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ORIGINAL

INJURY EPIDEMIOLOGY IN COMPETING AND NON-COMPETING SPANISH CROSSFIT® PRACTITIONERS

EPIDEMIOLOGÍA LESIONAL EN PRACTICANTES DE CROSSFIT® COMPETIDORES Y NO COMPETIDORES ESPAÑOLES

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ABSTRACT

The lack of studies on Crossfit® injuries in Spain, motivates the realization of this descriptive, observational and retrospective epidemiological study, analyzing the incidence and characteristics of injuries suffered by Crossfit® competitors and non-competitors.The injuries suffered by 434 athletes between from January 1st to December 31st 2019 were recorded. We collected data on the number of injuries, the most frequent injuries, their distribution, type, location, the moment at which these occurred and the cause of the injuries affecting the musculoeskeletal system. We found that the injury rate in this population was 3,48 injuries per 1000 hours of risk. The shoulder and lumbar area were the most frequently injured anatomical areas, with muscle and tendon being the most common seat tissue of injuries. Powerlifting was the most damaging activity.

KEYWORDS: Crossfit®; epidemiology; injury; shoulder; powerlifting.

RESUMEN

La falta de estudios sobre lesiones en Crossfit® en España, motiva la realización de este estudio epidemiológico descriptivo, observacional y retrospectivo, analizando la incidencia y las características de las lesiones sufridas por practicantes de Crossfit® competidores y no competidores. Se registraron las lesiones sufridas por 434 deportistas entre el 1 de enero y el 31 de diciembre de 2019. Se registraron datos sobre el número de lesiones, lesiones más frecuentes, distribución, tipo, ubicación, el momento en que ocurrieron y la causa de las lesiones que afectan el sistema musculoesquelético. La tasa de lesiones en esta población fue de 3,48 lesiones por 1000 horas de exposición al riesgo. El hombro y la zona lumbar fueron las zonas anatómicas más frecuentemente lesionadas, siendo el musculo y el tendón el tejido de asiento más habitual de las lesiones. El Powerlifting fue la actividad más lesiva.

PALABRAS CLAVE: Crossfit®; epidemiología; lesión; hombro; powerlifting.

INTRODUCTION

CrossFit® is one of the sport disciplines to have experienced the greatest growth in recent years. The first "box", the term used to denominate the place in which this sport is performed, was created in the year 2000, although its creator Greg Glassman had already started to develop the first training routines in Pasadena in 1974 which would go on to become CrossFit® (1, 2). In 2007, "the CrossFit® Games" were born. This competition brought together athletes from around the world once a year to take part in this sporting discipline. In 2011, the sports brand Reebok® entered into an endorsement and sponsorship agreement with this sport for the following 10 years, with 2020 being the final year of this deal (3, 4). During this period, the name of the games was changed to the Reebok CrossFit® Games. In the present day, there are estimated to be more than 13.000 official boxes around the world and around 500 in Spain (3).
The rules of this sport are modified every year. They are listed on the official CrossFit® webpage, where the "competition rulebook" can also be found. This rulebook describes all that is relevant to "the open", which consists of five different routines denominated "workout of the day (WOD)" for 5 consecutive weeks. These training routines are published on the official website and serve to classify the best athletes in each country and the 20 best worldwide. It also provides information about participating age groups, the way in which the competition is structured and how WOD's are judged, and antidoping tests (5).
All official boxes base their activities on the same format in which training routines or WODs are performed that are consistent with regards to Olympic movements (snatch, clean and jerk) and powerlifting (squat, deadlift, press/push

press, bench press), which are performed by adding external loads, gymnastic movements (pull-ups, toes-to-bar, lunges, burpees, box jump) or against ones' own body weight, in addition to metabolic conditioning exercises (running, rowing, cycling)(6, 7). Training routines are designed by combining the aforementioned exercises so that users reach maximum intensity under conditions of cardiovascular and muscular fatigue, with a minimum, or zero, recovery time between them(6, 8).

Various approaches to training exist to achieve this type of sporting practice. Routines vary with regards to timings and the way in which the activity is performed, and can be described as follows(7):

a) As many rounds as possible (AMRAP), in other words, to repeat as many cycles as possible of the indicated exercises in the time given, normally between 10 and 20 minutes.

b) Every minute on the minute (EMOM): In this training type, each exercise or set of exercises indicated by the trainer is performed for 1 minute of the overall time indicated.

c) Rounds for time (RFT): This type of WOD aims for the athlete to perform a determined number of rounds or repetitions within a set time or "time cap".

