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# Physiological responses over CrossFit athletes in the Brazil CrossFit championship

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## Abstract

CrossFit is a high intensity interval training program. Is was founded in 2000, becoming a very common practice in many countries. CrossFit can improve general resistance condition enabling numerous benefits. Well trained CrossFit practitioners seen to take lower intensity than elite CrossFit athletes, and it leads researchers to believe that CrossFit is a fast adaptation program through different group of age and levels. The main objective of the present study was to evaluate 5 elite CrossFit athletes analysing real time load physiological internal load in the semi-final of Brazil CrossFit Championship.

Athletes showed great changes in all physiological measures after semi-final. There was physiological difference between athletes. The present study concluded that elite CrossFit athletes can withstand heavy training loads with great physiological changes, supporting the idea of fatigue/overtraining and recovery necessity in CrossFit competition. There is great difference demand in physiological values between elite athlete levels, expending more energy athletes who shows bigger heart rate.

## Introduction

Founded in 2000, CrossFit is a high intensity interval training program that can improve physiological responses enabling numerous benefits [1-3]. CrossFit became world known, due it's high functionality, englobing high intensity exercise made in constantly variated form; exercises such as metabolic conditioning (running, bike, row, skip rope, swimming, skiing, etc.), Olympic Gymnastic (ring dip, ring row, hand stand walk, hand stand push-ups, etc.) and weightlifting (deadlift, back squat, snatch, clean, jerk, etc.) [4,5]. Since 2013, the number of affiliates more than doubled, from 5000 CrossFit centre (box) to 13.000, with more than 300.000 practitioners around the world and it encourages sports scientists to research CrossFit [6]. Physiological responses in CrossFit Athletes is poorly studied. Most of the CrossFit studies evaluated injury and physical capacity, in eventual practitioners (none in elite athletes). The basic physiological responses such intensity analyses of the competition, excessive post-exercise oxygen consumption (EPOC) levels and calories expenditure are remaining unknown in elite CrossFit athletes. Recently studies evaluating elite CrossFit athletes exposed activation of aerobic and anaerobic responses through short and very intense workout of the day (WOD [specific CrossFit training]) and high lactate concentration after one WOD englobing moderate volume and high intensity [7,8]. A recent study evaluates physiological levels of testosterone, IL-1, IL-10, etc in CrossFit amateur athletes in a competition. After the last day of the competition, testosterone and IL-10 (anti-inflammatory interleukin) levels were diminished, demonstrating hormonal and molecular disturbance, giving the idea of the importance of life style to be able to wellbeing in competition and adequate periodization to participate of a competition [9]. Well trained CrossFit practitioners seem to take lower intensity than elite CrossFit athletes, and it leads researchers to believe that CrossFit is a fast adaptation practice through different group of age and levels [8-11]. Through the stress given by CrossFit, physiological factors tend to exacerbate. Schubert at al. found that amateur CrossFit practitioners can account for a significant portion of daily energy expenditure, and consecutive training can induce meaningful weight loss [12].

Elite athletes can worse their competition development because of many factors, such as physiological (expending calories cited above, excessive intensity, overtraining due past trainings, etc.) and psychological (internal or external stress, family support, etc.) [13,14].

In this paper, detailed physiological characteristics of the CrossFit elite athletes over a competition that leads to the world CrossFit championship (CrossFit Games).

To the best of our knowledge this is the first study analysing physiological responses in performance during a competition, that leads to the CrossFit Games in elite athletes during an official competition. In this paper detailed characteristics of the physiological internal load in real time in the semi-final of Brazil CrossFit Championship (BCC).

## Methods

4 elite men and 1 elite woman CrossFit Athletes (2 males for individual (elite athlete A and elite athlete B, (EAA and EAB)) competition and 2 males and 1 female (EAC) for team competition

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were analysed in the 2019 semi-final of BCC, that is one of the phases of competition which lead the winners to the CrossFit Games; each phase there is only one man and 1 woman, and 1 team (the 1º place of each category) that is able to compete the CrossFit Games. To participate in the BCC there is a qualifier which the best 28 individual athletes and 14 team athletes are classified.

The analysed semi-final WOD in individual group was: "Up and side down" for time. All the athletes must perform in 7 minutes, 10-8-6-4-2 repetitions of muscle-ups (very common movement in Olympic gymnastics composed by holding the suspended rings and throwing the body over the rings with specific technique) and 16 meters of hand stand walk (walk using hands in upside down position) after each round.

The analysed semi-final WOD in team was: "The long way home" for time: All the teams must perform 5 rounds for time (12'). The team must complete 10 ring muscle-ups (one athlete do the movements and the others athletes must hold the anaconda (176 kg) – 10 anaconda thrusters (all the team together).

