

## Injury patterns and rates of Costa Rican CrossFit® participants - a retrospective study

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**Abstract.** CrossFit® has been defined as a constantly varied, high intensity, functional movement strength/conditioning program that has seen a large increase in popularity. Few studies have specifically investigated either injury patterns, injury incidence (per 1000 hours), and/or injury prevalence sustained in the sport.

**Material and Method.** Eighty-eight males ( $31.3 \pm 8.4$  yrs,  $1.74 \pm 0.06$  m,  $79.45 \pm 12.02$  kg) and 71 females ( $31.3 \pm 9.1$  yrs,  $1.62 \pm 0.07$  m,  $60.75 \pm 9.37$  kg) filled the survey to completion and were included in this investigation. The survey covered demographics, length of time performing CrossFit®, average number of days per week/minutes per workout performing CrossFit®, injuries obtained during CrossFit® within the last 12 months, and specific characteristics of injuries sustained. This was a descriptive survey study.

**Results.** Participants reported an average of  $4.3 \pm 0.9$  CrossFit® workouts per week at an average of  $1.19 \pm 0.37$  hours per workout. More than half of the participants (50.3%) reported only doing CrossFit® as their mode of exercise; the other 49.7% reported doing sports such as running/swimming/weightlifting. Seventy-four participants reported 127 CrossFit® related injuries, yielding an injury prevalence of 46.5% and an estimated incidence of 3.3 per 1000 hours. Of the 127 injuries reported, the most commonly injured body parts were the shoulder (33.1%), low back (18.1%), knees (12.5%), wrists (10.2%), and elbows (5.5%). Only 1 case of rhabdomyolysis (0.8%) was reported. There was a significant relationship between getting injured and length of time in doing CrossFit® ( $p < 0.01$ ) and getting injured and participating in CrossFit® competitions ( $p = 0.02$ ).

**Conclusion.** The injury incidence rates in this study are similar to those reported in other CrossFit® and weightlifting studies and less than those reported in American football and soccer studies. Participants that compete in CrossFit® competitions and have been doing CrossFit® for longer periods of time are also more likely to sustain an injury related to CrossFit®.

**Key words:** *crossfit, injury rate, weightlifting, injury prevalence.*

### Introduction

Since the introduction of *CrossFit®* in 2000 by CrossFit® Inc., the training program has expanded to over 13,000 affiliate gyms across the globe. According to the CrossFit® Inc. website, CrossFit® is defined as functional movements performed at a high intensity that are constantly altered (1). CrossFit® utilizes a Workout of the Day (WOD) approach where each daily workout is meant to target different areas of fitness by continually rotating the exercises. Although competitive in nature, the WOD can be adjusted to meet the needs of the individuals by modifying the volume and load. Focusing on high intensity and power output in varying conditions to prepare individuals for unknown situations and conditions, this program seems to have applicability to a wide range of individuals across various interests and certain careers (1). Police officers, fire fighters, and military personnel are examples of careers where CrossFit® may prove to be particularly beneficial.

The effectiveness of CrossFit® training has been documented in several studies. An eight-week study conducted by the United States Army reported that CrossFit® training improved their power output by 20% and concluded that the CrossFit® program was successful in improving each soldier's general level of fitness (2). While CrossFit® workouts appear to be effective at improving levels of physical fitness, there are mixed results regarding the rates of injuries as a result of CrossFit® training.

Some of the information reported thus far has been controversial and only a few studies have specifically focused on investigating injury rates among CrossFit® participants. Several case reports have suggested that CrossFit® training has caused injuries such as retinal detachment (3), cervical internal carotid artery dissection (4), a latissimus dorsi tear (5), and rhabdomyolysis (6, 7); however, it is difficult to generalize information from a single case and to draw definitive cause-effect conclusions.

Several studies utilizing surveys have surmised that the injury rate associated with CrossFit® participation is similar to other forms of exercise. For example, Summitt et al (8) surveyed 980 individuals regarding shoulder injuries due to participation in CrossFit® and discovered a rate of 1.94 injuries per 1000 hours and an injury prevalence of 23.5%; the authors concluded that injuries were comparable to other types of recreational exercises. Similarly, Aune and Powers (9) compared the injury rates of weightlifting and extreme conditioning programs (ECP) that included CrossFit® by surveying 247 athletes.