In contrast to other sports such as football, in which the International Federation of Association Football (FIFA) has developed an agreed upon definition of injury (9, 10), no consensus definition exists in CrossFit® about what constitutes an injury. This makes it challenging to conduct epidemiological studies which, amongst other things, could be compared with other sports. A lack of studies have been carried out on injuries picked up during engagement in CrossFit®. Those that are available, place injury incidence within a range of 0.74 to 9.5 injuries per 1000 h of risk exposure(11).

Up until the time of writing, epidemiological studies have yet to be conducted in Spain on individuals engaging in CrossFit®. For this reason, the main aim of the present study is to describe and evaluate the number of injuries, most common injuries, injury distribution, type and anatomical location, affected tissue, and cause of musculoskeletal injury. Results of the present research may serve to help identify the factors that affect the emergence of these injuries and aid in establishing preventative measures.

MATERIAL AND METHODS

Study design

The study was epidemiological, observational, descriptive, retrospective and cross-sectional in nature.

Methods

It was decided to include any CrossFit® practitioner in the study who was of Spanish nationality, belonged to any of the autonomous regions and was aged between 18 and 65 years. Participants were included whether or not they competed and regardless of sex, nor were they excluded based on whether they had suffered an injury in the 12 months prior to study start. This was to enable injury incidence and prevalence during CrossFit® engagement to be determined. After informing the members of 85 official and unofficial BOX CrossFit® gyms across Spain about the methods and aims of the research study, 478 individuals voluntarily agreed to participate, of which 434 (90.7%) met inclusion criteria (Figure 1). A total of 29.72% (n=129) reported competing, of which 58.91% (n=76) were men and 41.09% (n=53) were women. On the other hand, 70.28% (n=305) did not compete, of which 56.72% (n=173) were men and 43.28% (n=132) were women. All participants signed an informed consent form prior to data collection and the study was conducted in accordance with the principles laid out in the Declaration of Helsinki for research with human beings(12).

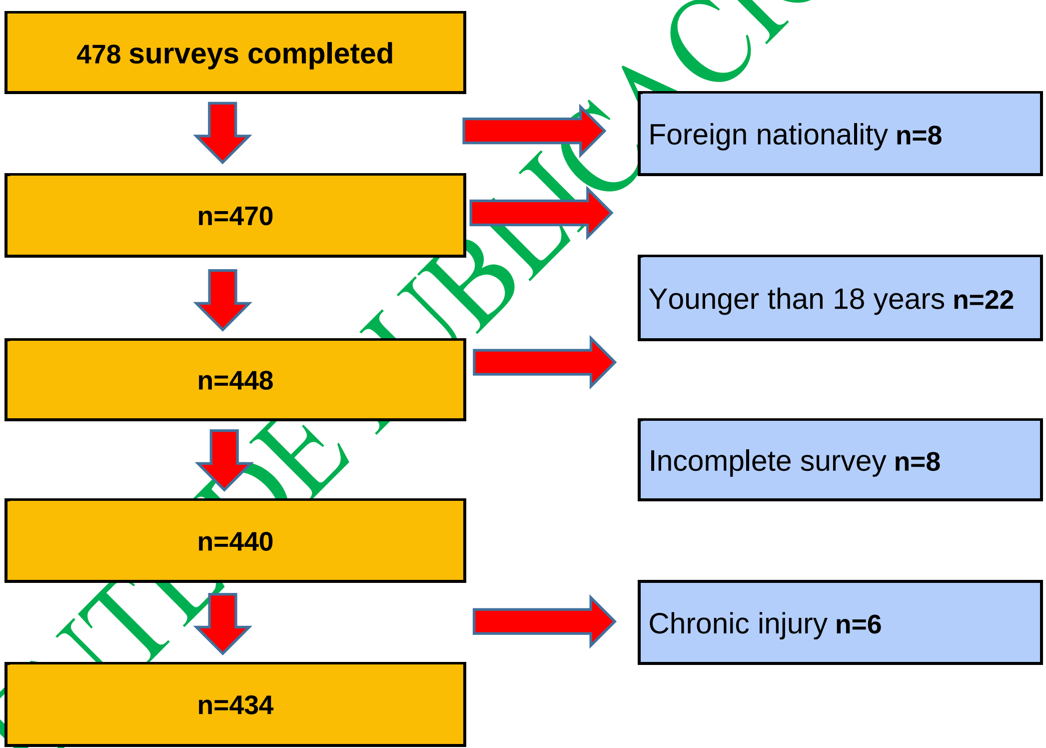

Figure 1. Flow diagram of study inclusion.