The main instrument used to analyse the physiological responses in the selected elite athletes was the Firstbeat Sports® (Firstbeat Sport, Finland), and it was exported to the Firstbeat Sports Server software (version 4.7.3.1). The physiological responses analysed was calories (kcal), medium heart rate (MHR), training load in arbitrary units ((AU)TRIMP), Excessive post-exercise oxygen consumption (EPOC) and training effect. Training effect predicts how the effort will impact the $VO_2$ max fitness level through the EPOC (Figure 1). The rate perceived exertion (RPE) was analysed, it was originally proposed by Borg, and modified by Foster et al. [15,16] using time of the exercise performed x RPE. RPE was measured 30 minutes after the WOD with the athletes pointing 0 to 10 foster scale (from 0 = rest to 10 = extremely intense), measuring the intensity of the WOD. 1 repetition maximum (1RM) of back squat propose by Kraemer et al. [17] and the "FRAN" WOD was used to determine strength and intensity [18]. The WOD named "FRAN" is one of the most common WODS, it was used to describe individual performance condition. The FRAN WOD is composed by 21, 15 and 9 repetition of thruster exercise (the barbell starts in shoulder position and the athlete must do a front squat with the extension of elbows at the end of hip extension) and pull-up (the athlete must hang the fixed bar and start from stretched elbows to bend elbows until the chin goes up to the bar), as fast as possible (for time). This WOD was described before [19,20].

Prior to the case report, the participant signed a written informed consent, which was approved by the local ethics committee (Protocol number: 13353719.4.0000.5659).

Statistical analyses: It wasn't made because the participants number is too low. So, this is only an observational study.

## Results

The characteristics of each athlete are exposed in table 1.

EAA did not do the CrossFit Open due to a knee injury (he was classified to the BCC qualifier before the injury). Only the EAC was classified to the BCC finals, but she didn't classify to the CrossFit Games.

Table 2 exposes the physiological values obtained in real-time assessment during the semi-final WOD.

Training Effect showed improvement in $VO_2$ max in both athletes (Table 2 and Figure 1).

**Table 1a.** Elite athletes characteristic (individual competition)

| | EAA | EAB |
|---|---|---|
| Age | 30 | 23 |
| Weight (kg) | 80 | 90 |
| BMI | 25,88 | 26,62 |
| 1RM Back Squat (kg) | 170 | 195 |
| WOD "Fran" best time | 2'18" | 2'28" |
| 2019 CrossFit Open ranking (Brazil) | - | 12º |
| 2019 CrossFit BCC semifinal | 26º | 26º* |
| Final Position BCC | 29º | 15º |

*Draw event

**Table 1b.** Elite athletes characteristic (team competition)

| | EAC* | EAD | EAE |
|---|---|---|---|
| Age | 28 | 24 | 21 |
| Weight (kg) | 64 | 92 | 96 |
| BMI | 27.35 | 28.39 | 27.82 |
| 1RM Back Squat (kg) | 145 | 211 | 205 |
| WOD "Fran" best time | 2'28" | 2'32" | 2'15" |
| 2019 CrossFit Open ranking (Brazil) | 1º | 5º | 5º* |
| 2019 CrossFit BCC semifinal | 4º | 17º | 13º |
| Final Position BCC | 4º | 11º | 13º |

** Female athlete; *Draw competition

**Table 2.** Physiological characteristics

| | EAA | EAB | EAC | EAD | EAE |
|---|---|---|---|---|---|
| Cal | 109 | 74 | 94 | 116 | 186 |
| MHR | 168 | 170 | 167 | 166 | 174 |
| Training load (AU) | 106 | 27 | 26 | 24 | 38 |
| EPOC | 112 | 66 | 61 | 55 | 84 |
| RPE | 9 | 8 | 7 | 7 | 8 |
| Training Effect | 3.3 | 3.1 | 2.3 | 2.2 | 3.4 |

* Cal: calories (Kcal); MHR: medium rate rate (BPM); TRIMP: training impulse; EPOC: excessive post exercise oxygen consumption; RPE: Rating perceived exertion; Perceived Training effect: based on VO2max fitness level.

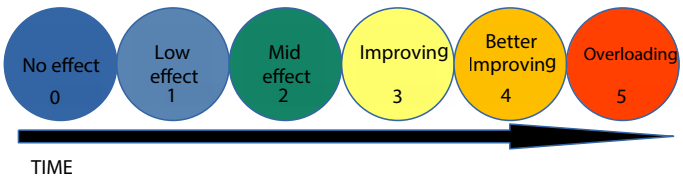


**Figure 1.** Training effect levels

## Discussion

The present study is a new way of investigation to the coaches understand how the athlete physiological responses over a competition in real time mensuration is. The purpose of the present study was about tracking physiological responses (performance) in elite CrossFit athletes in real time over one considerable CrossFit championship. Furthermore, the present study exposed the impact performance of freshly treated injury in elite athlete in one international competition.