The participants self-reported injury rates of 2.71 injuries per 1000 hours of training and an injury prevalence of 34%; these results were reported to be similar to those of weight lifting and other recreational activities. In addition, Weisenthal et al (10) surveyed athletes in a CrossFit® program and estimated the prevalence of injury in the 6 months prior to the survey to be 19% and the incidence of injury to be 2.4 per 1000 hours. Furthermore, Klimek et al (11) reviewed three studies, including Weisenthal et al (10) and Hak et al (12), and found that reported injury rates were similar to or lower than those found in Olympic weightlifting, distance running, track and field, rugby, or gymnastics.

Although multiple articles state that CrossFit® injuries are comparable to various types of exercise, other findings have been to the contrary. One such study compared overtraining and injury rates in CrossFit® participants ( $n=101$ ) to those who participated in exercise regimens that followed the American College of Sports Medicine (ACSM) guidelines ( $n=56$ ). Validated questionnaire responses suggested that the detrimental post-exercise effects on muscle and ventilatory function among CrossFit® participants was significantly higher than those who followed the ACSM guidelines (13).

Additionally, in a retrospective study performed by Hak et al (12), the calculated incidence of injury from CrossFit® participation was 3.1 injuries per 1000 hours with an injury prevalence of 74% as indicated by a survey. However, the authors did not clearly define the injuries or a time period during which the injuries occurred. Currently, research related to CrossFit® injury rates is limited and seems equivocal with regard to the rate at which participants become injured participating in CrossFit® compared to other popular forms of exercise. Despite its popularity, research on CrossFit® injuries has been limited to the United States and a single study in Brazil (14). In the Brazilian study, survey results of 176 participants stated that 31% experienced some sort of injury; however, injury rates were comparable to that of weight lifting, power lifting, Olympic weightlifting, gymnastics, running, and other recreational and competitive sports. Similar studies need to be conducted due to the growing popularity of CrossFit® across the world. Such information will allow consumers to make an informed decision on the safety and efficacy of CrossFit®. The purpose of this study was to examine the injury rates and injury patterns among CrossFit® participants in Costa Rica where the sport has gained much popularity over the last five years.

### **Material and Method**

Eighty-eight males ( $31.3 \pm 8.4$  yrs,  $1.74 \pm 0.06$  m,  $79.45 \pm 12.02$  kg) and 71 females ( $31.3 \pm 9.1$  yrs,  $1.62 \pm 0.07$  m,  $60.75 \pm 9.37$  kg) signed an informed consent approved by the university Institutional Review Board, filled a retrospective self-reported injury survey to completion, and were included in this cross-sectional design study.

The data was collected utilizing the secure website qualtrics.com in-person with iPads, iPods, and laptops between 11/23/16 -11/30/16 at various CrossFit® gyms in Costa Rica and at the largest CrossFit event in Central America: the 2016 WODFest-Costa Rica.

The survey included items related to participant demographics, total experience (months) in CrossFit®, average number of days per week and minutes per workout performing CrossFit®, involvement in other sports, and injuries obtained during CrossFit® within the last 12 months. In addition, participants were asked

about the involvement of their respective CrossFit® coaches, including whether they experienced injury while under the supervision of a CrossFit® coach.

Injuries were defined as an injury that met one of the following criteria within the last 12 months of CrossFit® participation:

- a) required the individual to seek a healthcare professional to diagnose/treat the injury;
- b) modification of normal training activities for more than two weeks;
- c) total removal from CrossFit® and other physical activity for more than one week; or
- d) any injury that required loss of time from employment. The survey also asked about injury location as well as the diagnosis (if applicable), severity, time lost from training, and history of a related injury.

Descriptive statistics and frequencies were generated to describe the general characteristics of the participants. Furthermore, the relationship between the occurrence of experiencing an injury during CrossFit® during the last 12 months and length of time (months) doing CrossFit®, participation in CrossFit® competitions, gender, rating of their CrossFit® coaches, rest days per week, average length of each CrossFit® workout, experience in other sports, and current participation in other sports were analyzed using Chi Square.

