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Modulation of heart rate variability in CrossFit® practitioners

Modulação da variabilidade da frequência cardíaca em praticantes de CrossFit®

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RESUMO | INTRODUÇÃO: O CrossFit® é um tipo de exercício físico que afeta a homeostase do corpo exigindo ajustes pela via autonômica. Devido sua intensidade de treino ocorre uma modificação no tônus vagal e adaptações fisiológicas cardiovasculares. **OBJETIVO:** Verificar a variabilidade da frequência cardíaca em praticantes de CrossFit®. **MATERIAIS E MÉTODOS:** Corte transversal em praticantes de CrossFit® no período de março a junho de 2017, com idade ≥18 anos, tempo de prática ≥3 meses e uma frequência ≥2 vezes na semana. Excluídos: fumantes, gestantes, comorbidades auto referidas (Diabetes Mellitus, hipertensão, doenças cardiorrespiratórias e disfunção na tireoide), mulheres no período menstrual, menopausa, ou aqueles que tiveram dificuldade na compreensão do teste proposto. Para a mensuração da variabilidade da frequência cardíaca (VFC) foi utilizado o cardiofrequencimetro da marca Polar® modelo V800 heart rate monitor, para a sua análise foi utilizado KUBIOS HRV versão 2.0. Aprovação do CEP-BAHIANA (CAAE 46685415.0.0000.5544). **RESULTADOS:** Foram pesquisados 16 participantes, com idade média de 32,11 ± 6,44 anos, 10 (62, 5%) homens. O IMC encontrado foi de 26,39± 3,80 kg/m², classificando 9 (56,3%) indivíduos como sobrepeso e 6 (37,5%) com peso normal. Os valores obtidos da VFC no domínio do tempo:VLFms²:1544(859-3640); LFms²:827(550-2115); HFms²:661(335-1577);LF/HF:1,18(0,86-1,8). **CONCLUSÃO:** Na amostra estudada, observou-se que praticantes de CrossFit® possuem leve predomínio da atividade simpática, especialmente o sexo masculino e naqueles que praticam atividade física cinco ou mais vezes por semana.

PALAVRAS-CHAVE: Atividade física. Frequência cardíaca. Treinamento intervalado de alta intensidade. Sistema nervoso autônomo.

ABSTRACT | INTRODUCTION: CrossFit® is a type of physical exercise that affects the homeostasis of the body requiring adjustments through the autonomic pathway. Due to its intensity of training there is a modification in vagal tone and cardiovascular physiological adaptations. **OBJECTIVE:** To verify heart rate variability in CrossFit® practitioners. **MATERIALS AND METHODS:** Cross-section in CrossFit® practitioners from March to June 2017, aged ≥18 years, practice time ≥3 months and a frequency ≥2 times in the week. Excluded: smokers, pregnant women, self-referenced comorbidities (Diabetes Mellitus, hypertension, cardiorespiratory diseases and thyroid dysfunction), women in the menstrual period, menopause, or those who had difficulty understanding the proposed test. For the measurement of heart rate variability (HRV), the heart rate monitor model V800 heart rate monitor was used for its analysis was KUBIOS HRV version 2.0. Approval of CEP-BAHIANA (CAAE 46685415.0.0000.5544). 5544. **RESULTS:** 16 participants were studied, with a mean age of 32.11 ± 6.44 years, 10 men (62.5%). The mean BMI found was 26.39 ± 3.80 kg / m², classifying 9 (56.3%) individuals as overweight and 6 (37.5%) with normal weight. The values obtained from HRV in the time domain: VLF: 1544 (859-3640), LF: 827 (550-2115), HF: 661 (335-1577), LF / HF: 1.18 (0.86-1,8). **CONCLUSION:** In the studied sample, it was observed that CrossFit® practitioners have a slight predominance of sympathetic activity, especially males and those who practice physical activity five or more times per week.

KEYWORDS: Physical activity. Heart rate. Interval training of high intensity. Autonomic nervous system.

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Introduction

The CrossFit® training method aims to develop fitness in a broad, inclusive and general manner[1]. Regular practice, there is a tendency to gain physical competence in the ten domains of physical conditioning, preparing the practitioner for the necessary contingencies in daily life[1,2]. These practices include muscle endurance, strength, flexibility, power, speed, coordination, agility, balance, accuracy and gain in cardiorespiratory performance, and are primarily used for Olympic weightlifting, rhythmic gymnastics movements and calisthenics[3-5]. Increasingly, women and men are adapting to this new lifestyle[1,6].