Procedure

Data was gathered on all injuries suffered from the 1st of January to the 31st of December 2019. Surveys were completed during the period between the 1st of February and the 30th of May 2020. All injuries suffered during training or competition whilst engaged in CrossFit® were included in the study. An injury was considered to be any new musculoskeletal pain or discomfort resulting from CrossFit® training which fulfilled one or more of the following requirements(4):

1) Leads to the total cessation of CrossFit® training and other physical routines (or physical activity for more than a weak); 2) Leads to the modification of regular training with regards to duration, intensity or approach for more than 2 weeks; 3) Causes any type of pain that is strong enough to have to seek help form a medical professional.

Individuals with one or several injuries had to have achieved a full recovery from these injuries in order to enable correct analysis of their consequences in the present study. Injuries arising during the study period were included, excluding those that marked a recurrence of a previous injury and chronic injuries, in addition to any injury not related with engagement in this sport.

Instruments

The present study used a data collection form based on a study conducted in 2017 by Mehrab et al.(13) in CrossFit® practitioners from Holland. In this aforementioned survey, personal and anthropometric data were collected, alongside data on sport engagement and specific data on the injuries suffered. Injuries were classified in accordance with their anatomical location with regards to main areas and categories pertaining to the OSICS system (Orchard Sports Injury Classification System)(14). In order to classify injury type, the mentioned OSICS system (version 10) was used which includes a total of 1,626 diagnostic types (15).

Injury incidence was calculated as the number of new injuries per 1000 hours of exposure.

Statistical analysis

Gathered data were digitalised and analysed using SPSS® Statistics version 25 (IBM Corp.). Outcomes pertaining to qualitative variables are expressed as percentages. Firstly, the overall sample is described. Secondly, data are stratified according to sex and, thirdly, competition, in other words, whether or not participants were involved in a specific training program developed for competitors. In the same way, means, standard deviations (SD) and 95% confidence intervals (CI) were employed to describe quantitative variables. The normality of gathered data was analysed using the Kolmogorov-Smirnov test. Categorical variables were analysed with the chi-squared test and injury risk was calculated via logistic regression and univariate analysis in order to estimate differences in injury risk between groups (ORs). P-values of <0.05 were considered to be statistically significant.

RESULTS

Of the total sample analysed, 57.4% (n=249) were men and 42.6% (n=185) were women. The anthropometric characteristics of the same are presented in table 1. A total of 418 injuries were recorded, with overall exposure declared by study participants being 120,096 hours. Injury incidence or number of injuries per 1,000 hours of risk exposure was 3.48 injuries per 1000 hours of sport engagement. From this, individual injury rate was calculated as 64.2%. Injury rate or the number of injuries per 100 athletes was 96.31 injuries.

Table 1. Anthropometric characteristics.

	TOTAL		**MEN**		**WOMEN**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
		8.28		8.3		8.24
Age (years)	32.49	**95%CI**	32.85	**95%CI**	32	**95%CI**
		(31.71-33.27)		(31.82-33.89)		(30.87-33.20)
Weight (kg)	69.5	9.22	77.8	7.8	63.2	7.22
		(68.8-72.9)		(76.5-78.5)		(62.5-64.2)
Height (cm)	172.01	9.05	177.53	6.52	164.59	6.23
		(171.1-178.1)		(176.7-178.3)		(162.5-165.2)

Table 2. Characteristics of training habits.