*Statistically analyses.* All statistics were analyzed using SPSS version 24 (SPSS Inc., Chicago, IL). Injury prevalence, defined as the proportion of injuries reported at the time of data collection, and injury incidence as the mean number of injuries incurred in the past 12 months per 1000 hours of CrossFit® participation, were also calculated.

## Results

Although weekly activity participation and sport participation were requested to gain an overall picture of the participants, they were asked to only provide information on injuries that were a direct result of CrossFit® participation. This was stressed in the injury survey to eliminate mention of injuries occurring from participation in other sports or activities. As with all recall studies, this information depends on the reliability of the participant responses.

There was a significant relationship between experiencing an injury during CrossFit® within the last 12 months and length of time (in months) of doing CrossFit® ( $p < 0.01$ ).

There was also a significant relationship between having an injury during CrossFit® within the last 12 months and participating in CrossFit® competitions ( $p = 0.02$ ).

There was a trend for the relationship between gender and suffering a CrossFit® injury ( $p = 0.06$ ), but significance was not reached. No significant relationships were found between suffering an injury during CrossFit® within the last 12 months and rating of their CrossFit® coaches, rest days per week, average length of each CrossFit® workout, experience in other sports, and current participation in other sports.

Participants reported an average of  $4.3 \pm 0.9$  CrossFit® workouts per week at an average of  $1.19 \pm 0.37$  hours per workout.

One hundred and five participants (66%) had at least 12 months of CrossFit® experience, 27 (17%) had 6-11 months experience, 20 (12.6%) had 2-5 months experience, and 7 (4.4%) had less than 1 month of experience. On average, 81 participants (50.9%) reported doing 5 or more CrossFit® workouts per week, 45 (30.8%) performed 4 workouts per week, 25 (15.7%) performed 3 workouts per week, and 8 (5%) performed 2 or less CrossFit® workouts per week.

Eighty-two participants (50.3%) reported doing CrossFit® as their only mode of exercise; the other 77 participants (48.4%) reported doing sports such as running, swimming, weightlifting, soccer, and other sports in addition to doing CrossFit®.

Fifty-eight participants (36.4%) reported doing another sport 1-2 days per week, 10 (6.6%) did another sport 3 days per week, and 9 (6%) did another sport 4 days per week or more.

Only 27 (17%) participants reported no previous involvement in another sport; however, 132 participants (83%) reported doing other sports such as running, swimming, soccer, weightlifting, and other sports prior to starting CrossFit®.

Eighty-nine participants (66%) stated that they rest an average of two days per week, 43 (27%) rest one day per week, 22 (13.8%) rest 3 days per week, and 5 (3.1%) rest 4 days per week.

Fifty-six participants (35.2%) participate in CrossFit® competitions, but 103 participants (64.8%) reported not competing. Seventy-two participants rated their CrossFit® coaches as 10/10 (45.2%) on their knowledge about fitness (with 10 being excellent knowledge and 1 being very poor knowledge), another 72 (45.2%) rated their CrossFit® coaches 8-9/10, and 15 (9.4%) rated their CrossFit® coaches 6-7/10.

**Table 1. Upper Extremity Reported Injuries**

	Right Shoulder	Left Shoulder	Left Triceps	Right Elbow	Left Elbow	Right Forearm	Left Forearm	Right Wrist	Left Wrist	Left Fingers
<b>Number of Injuries Reported</b>	24	18	1	4	3	1	3	6	7	1
<b>Mean Severity (1/10 = not serious 10/10 = extremely serious) and Range</b>	5.3/10 (Range: 3 - 8)	5.1/10 (Range: 3 - 8)	1/10 (Range: 1 - 1)	5.8/10 (Range: 5 - 6)	6. /10 (Range: 6 - 8)	8/10 (Range: 8 - 8)	4.3/10 (Range: 1 - 9)	5.5/10 (Range: 2 - 10)	5.6/10 (Range: 2 - 10)	8/10 (Range: 8 - 8)
<b>Average Days Lost from CrossFit®</b>	9.4 (Range 0-90)	14.2 (Range 0-120)	0 (Range 0 - 0)	16.8 (Range 7-30)	21.7 (Range 15-30)	14 (Range 14- 14)	5.3 (Range 0 - 14)	13.7 (Range 0 - 60)	14.9 (Range 0 - 60)	0 (Range 0 - 0)
<b>Received Medical Treatment</b>	22 = yes 2 = no 0 = yes	14 = yes 4 = no 0 = yes	0 = yes 1 = no 0 = yes	4 = yes 0 = no 0 = yes	3 = yes 0 = no 0 = yes	0 = yes 1 = no 0 = yes	1 = yes 2 = no 0 = yes	4 = yes 2 = no 0 = yes	2 = yes 5 = no 0 = yes	0 = yes 1 = no 0 = yes
<b>Required Surgery Occurred While Supervised by Coach</b>	24 = no 17 = yes 7 = no	18 = no 14 = yes 4 = no	1 = no 1 = yes 0 = no	4 = no 2 = yes 2 = no	3 = no 1 = yes 2 = no	1 = no 1 = yes 0 = no	3 = no 1 = yes 2 = no	6 = no 4 = yes 2 = no	6 = no 5 = yes 2 = no	1 = no 1 = yes 0 = no
<b>Previous injury to body part</b>	6 = yes 18 = no	1 = yes 17 = no	0 = yes 1 = no	0 = yes 4 = no	0 = yes 3 = no	0 = yes 1 = no	0 = yes 3 = no	2 = yes 4 = no	2 = yes 5 = no	0 = yes 1 = no

