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Heart Rate Recovery is Blunted in Soccer Athletes During a Competitive Season

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Abstract

Since vagal control of the heart rate (HR) is impaired in athletes during the competition period, we hypothesized that soccer athletes engaged in a competitive season would exhibit an impaired HR recovery after exercise. Seven male soccer athletes and 9 male sedentary individuals were matched for age. Heart rate variability (HRV) was assessed in sitting and upright position for 10 min. The HR and blood pressure (BP) were measured at rest, during treadmill exercise test and recovery period. Individuals were 24 ± 3 years old. The athletes had a lower HR (55 ± 3 bpm vs. 72 ± 10 bpm; P< 0.001) and systolic BP (108 ± 4 mmHg vs. 118 mmHg ± 6; P< 0.001) than sedentary individuals at rest. Low frequency (LF) and high frequency (HF) component of the HR were similar in both groups at sitting position. Active orthostatic test increased LF and reduced HF in both groups. Soccer athletes showed a higher maximal oxygen consumption (63 ± 5 ml.kg-1.min-1 vs. 47 ± 5 ml.kg-1.min-1; P= 0.001). The HR recovery in the first minute after exercise was similar in both groups. High-intensity exercise performed at the competition season may blunt heart rate recovery in soccer athletes.

Keywords: Exercise; Sympathetic nervous system; Hemodynamics

Introduction

Post-exercise heart rate recovery depends on vagal reactivation [1] and sympathetic withdraw [2]. However, in the first minute after exercise heart rate recovery seems mainly mediated by the vagal reactivation [3]. In patients with heart disease [1] and in individuals with cardiac risk factors heart rate recovery is slow [4]. An abnormally slow heart rate recovery is an independent predictor of mortality [5-7] and represents an important marker of impaired vagal control [4,5,8]. On the other hand, regular physical exercise accelerates heart rate recovery in several diseases [9-12] and even in sedentary healthy individuals [13]. Therefore, regular physical exercise improves vagal modulation of the heart rate. In fact, athletes show greater vagal modulation of heart rate at rest [14] and increased vagal reactivation after exercise, assessed by heart rate recovery, compared with sedentary individuals [13].

This faster heart rate recovery in athletes seems to be an important mechanism to avoiding excessive cardiac work after exercise. Furthermore, a faster heart rate recovery identifies individuals with cardiovascular protection associated with higher parasympathetic activity [4,15]. However, athletes during competition periods are subject to high physical workload and emotional stress that could affect autonomic cardiovascular activity and the cardiovascular responses to exercise [16-19]. This is evidenced in a study of *Iellamo et al* [20] that demonstrated that rowing athletes at the competition season showed reductions in the vagal modulation of the heart rate and increases in the sympathetic tone assessed by spectral analysis. However, it is still unknown whether heart rate recovery is affected by the competition season in athletes.

Soccer is the sport most known and practiced in the world. Currently some cases of sudden death in soccer players during the exercise has reinforced the importance of cardiovascular evaluation, emphasizing the hemodynamic behavior during exercise and heart rate recovery immediately after exercise, which assesses indirectly cardiovascular autonomic control. In South America the training and competition season involve approximately 10 months without interruption. Thus, the optimal preparation of the soccer players might to require a specific training program that involves technical, tactical and physical preparation with appropriate quantity, volume and intensity of training [21,22]. Usually the training intensity is higher at the competitive season what could change the autonomic control. Since vagal control of the heart rate is impaired in athletes during the competition period [20], we hypothesized that soccer athletes engaged in a competitive season would exhibit an impaired heart rate recovery after exercise. The objective of this study is to evaluate heart rate recovery in soccer athletes at the competitive season.