	Competes			Doesn't compete		
	(n= 129)			(n=305)		
	Men (n=76)	**Women** (n=53)	*P*	**Men** (n=173)	**Women** (n=132)	*P*
Training length						
<30 min	-	-		-	-	
30–60 min	29 (38.2)	23 (43.4)		75 (43.4)	58 (43.9)	
60–90 min	23 (30.3)	19 (35.8)	p=0.434	61 (35.3)	60 (45.5)	p=0.132
90–120 min	17 (22.4)	5 (9.4)		30 (17.3)	12 (9.1)	
>120 min	7 (9.2)	6 (11.3)		7 (4.0)	2 (1.5)	
Beginner program, n (%)						
Yes, compulsory	35 (46.1)	21 (39.6)		73 (42.2)	56 (42.4)	
Yes, voluntary	25 (32.9)	15 (28.3)	p=0.233	45 (26.0)	39 (29.5)	p=0.683
No	16 (21.1)	17 (32.1)		55 (31.8)	37 (28.0)	
Training days a week						
Mean ± SD	4.42d ± 1.30d	4.01d ± 1.26d	p=0.082	4.34d ± 1.13d	4.03d ± 1.24d	p=0.027
Rest days a week						
Mean ± SD	1.81d ± 0.76d	1.75d ± 0.78d	p=0.658	2.50d ± 1.03d	2.37d ± 1.00d	p=0.267
Length of engagement						
0-6 months	6 (7.9)	5 (9.4)		14 (8.1)	13 (9.8)	
6-12 months	8 (10.5)	9 (17.0)	p=0.042	16 (9.2)	23 (17.4)	p=0.016
12-24 months	20 (26.3)	21 (39.6)		50 (28.9)	45 (34.1)	
>24 months	42 (55.3)	18 (34.0)		93 (53.8)	51 (38.6)	
Strength days a week						
Mean ± SD	3.34d ± 0.91d	3.60d ± 0.74d	p=0.088	2.65d ± 0.91d	2.8d ± 0.94d	p=0.126
Technical days a week						
Mean ± SD	3.00d ± 1.08d	3.21d ±0.92d	p=0.259	2.41d ± 1.06d	2.26d ± 1.10d	p=0.223
Mobility days a week						
Mean ± SD	2.78d ± 1.29d	2.60d ± 1.36d	p=0.467	2.25d ± 1.31d	2.25d ± 1.26d	p=0.992

In table 2, data from study participants are presented that pertain to sport habits and are stratified according to sex and level of engagement in CrossFit®. It was found that 431 (99.3%) participants performed warm up exercises including specific movements (n=355; 81.8%), whole body movements (n=373; 85.9%), technical movements prior to the WOD (n= 305; 70.3%), dynamic stretching (n=152; 35%) and static stretching (n=176; 40.6%). Only 3 individuals (0.7%) did not perform any type of warm up. Statistically significant differences were not observed between men and women with regards to whether or not they belonged to an official box (57.4% men [n=249]; 42.6% women [n=185]; χ^2=0.59 (*P*=0.808).

Table 3. Number of injuries according to competition level and sex

Injuries	Compete (n=129)			Doesn't compete (n=305)		
	Men (n=76)	Women (n=53)	*P*	Men (n=173)	Women (n=132)	*P*
0	20 (26.3)	11 (20.8)	P=0.346	71 (41.0)	53 (40.2)	P=0.904
1	36 (47.4)	20 (37.7)		59 (34.1)	48 (36.4)	
2	15 (19.7)	16 (30.2)		37 (21.4)	25 (18.9)	
3	5 (6.6)	6 (11.3)		6 (3.5)	6 (4.5)	

Significant differences were not observed between men and women who had suffered injury (57.2% men [n=158]; 42.8% women [n=121]; χ^2=0.011; *P* = 0.916), however, differences were seen between those who competed and those who did not (35.1% those who competed [n=98]; 64.9% those who didn't compete [n=181]; χ^2 = 10.91; *P* = 0.01). Significant sex differences were not found in regards to the number of injuries, regardless of competitive level (table 3).

With regards to injury risk, participants who participated in competitions were observed to be at 2.166 times greater risk of suffering any type of injury than those who did not compete (95% CI = 1.362-3.445; *P* = 0.001), whilst athletes who engaged in CrossFit® at unofficial box gyms were at 30.9 times greater risk of suffering any type of injury than those who participated at official CrossFit® box gyms (OR= 0.309; 95% CI = 0.134-0.712]; *P* = 0.004). On the other hand, risk of suffering each one of the most common injuries described above was examined without obtaining statistically significant outcomes in any instance.