**Table 2. Lower Extremity Reported Injuries**

	Hips	Right Quad	Right Hams.	Left Hams.	Right Knee	Left Knee	Left Calf	Left Ankle	Right Foot	Left Foot	Right Gluteus
<b>Number of Injuries Reported</b>	5	2	1	1	10	6	2	1	2	1	1
<b>Mean Severity (1/10 = not serious 10/10 = extremely seriously) and Range</b>	8.6/10 (Range 7 - 10)	6.5/10 (Range 3 -10)	5/10 (Range 5 - 5)	6/10 (Range 6 - 6)	6.5/10 (Range 4 - 10)	5.7/10 (Range: 4 - 7)	10/10 (Range 10- 10)	9/10 (Range 9 - 9)	3.5/10 (Range 3 - 4)	7/10 (Range 7 - 7)	3/10 (Range 3 - 3)
<b>Average Days Lost from CrossFit®</b>	13.8 (Range 4-30)	6.3 (Range 3-10)	7 (Range 7 - 7)	5 (Range 5 - 5)	46.7 (Range 0-36.5)	7.2 (Range: 0 - 14)	6 (Range 6 - 6)	60 (Rang 60- 60)	7.5 (Range 0-15)	0 (Range 0-0)	0 (Range 0-0)
<b>Received Medical Treatment</b>	5 =yes 0 = no	2 =yes 0 = no	1 =yes 0 = no	1 =yes 0 = no	10=yes 0 = no	6= yes 0 = no	2 =yes 0 = no	1 =yes 0 = no	1 =yes 1 = no	1 =yes 0 = no	0 = yes 1 = no
<b>Surgery</b>	1 = yes 4 = No	0 = yes 2 = no	0 = yes 1 = no	0 = yes 1 = no	1 = yes 9 = no	1 = yes 5 = no	0 = yes 2 = no	0 = yes 1 = no	0 = yes 2 = no	0 = yes 1 = no	0 = yes 1 = no
<b>Supervised by Coach</b>	5= yes 0 = no	2 = yes 0 = no	0 = yes 1 = no	1 = yes 0 = no	7 = yes 3 = no	4 = yes 2 = no	2 = yes 0 = no	1 = yes 0 = no	2 = yes 0 =no	0 = yes 1 = no	1 = yes 0 = no
<b>Previous injury to body part</b>	0 = yes 5 = no	1 = yes 1 = no	0 = yes 1 = no	0 = yes 1 = no	3 = yes 7 = no	3 = yes 3 = no	0 = yes 2 = no	1 = yes 0 = no	0 = yes 2 = no	0 = yes 1 = no	0 = yes 1 = no

Similarly, 72 participants (45.2%) rated their CrossFit® coaches 10/10 on their ability to coach group exercise classes (with 10 being excellent and 1 being very poor), 67 (42.1%) rated their CrossFit® coaches 8-9/10, 17 (10.7%) rated their coaches 6-7/10, and 3 (1.9%) rated their CrossFit® coaches 5/10.