The training session is characterized by alternation of high intensity activities with high volume, providing higher training density. Therefore, there is a change in vagal tone resulting from cardiovascular physiological adaptations such as increased heart rate, stroke volume, cardiac output, besides promoting active muscle vasodilation and increased oxygen demand[3,7].

The regulation of the cardiovascular system is made by the autonomic nervous system (ANS) through the parasympathetic and sympathetic pathways, which makes rapid adjustments during distinct stimulus such as postural change, physical activity and mental stress. This autonomic function can be measured by analyzing heart rate variability (HRV)[3,4,7].

HRV has become an approachable tool for monitoring training and adaptation in athletes. It describes and analyzes the oscillation of the interval between two heart beats (R-R interval)[3,4]. The variation reflects the function of the autonomic nervous system (ANS) in the sinoatrial node (SAN). Results may indicate possible comorbidities, such as the risk of cardiovascular disease, general conditions and adaptations of the body system as whole[3,7].

Reduction in HRV is associated with higher risks of cardiovascular events, however in athletes, it may be associated with overtraining, while increased HRV is associated with efficient autonomic mechanisms, better agility, response and adaptation to various stimulus given to ANS. Therefore, when there is a high HRV, there is a predominance of the vagal nerve, and a low HRV reveals a decrease in this tone and a greater predominance of the sympathetic[3,8-10].

Excessive intense training stresses the autonomic nervous system, which tends to decrease its parasympathetic afference, as it does not have adequate recovery and adaptation time, which can lead to overtraining. Based on these basic principles of training in a high intensity and frequency CrossFit session[11,12,13]. It´s important to check Heart Rate Variability in CrossFit® Practitioners.

Materials and methods

Cross-sectional observational study approved by the Ethics Committee of the Bahiana School of Medicine and Public Health (EBMSP), under the CAAE ruling number 46685415.0.0000.5544. The collect took place from March to June 2017 at the EBMSP Movement Laboratory. CrossFit® practitioners 18 years of age or older, practice time of more than 3 months and more than 2 times a week were included. Excluding smokers, people who had a history of infection in the last 30 days, pregnant women, self-reported comorbidities (Diabetes Mellitus, thyroid dysfunction and cardiorespiratory problems) and women who were menstrual cycle, menopause.

The participants were recruited through dissemination of the study on social networks (Facebook®, Instagram® and WhatsApp®) following the "snowball" methodology (14), in which one participant indicates the other and so on, until reaching the saturation point. Initially, interested parties contacted each other to schedule the assessment day, at which time they were asked not to use caffeine the day before. In the first stage of the research, the sociodemographic questionnaire, sports history and the anthropometric measures such as age, weight, height, BMI, education, CrossFit® time, weekly training frequency (in days), supplement use, thermogenic, contraceptive and diet were measured.

For the measurement of HRV, the participant had an initial 5-minute sitting rest. During this period, the V800 heart rate monitor® Polar heart rate monitor tape was fixed at the sternum height. After this stage, the participant was positioned supine on the stretcher in a room, with no noise, low light, ambient air temperature, oriented not to sleep, and to avoid sudden movements for 10 minutes[15].

The collected data were transferred to the computer using polar KUBIOS HRV version 2.0 software to analyze HRV. This analysis was done through time and frequency domain, which were calculated by the software through the RR interval ratio, in the cut off the most stable 5 minutes of total time to avoid ectopic beats and measurement artifacts.

For the statistical analysis, the dependent variable was heart rate variability in the frequency domain (LF, HF, HF / LF). Where the frequency domain, Low Frequency (LF): Low frequency component, ranging from 0.04 to 0.15Hz, which results from the joint action of the vagal and sympathetic components on the heart, with predominance of the sympathetic; High Frequency (HF): High frequency, ranging from 0.15 to 0.4Hz, which corresponds to respiratory modulation and is an indicator of the vague nerve acting on the heart. The LF / HF ratio reflects the absolute and relative changes between the sympathetic and parasympathetic components of the ANS, characterizing the sympathovagal balance over the heart. To verify the autonomic predominance, the HF / LF ratio was used, where the relationships that obtained a value lower than 1 (one) were classified as parasympathetic predominance[3,4].