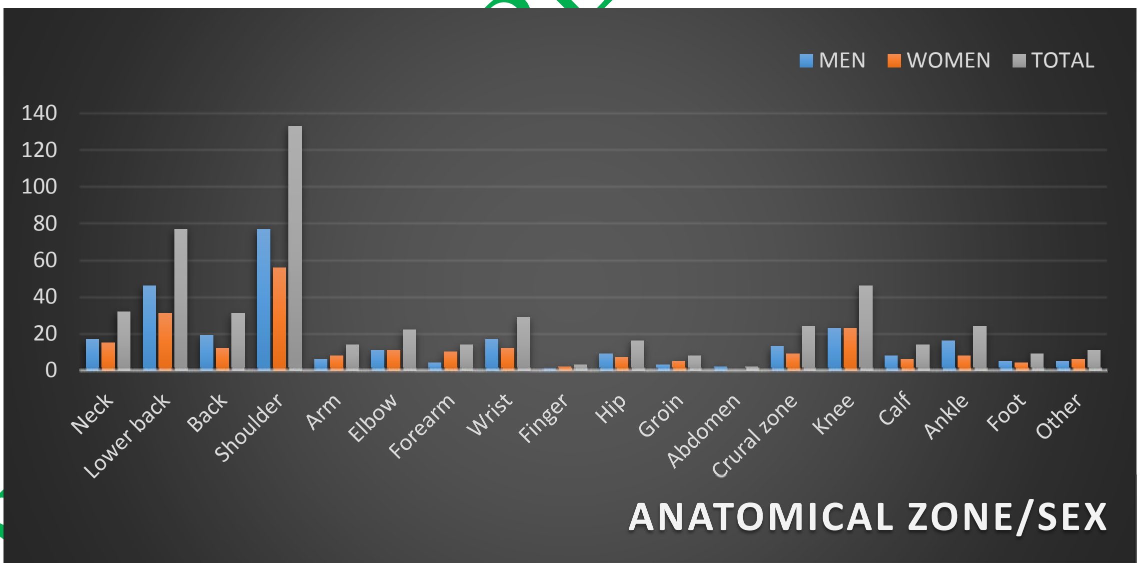

Figure 2. Anatomical location of injuries.

With regards to location of the injury, outcomes were similar between men and women, and independent of level of engagement. Most injuries occurred in the shoulder (n= 133, 30.6%), lumbar region (n= 77, 17.7%), knee (n= 46, 10.6%) and wrist (n= 29, 6.7%) (figure 2).

The most commonly affected tissue was muscle tissue (n=141, 33.7%), followed by tendon (n=129, 30.8%) and, thirdly, joint tissue (n=104, 24.8%).

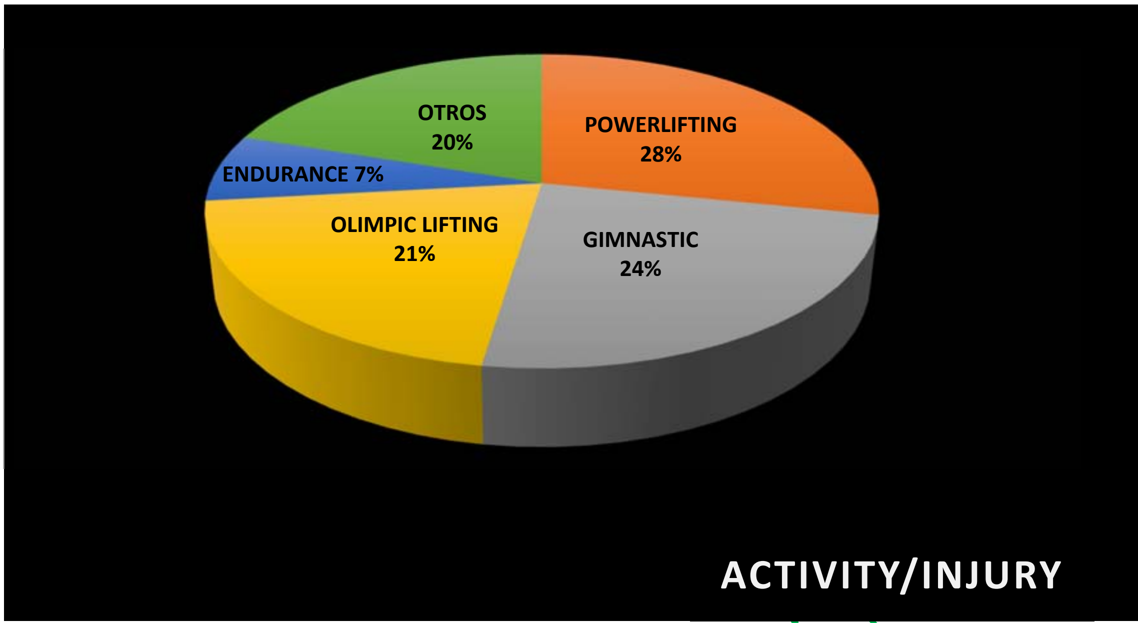

Figure 3. Activity being performed at the time of injury.