A total of 74 participants reported 127 CrossFit® related injuries, yielding an injury prevalence of 46.5% and an estimated injury incidence of 3.3 per 1000 hours.

Of the 127 injuries reported, the most commonly injured body parts were the shoulder (33.1%), low back (18.1%), knees (12.5%), wrists (10.2%), and elbows (5.5%). Only 1 case of rhabdomyolysis (0.8%) was reported among the respondents.

Four participants reported needing a surgery for their injury, but three out of the four had a related pre-existing injury before ever starting CrossFit®. Tables 1, 2, and 3 identify all injuries reported and specific answers to their respective injuries.

**Table 3. Other Reported Injuries**

	Rhabdomyolysis	Compartment Syndrome	Inguinal Hernia	Thoracic Spine	Lumbar Spine
<b>Number of Injuries Reported</b>	1	1	1	1	23
<b>Mean Severity (1/10 = not serious 10/10 = extremely serious) and Range</b>	3 (Range: 3 to 3)	6 (Range: 6 to 6)	1 (Range: 1 to 1)	7 (Range: 7 to 7)	4.9 (Range: 1-10)
<b>Average Days Lost from CrossFit®</b>	30 (Range: 30 to 30)	7 (Range: 7 to 7)	30 (Range: 30 to 30)	21 (Range: 21 to 21)	11.9 (Range 0 to 60)
<b>Received Medical Treatment</b>	1 = yes 0 = no	1 = yes 0 = no	1 = yes 0 = no	1 = yes 0 = no	18 = yes 5 = no
<b>Surgery</b>	Not applicable	0 = yes 1 = no	1 = yes 0 = no	0 = yes 1 = no	0 = yes 23 = no
<b>Supervised by Coach</b>	0 = yes 1 = no	1 = yes 0 = no	0 = yes 1 = no	1 = yes 0 = no	19 = yes 4 = no
<b>Previous injury to body part</b>	0 = yes 1 = no	0 = yes 1 = no	1 = yes 0 = no	0 = yes 1 = no	4 = yes 19 = no

## Discussion

When comparing the results of this study to previous studies, a fair comparison must take in to account the definition of an injury. The relative rigidity of an injury definition has a major impact on the results. The four-fold definition provided for the current study is similar to other studies reviewed (8, 10, 14). These studies, guided by the original definition provided by Weisenthal et al (10), explained an injury as any new musculoskeletal pain, feeling or injury that results from a CrossFit® workout and leads to at least one of the following: (a) Total removal from CrossFit® training and other outside routine physical activities for >1 week, (b) Modification of normal training activities in duration, intensity, or mode for >2 weeks, or (c).

Any physical complaint severe enough to warrant a visit to a health professional. In addition to meeting one of these criteria, the definition of an injury for this study also included any injury that required loss of time from employment. This was added to the definition because the authors surmised that missing work due to an injury during a workout should be considered when evaluating the safety of a training program. In addition, Hak et al (12) also utilized missing work as part of defining an injury.

Aune et al (9) provided a less stringent definition of an injury. The authors stated that an injury required one of the following: (a) required medical treatment, (b) caused the athlete to miss any time from participation, or

(c) caused the athlete to make any modifications to his or her technique to continue.

Despite these less confining requirements, the study reported an injury prevalence of 34% and incidence of injury of 2.71 injuries per 1000 hours of training.

This was not the only study to include a less stringent definition. Although the incidence of injury in the current study was higher than that reported by Hak et al (12) (3.3 vs 3.1 per 1000 hours), the prevalence of injury was quite lower (46.5% vs 74%).

It would make sense that the gap between prevalence of injury was at least in part related to the differences in defining an injury. Hak et al (12) defined an injury as anything that prevented the individual from training, working, or competing in any way for any period of time.

Recall bias should be taken into consideration when comparing the results of retrospective studies. It is plausible that all participants can recall whether or not an injury/injuries occurred, but the recall of the location of and diagnosis of injuries, the severity of injuries, and the number of injuries, may be unreliable. Many of the studies discussed, including this study, were defined as retrospective (8-10, 12).

It should also be noted that the current study and all studies reviewed here surveyed participants of CrossFit® who were still engaged in CrossFit® training in spite of some experiencing injury.