The time domain variables used for analysis were RMSSD: the square root of the square mean of the differences between adjacent normal RR intervals; SDNN: standard deviation of all normal RR intervals; PNN50: Percentage of adjacent RR intervals with duration differences greater than 50ms. All of these variables reflect parasympathetic activity, in a direct relationship between the variables and vagal activity.

Data analysis was performed using Statistical Package for Social Sciences (SPSS) version 14.0 for Windows. Categorical variables were expressed as absolute and relative frequencies. Descriptive analysis was used to define the normal distribution of numerical variables. Those with normal distribution were expressed as mean and standard deviation, those with non-normal distribution as median and interquartile range.

For inferential analysis, the sample was stratified by gender and training frequency (≤ 5 days> per week), stratification according to the sample median. For association between HRV behavior (LF ms^2, HF ms^2, LF / HF) between gender, CrossFit® time and training frequency, the Man-Whitney test was used due to the non-parametric behavior of the studied variables.

Results

Initial sample composed by 16 participants, in which 10 (62.50%) were male, mean age 32.11 ± 6.44 and BMI of 26.39 ± 3.80 Kg / m^2. Regarding the report of the time of physical activity, it had a median of 90 (29 - 240) months. While CrossFit® practice had a median of 17 (8.75— 23.25) and a training frequency per week on days averaging 4.69 ± 0.87.

Concerning the type of dietary restriction, three participants (18.8%) do diet diets, while nine (56.3%) do not use any type of supplementation. Of the 16 evaluated, 12 (75%) do not use thermogenic in their daily activities. Of the six women evaluated, three (18.75%) use oral contraceptives. Table 1.

Table 1. Demographic characterization, anthropometric measurements, regularity and frequency of training, eating habits of CrossFit® practitioners, Salvador- BA, 2017. N = 16

Variable	Mean	SD
Age (years)	32,11	06,44
Weight	77,52	15,74
Height (meters)	01,72	00,11
IBM[1]	26,39	03,80
Variable	**n**	**%**
IBM		
Overweight	9	56,3
Normal Weight	6	37,5
Under Weight	1	06,3
Gender		
Male	10	62,5
Female	6	37,5
Variable	**Median**	**Quart**
Time of Physical Activity (months)	90	28,75 –240
CrossFit® Time (months)	17	8,75 –23,25
Variable	**Mean**	**SD**
Training frequency per week (days)	4,72	0,82
Variable	**n**	**%**
Diet Diets	3	18,80
Do not use supplement	9	56,30
Do not use thermogenic	12	75,00
Oral contraceptive use	3	18,75

[1]Body Mass Index; 'Corporal Body mass index in category; SD= Standard deviation

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Table 2 describes the values obtained from HRV in the time and frequency domain of the studied sample. The variables VLF, LF, HF and the LF / HF ratio were normally distributed and are described by mean and standard deviation. The time domain variables presented non-symmetrical distribution and, therefore, are described in median and interquartile range.

Table 2. Analysis of heart rate variability in CrossFit® practitioners from Salvador-BA, Brazil, from March to August 2017

Heart Rate Variability in the frequency domain		
Variable	**Median**	**Quart**
VLF (ms^2)	1544	859-3640
LF (ms^2)	827	550-2115
HF (ms^2)	661	335-1577
LF / HF	1,18	0,86-1,8
Time domain Heart Rate Variability		
Variable	**Median**	**Quart**
RMSSD	50,6	32,92-82,55
SDNN	68,40	49,65-93,35
PNN50	26,95	10,07-41,57

When comparing time domain and frequency variables with weekly training and gender, we found no statistical difference between the groups, as described in Table 3.

Table 3. HRV association with gender and training frequency week in CrossFit® practitioners. Salvador BA. 2017. N = 16

Domain Frequency Variables	**Gender**			**Weekly training frequency**		
	Male n=10	**Female n=6**	**p Value**	**≥5**	**<5**	**p Value**
LF*	791 (511-2059)	1109 (670-5900)	0,59	1165 (570-2059)	890 (437-4768)	0,79
HF*	459 (263-1520)	1028 (565-5253)	0,299	781 (350-1520)	796 (231-4303)	0,79
LF/HF*	1,3 (0,84-1,95)	1,13	0,65	1,4 (1,15-1,95)	1,05 (0,78-1,2)	0,1
Time Domain Variables	**Male n=10**	**Female n=6**	p **Value**	**≥5**	**<5**	**p Value**
RMSSD*	37 (29-61)	60 (37-148)	0,147	47 (31-71)	42 (31-129)	0,798
PNN50*	16,8 (6-33)	27 (13-59)	0,428	24,5 (6-35)	20,1 (9-49)	0,958
SDNN*	67 (42-76)	62 (49-137)	0,492	67 (49-87)	60 (44-121)	0,878