Our results showed high RPE in an individual athlete (EAA) when compared with EAB and team athletes, but all the athletes demonstrated high RPE. Because this WOD was made in one semi-final of a CrossFit Games stage, these athletes gave the best to classify (increasing intensity to almost 100% of RPE). These results confront the study of Shaw et al. 2015 who found moderate intensity in well-trained practitioners in a single bout of CrossFit WOD, perhaps because it wasn't an important competition [21]. A recent study evaluated two CrossFit workouts and the intensity. One with high WOD volume and one with low WOD

volume. The results showed that low WOD volume exhibits lower RPE than high volume, but lactate was higher in the lower WOD volume, concluding that higher WOD volume can increase more intensity through lactate, but not through RPE. The semi-final WOD can be classified as low WOD volume (lower than 10') in individuals and medium volume (more than 10') for the teams.

The WOD "FRAN" which is performance reference in CrossFit practitioners showed better WOD time in EAA than EAB, and it had been previously demonstrate high correlation with back squat 1RM [4], confirmed in the present study (EAA with bigger RM back squat than EAB). EAE showed better "FRAN" time than the others team athletes and individual athletes (EAD and EAE showed back squat RM higher than 200 kg).

The individual WOD had a duration of 7 minutes and none of these two athletes completed the WOD in the time cap (limit time). The kcal spent in the short WOD was higher in EAA. EAE demonstrated higher energy expenditure when compared with individual and team athletes. Interestingly there is relationship between MHR and Cal, as bigger is the MHR, bigger is the energy expenditure. According to the intensity of exercise increases, the HR and the total calories increase faster. A study analysing the effect of caffeine (caffeine vs placebo) on energy expenditure showed that hypertrophy training at a gym at sub maximal intensity until failure (bout of 45-50 minutes at 70-80%1RM) expended medium of 137 kcal (caffeine) and 118 kcal (placebo) after 75 minutes past High volume training at submaximal intensity have similar kcal expenditure that 7 minutes high intensity interval training [22].

Some studies investigated the intensity of CrossFit training in injury risks, correlating higher intensity and fatigue with higher levels of injury [23,24]. The present study could analyse the training effect level (exposed in Figure 1) of these elite athletes, and it was demonstrated that the intensity was enough to improve aerobic capacity and not overloading it. It is believed that the semi-final of CrossFit BCC didn't increase the level of all athletes to be more susceptible to develop injury, perhaps due the time of the WOD (little exercise intensity time).

The training load (AU) demonstrated higher values in EAA when compared with all the other athletes. One study evaluating the reliability of TRIMP in athletes through Firstbeat® showed this software to be a good predictor of training load [25]. CrossFit athletes training weekly about 2092 AU [26]. In one international competition there is often 6 to 10 events, indicating that the intensity/volume of training is even higher in than competition amount, but there is many factors in competition that can interfere the performance (sound, climate, events in a row, etc).

EAA exposes higher EPOC than all of the other athletes. EPOC is correlated with HR in Firstbeat®, so as higher the training intensity is (RPE), higher is the EPOC after the WOD for a longer time. The high EPOC value demonstrate a possible better adaptation after some days of appropriated rest, as cited in the study of Herbert et al. [27].

The present study researched physiological adaptation in a real time of a great CrossFit competition.

Training effect, EPOC and RPE demonstrated that EAA was less adapted when comparing with all the others (individual and team), and this can possibly have relationship with the limitation of the study. EAD seems to be the more adapted athlete (team) to the semi-final, through his physiological data (MHR, training load (AU), EPOC, RPE and training effect). It is important to emphasize that EAD was 4x winner Brazilian Championship (TCB), but he didn't classify to the finals, perhaps due his team.

Using this data, a coach staff may be better met the individual needs of athletes, competing individually or team sports. This method may increase the like hood of maintaining good performance without overtraining. Also, it is important for trainers and coaches to develop balanced WODs that do not exacerbate the volume and intensity in the same way.

## Limitation of the study

This study is not without limitation: 1) the study analysed only 5 athletes due the complexity and difficult to contact the elite athletes in this competition organization level; 2) EAA had recent surgery, so it was expected that he wasn't in his best performance.

## Conflict of interest

The authors have no conflicts of interest to disclose.

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