Therefore, it is impossible to know the prevalence or incidence of injury of CrossFit® participants who stopped participating in CrossFit® due to an injury. Though beyond the scope of this study, this remains an important part of determining the relative safety of CrossFit®, and future research should measure attrition rates due to injuries incurred while participating in CrossFit® as part of a prospective study.

Multiple studies that reported the most common injury sites among those who participate in CrossFit® were similar to this study. One study recorded that the most common injury site locations were the shoulder, low back, and knee in that order (10). Similarly, another study examining injury rates in extreme conditioning programs found injuries to the shoulder or upper arm most prevalent followed by the trunk, back, head, or neck, and leg or knee (9).

The results of this study suggest that CrossFit® is safer than competitive contact sports such as soccer (17.1 injuries per 1000 hours) (15) and American football (16 injuries per 1000 hours) (16). However, these studies are difficult to compare because Børneboe et al (15) defined injuries as anything that limited a player from a soccer activity or match play and Baltzer et al (16) defined injuries as minor (an absence from practice or games for less than one week that did not require surgery), severe (an absence from practice or games for a time spanning one week to three months or if the injury required surgery or hospitalization), or catastrophic (resulting in persistent neurological or orthopedic disability or leading to intensive care treatment or death).

The CrossFit® injury rate in this study (3.3 injuries per 1000 hours) is also comparable to that of powerlifting (1 to 4.4 injuries per 1000 hours) (17, 18) and Olympic weightlifting (3.3 injuries per 1000 hours of training/competition) (19). However, the definitions used to define injuries must also be considered when comparing these studies. Keogh et al (17) defined injuries as physical damage that led to modifications to or the missing of training sessions, Siewe et al (18) defined injuries as those leading to time away from training or competition, and Calhoon et al (19) defined injuries as acute (rapid onset injuries with short duration) and recurring injuries (recovery and re-injury). Bodybuilding appears to have fewer injuries (0.24 injuries per 1000 hours) than any weight training related activity despite the injury definition provided by the authors (20); Siewe et al (20) defined injuries as those that interrupted training or competition.

The results of this study also suggest that there is a relationship between experiencing a CrossFit® injury and the length of time (in months) in performing CrossFit®. Similarly, this study found a relationship between experiencing a CrossFit® injury and those that participate CrossFit® competitions. These relationships are expected as consistently training at a higher intensity, as is required when getting ready for a competition, is likely to lead to more injuries. Gabbet & Domrow (21), for example, concluded that there was a direct relationship between the log of the training load and odds of injury among 183 rugby players. Furthermore, more exposure in doing an activity is likely to lead to more injuries while performing that activity.

In addition to the potential fitness benefits of CrossFit®, several researchers have explored its usefulness in careers where being in peak physical condition is part of the job requirement. The self-described measureable and repeatable results of CrossFit® may lend itself to law enforcement, military personnel, and fire fighters who would benefit from high levels of fitness that are similar to real world situations they may encounter while on the job. Poston et al (22) reviewed multiple studies conducted by various branches of the military exploring the injury rates of high intensity functional training (i.e. CrossFit®) and traditional

physical training (i.e. running, soccer, and Olympic lifting). The authors noted five studies that determined programs such as CrossFit® appear to be appropriate for the military and may reduce the risk of injury while improving physical fitness.

When comparing injury rates to other exercise modalities, the experience of the trainers, participant overexertion, technique, and previous injuries should be explored to provide a clearer picture of cause and effect. Due to the continual expansion and popularity of CrossFit® and lack of studies conducted outside of the United States, additional external research is necessary to examine its utilization and injury rates around the world. Future studies should utilize a longitudinal approach to examine participant injuries over time. Such prospective studies may result in more reliable recall and allow for additional questioning to better understand the length and severity of injuries as they occur. This may also allow for an examination of the cause of injuries (i.e. a specific WOD or activity, a different sport, or other). Additionally, the comparable, or at times lesser, injury rates of CrossFit® compared to other forms of exercise provides reason for future studies as to examine its usefulness for those who are expected to perform in various real-world settings (military, law enforcement, firefighters, etc.). Finally, although participants were asked to only provide information about injuries that were a direct result of CrossFit® training, it is possible that an injury might have occurred as a result of other sports or activities. Future studies should consider comparing the injury rates of individuals whose only means of exercise is CrossFit® to those who participate in additional activities.

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