* Values presented in median and interquartile range; Man-Whitney Test

Discussion

The present study was the first Brazilian study to investigate the effect of regular CrossFit® practice on the autonomic system of healthy young people. We observed that the volunteers had, at the time of the research, a slight sympathetic predominance, especially men and those who practiced the activity five or more times a week.

HRV is a biological marker that is influenced by age, gender, systemic dysfunction, and regular physical activity. A previous study compared long-distance runners and bodybuilders in which the former had better autonomic function when compared to the latter, as aerobic exercise modulates the ANS by increasing parasympathetic efference because of increased HF, which causes lower LF / HF ratio of this group (16-18).

CrossFit® can be characterized as high intensity circuit training. This type of training uses exercises with large muscle groups and high training volume. This overload is important for the expected physiological adaptations (cardiovascular, respiratory and muscular), but adequate rest is required for physiological adjustments and muscle repair. HRV has already been identified as an early biological marker to identify overuse or overtraining, which is the previous fall in physical performance which promotes injury and loss of sports performance (6,13).

In this research, individuals with more than one year of CrossFit® practice and more than 3 years of regular physical activity were selected. Nevertheless, a slight sympathetic predominance (LF / HF> 1) was identified showing a possible initial state of overtraining (6-8). Although no statistical difference was found in the sample studied, a lower variability is observed in men and individuals who train more than 5 times a week, thus corroborating the hypothesis that some individuals are in a state of high physical stress.

Williams and contributors studied the HRV behavior of six high performance CrossFit® athletes during a training period. In this sample, it was possible to detect HRV fall during training overload moments, helping to fine-tune the training load and possible reduction of injuries related to physical training (19). In the study, the training phase of the volunteer was not controlled, therefore, it is likely that some individuals came with a high training load and were under high metabolic and inflammatory demand (19). Thus, the authors of the present study suggest that HRV is monitored by professionals and practitioners who are in the phase of high load volumes and training intensity.

Recently, the ELSA-Brazil study evaluated 2874 healthy individuals and was the first study to describe HRV normal values for the Brazilian population. In this study, it was identified that variability is strongly influenced by age, but the effect of physical activity on the autonomic control of the heart was not verified (17). When comparing the RMSSD variable of the ELSA-Brazil study population with the results of the present study, we found that CrossFit® practitioners had higher median values (41, IQ: 31-75) than the ELSA-Brazil study population (31, IQ: 23-42). However, when comparing the sympathovagal balance by the LF / HF variable, we observed that the participants in this sample presented values like the ELSA study (1.12 Vs. 1.18, respectively).

Aubert et al., in 2003 presented the difference in HRV between the gender. Women have lower LF, which may generally be a protective factor against cardiovascular comorbidities and slower cardiovascular aging. However, the menstrual cycle may be a potential confounding factor, as there is a change in autonomic tone as well as hormone replacement therapy. In this study there was no control of the menstrual cycle, it is possible that this variable influenced the results presented (7).

This study has as limitation a heterogeneous sample and the small number of the sample, which reduces the capacity of data extrapolation to other populations. In addition, the analysis of maximal physical capacity by a maximal test could assist in the effects of CrossFit® practice on the cardiovascular system.

Conclusion

In the sample studied, it was observed that CrossFit® practitioners have a slight predominance of sympathetic activity, especially males and individuals who practice physical activity five or more times a week.

Author contributions

Oliveira FO participated in the The project conception, statistical analysis and writing of the manuscript. Ramos ACC participated in the data collection and writing of the manuscript. Almeida CN participated in data collection and tabulation and statistical analysis. Plácido C participated in the database examination, statistical analysis and manuscript review. Oliveira IA participated in data collection, data tabulation and statistical analysis. Rocha MD participated in literature review and manuscript review. EC Milk participated in the team training (heart rate variability) and blinded data analysis. Dias CM participated in the project conception, data collection supervision and final manuscript revision.

Competing interests

No financial, legal or political competing interests with third parties (government, commercial, private foundation, etc.) were disclosed for any aspect of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.).

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