injuries during competitions in a sample of football players. The discrepancy could be attributed to the contest format of throwing competitions, which lacks direct contact or opposition. Additionally, the protective effect that coaches provide through direct feedback during competitions may contribute to these differences (D'Souza, 1994). A higher frequency of injuries during training could also be justified by a decrease in concentration, leading to a distortion of the load/technique (D'Souza, 1994).

The most of recorded injuries in Spanish throwers were in the lower limb, contrary to what might be expected based on the technical characteristics of the modalities. Similar findings were observed in the study by Ahuja and Ghosh (1985), which reported that the most of injuries in athletics were in the lower limb, ranging from 59% to 87%. It's important to note that this study does not differentiate between modalities. D'Souza (1994) also concurred that the most common injuries in throwers were in the lower limb, specifically in the ankle, followed by the back. These lower limb injuries could be attributed to a forced inversion

movement when stepping on the perimeter of the throwing area, the rotational technique, and biomechanical/morphological factors (inertia, mass centre, etc.).

The analysis of each throwing modality revealed that javelin throwers, who experienced a higher number of injuries during specific technique training, also stand out for suffering more injuries on the upper limb. Similar results were obtained by Schmitt et al. (2001), attributing it to the technique and/or biomechanics. The shoulder undergoes extreme forces in sports with a movement pattern similar to javelin throwing, such as baseball (Lin et al., 2018) or paddle tennis (García-Fernández et al., 2019). It's important to note that although shoulder and elbow injury patterns vary by sport and position, throwing sports share a common reliance on the kinetic chain integrity to generate and transfer energy from larger to smaller body parts (Edouard et al., 2010; Fleisig et al., 1996; Meron & Saint-Phard, 2017).

Finally, concerning the type of injury, the ones that most affected the sample were overloads, primarily muscle problems. Meron and Saint-Phard (2017) also highlighted muscle and tendon problems as the most common, irrespective of the throwing modality. Edouard et al. (2010) observed that the most prevalent injuries were tendinopathies (31%) and ligamentous injuries (33%). This type of pathology can influence joint stability and predispose individuals to future degenerative injuries (Schmitt et al., 2001).

Conclusions

Based on the obtained results, there are significant differences in the injury rate depending on the competitive level. The higher the level, the greater the number of exposure hours, but paradoxically, the lower the injury rate. This phenomenon could be justified by the preventive effects of enhanced physical fitness, technical proficiency, and the professionalization of athletes at an international competitive level.

The lower limb was the most affected area, with a notable prevalence of injuries in the upper limb, particularly in the javelin modality. The predominant type of injury was overload, attributed to the elevated physical demands of the sport.

Despite variations in coaches, training models, work plans, and the frequency of sessions and competitions per year within the sample, striking similarities have been observed in terms of the causes and timing of injuries. While the technique and biomechanics of each throwing modality entail specific demands, there is a consensus on the common need to generate high levels of force in very short periods, resulting in similar and generalizable injuries.

The adaptation of the ISS has proven to be a valuable tool for collecting epidemiological data, enabling the design and implementation of injury prevention plans.

A potential limitation of this research stems from the absence of a unified tool for collecting injury data, hindering direct comparisons with studies conducted in other countries. Consequently, future research endeavours should focus on standardizing this instrument to facilitate genuine quantification and the implementation of measures for injury reduction within the national sports context. Moreover, while the sample size could be deemed adequate concerning the population under study, its homogeneity might have influenced significant differences in some of the analysed independent variables.

Finally, it is worth noting that the applicability of this study lies in the wealth of data it provides. The study contributes to a more profound understanding of the injury phenomenon in this sport modality. This information can be valuable for future research, the formulation of primary prevention protocols, enhancing the injury readaptation process, reducing recovery times, and ultimately improving the performance and well-being of the athletes.

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