The activity that caused the most injuries was powerlifting (n=118, 28%), followed by gymnastics exercises (n=101, 24%) and, thirdly, Olympic movements (n=87, 21%) (figure 3).

DISCUSSION

The present epidemiological study is the first conducted in Spain in which CrossFit® practitioners are analysed in consideration of their competition level and sex. Findings of the present work revealed an injury incidence of 3.48 injuries per 1000 hours of engagement in the sport of CrossFit®, with incidence being 3.95 within those who competed and 3.28 within those who did not. Descriptive epidemiological studies on CrossFit®, which have employed a similar design and injury definition to that of the present study, have reported analogous injury incidences. Specifically, Szeles et al.(16) reported a rate of 3.24/1000h and Hak et al.(17) reported 3.1/1000h. Nonetheless, large variability exists in the injury incidence of previously published works. Rates range from 0.27 in highly experienced practitioners and 0.74 in recreational practitioners (18), up to 9.5 injuries recorded by Larsen et al.(11) in a study conducted over eight weeks in inexperienced practitioners. Further, large variability also exists with regards to the percentage of athletes injured. The present study recorded that 64.2% of athletes suffered an injury, though it is possible to find studies in the scientific literature that report proportions ranging from 26%(19) to 73.5%(17). These notable differences between different studies might be due to the different methodologies employed for data collection and study populations. This means that an agreed proposal is essential to unite the methods of epidemiological studies of this sport. This would enable more reliable conclusions to be reached and, consequently, make it possible to develop prevention strategies.

It is possible to compare the injury incidence uncovered in the present study with those of other sporting activities that can be considered to be similar. For instance, when considering Olympic weight lifting, injury incidences have been reported that range from 2.4 to 3.3 injuries (20, 21), whilst 1.0-5.8 injuries have been reported for weightlifting (21-25), indicating a similar injury incidence. When comparing this with other sports, such as pádel (racquet sport invented in Mexico and highly popular in Spain), 2.75 injuries/1000h have been reported(26). Athletics is a sport which could seem, at first, to be more conducive to injury. Indeed, injury incidence reported in a meta-analysis performed by Videbaek et al.(27) in 2015, was located between 7.7 and 17.8 injuries per 1000h of exposure. It can, therefore, be stated that CrossFit®, in contrast to that expected given its explosiveness, high stress and repetitive movements, is not particularly conducive to injury.

It was observed that participants who competed were at a 2.166 times greater risk of injuring themselves than those who did not compete (95% CI= 1.362-3.445; P = 0.001). In this sense, a number of studies support the present findings(16, 19, 28, 29). It is possible that the demands of competition, together with the greater hourly exposure that comes from preparing for events, are behind this greater injury risk. An important statistic to highlight from the present study is that athletes who engaged in CrossFit® at unofficial boxes had a significantly higher risk, concretely 30.9 times higher, of suffering any type of injury than those who engaged in CrossFit® ® at an official box. It is likely that these differences are explained by the lack of trainers and coaches with appropriate qualifications, together with incorrect load management and recovery time in athletes training at unofficial boxes.

In the present study, outcomes pertaining to the anatomical location of injuries found similarities between men and women and between those who competed and those who did not. The most frequently affected area was the shoulder (n= 133, 30.6%), followed by the lumbar region (n= 77, 17.7%) and, thirdly, the knee (n= 46, 10.6%). A large number of studies have pointed to these areas as the most commonly affected by injury (4, 8, 13, 19, 30-32). It is likely that the constant application of stress to these areas during CrossFit® and the nature of movements could negatively influence that technical quality of executed movements, alongside the speed of execution and the high number or repetitions performed in anaerobic conditions with little recovery time in between (in those WODs that include routines based on AMRAP or RFT). This would favour the appearance of injuries in the aforementioned structures. In their study with Olympic weightlifters, Keogh and Winwood(33) indicated in 2016 that injuries most often affected the knee, followed by the lumbar region and the shoulder. These athletes work regularly on the technical execution of a closed movement which is produced in conditions of low fatigue. For this reason, it would appear correct to argue that the argument made above, with regards to fatigue and lack of technique, provokes an increase in the number of injuries in more vulnerable areas such as in the shoulder.

Further, the relationship established between the lack of technique and injury incidence is strengthened by the fact that, in the present study, athletes with less than 6 months experience suffered 20.8% of the injuries reported, despite only representing 9% of the sample. Studies conducted by Feito et al. (13) and Mehrab et al. (18) also indicated that novice CrossFit® practitioners presented with a greater number of injuries. It is possible that the aforementioned lack of technique, lower levels of strength, absence of personalised planning and the fact that, often, athletes of different abilities perform the same work together as a group, is the reason behind the higher number of injuries seen in the most novice group. Nevertheless, many studies (16, 19, 28, 29, 34) have determined that athletes with the most experience are more propense to injure themselves that all other athletes. This indicates that the length of exposure and more demanding technical performance, together with the fact that more experienced athletes tend to be those who take part in competitions, could also lead to a meaningful increase in the number of injuries. For this reason, a clear correlation cannot be defined between level of experience and injury incidence in CrossFit®. This suggests that injuries in this sport are more related with length of exposure, level of engagement or habits during engagement, such as not performing an adequate warm-up or a correct cool down.

The most frequently injured tissue in the present study was muscle tissue (n=141, 33.7%), followed by tendon tissue (n=129, 30.8%) and, thirdly, joint tissue (n=104, 24,8%). Few studies in the scientific literature have approached this aspect and those that have suggest discrepancies. In a study conducted by Tafuri et al., with Italian CrossFit® practitioners, musculoskeletal injuries were uncovered to be the most common injury type, with tendonitis particularly standing out (16.7% of all injuries)(8). Nonetheless, Minghelli et al. (28) stated that joint injuries were the most common, followed by muscle injuries. It is likely that the fact that, in the present study, muscle injuries were the most common, followed closely by tendon injuries, is related with the nature of the WODs engaged in. Powerlifting tended to predominate, this being the most harmful activity causing 28% of injuries, followed by gymnastic injuries which were the reason behind 24% of injuries. In these types of routines, high load exercises are performed such as squats and deadlifts, in addition to explosive actions such as burpees or toes to bar. Such actions, when performed with an incorrect technique, or insufficient strength and flexibility, could lead to a high number of injuries. Such exercises have also been indicated by other studies as being more harmful, for instance in a study by Weisenthal et al.(4) and, more recently, by Alekseyev et al. in 2020(30). Given all of that presented above, we believe that the injury characteristics of athletes engaging in CrossFit® in Spain are similar to those seen in other countries in which the development and uptake of CrossFit® is comparable and where, in addition, similar income and socioeconomic development is seen.

Given the large uptake and exponential growth of the number of individuals having participated at least once in this activity in recent years, it would be prudent to establish preventative measures to apply during engagement in CrossFit®. Such measures ought to contribute to a reduction in the number and severity of injuries. Given that it has been confirmed that training at an official box reduces injury risk, practitioners and, above all, those who are just starting out, should opt to join these types of centres. Programs should be established for beginners which include follow-up by experienced trainers. These programs should work, in depth, on technique, especially in those activities highlighted as being more conducive to injury, such as powerlifting, focusing efforts on the most vulnerable regions such as the shoulder joint and the lumber region.

Workloads and rest breaks must be correctly planned, both in terms of the external and internal load. In the case of the former, the use of new technologies such as GPS, local positioning systems and devices that measure the speed of execution or the time subjected to stress offer highly interesting options. For evaluation of the internal load, use of wellbeing questionnaires, sleep quality monitoring systems and tracking of recovery between sessions could be useful.

Of the limitations of the present study, it serves to highlight that the recording of data through a questionnaire about injuries suffered during the previous year could be biased due to important information sometimes being lost. Further, sometimes this information may be influenced by subjective aspects such as the athlete's pain perception.

CONCLUSIONS

The lack of epidemiological studies in CrossFit® in Spain makes examination of sport habits and injuries resulting from this type of sport necessary to be able to contribute towards better prevention. Injury incidence as a result of engaging in CrossFit® was 3.48 injuries/1000h. The shoulder and the lumbar region were the two most frequently injured anatomical regions, with muscles and tendons being the most commonly injured tissues.

Training in an unofficial box, having less than 6 months experience and participating in competitions significantly increases the risk of suffering an injury. No sex differences were found in injury behaviour. Powerlifting is the most injury conducive activity.

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