Materials and Methods

Study design

Healthy sedentary individuals (n=9) and soccer athletes (n=7) participated in this cross-sectional study. The groups were matched for age and body mass index (BMI). All soccer athletes were in a competitive season. Exercise training program at the competitive season was characterized by 2 hours of exercise per day. Sedentary group did not practice regular physical exercise at least 1 year before the study. Physical activity status was determined using the Physical Activity Index of Kasari [23]. This index is based on points allocated depending on the frequency, intensity and time spent performing physical activity per week, with scores ranging from 1 (minimum activity) to 100 (training at a high intensity every day of the week). Subjects with BMI<25 kg/cm^2, with history of exercise-induced asthma, hypertension, diabetes mellitus, renal, cardiac and pulmonary diseases, regular alcohol and tobacco consumption were excluded from this study. The research protocol was approved by the Committee for Ethics

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in Research of the Regional University Northwest State of Rio Grande do Sul, and all subjects signed a written informed consent form.

Individuals were initially evaluated by medical history and physical examination. Maximal exercise testing was maintained until voluntary exhaustion to determine peak oxygen uptake (VO_2peak) and maximal heart rate. The hemodynamic variables were all monitored during the resting, exercise testing and recovery period. All experiments were performed in a temperature-controlled room and all subjects were in the fasting state (at least for 3 hours), had refrained from consuming caffeinated beverages and alcohol for at least 12 hours, and had not exercised for at least 48 hours prior to the evaluation to minimize possible effects on dependent variables. All baseline measurements were executed with the individuals resting for at least 10 min.

Heart rate variability

Heart rate variability was evaluated by spectral analysis using the fast Fourier transform with subjects in the sitting and in the upright position for 10 min. Low frequency (LFnu) (0.04–0.15 Hz) and high-frequency components (HFnu) (0.15–0.5 Hz) were calculated and spectral power density was expressed in normalized units [24].

Exercise Testing

Maximal functional capacity was conducted according to the standard and Bruce protocols on a treadmill (ATL Inbrasport, Brazil). Twelve-lead electrocardiographic tracings were obtained every minute (Micromed with software ErgoPc, Brazil) and blood pressure was measured by the end of each Bruce protocol´s stage with a standard cuff sphygmomanometer (Sankey, Brazil). The test was discontinued in the presence of signs of fatigue incompatible with continued exercise or ECG changes, and the test was directly supervised by a cardiologist. During the test, the VO_2peak was obtained indirectly through the program ErgoPC [25].

Heart rate recovery

When the exercise test was interrupted, the individuals immediately passed to the sitting position, starting the recovery period. The blood pressure and the heart rate were checked every minute, during the first 5 minutes of recovery. Heart rate recovery was defined as the decrease in the heart rate from the rate at the peak exercise to the rate one minute after the cessation of exercise and than four following minutes.

Statistical analyses

Data were analyzed on the Statistical Package for Social Sciences (version 16.0 for Windows, SPSS, Chicago, Illinois). Descriptive data are presented as mean ± SD. The clinical characteristics of athletes and sedentary, the values of systolic blood pressure (SBP), diastolic blood pressure (DBP) DBP) and heart rate (HR) at maximal exercise were compared using the *Student's t test*. ANOVA for repeated measures was used to evaluate the hemodynamic variables during exercise and recovery period. The association between heart rate recovery and HFnu was assessed by Pearson Correlation. It was accepted as significant $p<0.05$.

Results

Participants

Table 1 shows the higher aerobic capacity of the athletes compared to sedentary group, expressed by higher VO_2 peak; ($p<0.001$) and Physical Activity Index ($p<0.001$). The HR and SBP in the sitting resting condition was significantly lower ($p<0.001$) in athletes than sedentary group. There were no differences between individuals in age, weight, height, BMI and DBP.

Hemodynamic responses during the exercise testing

Table 2 presents the average values of SBP and DBP in the warm up in a stand up position, immediately before and during exercise testing. Athletes showed a greater increase in heart rate during the exercise (Δ 114 ± 9 bpm vs. ± Δ 88 ± 14 bpm, $p<0.05$).

Heart rate recovery

Figure 1 shows the lower heart rate in athletes and sedentary during the rest (55 ± 3 *vs*. 72 ± 10 bpm; $p<0.001$) and before starting the exercise test (67 ± 14 *vs*. 89 ± 16 bpm; $p<0.05$). However, heart rate recovery was similar between groups during the first 5 minutes of recovery after the exercise.

Heart rate variability

In the sitting position all the index of the heart rate variability was similar between athletes and sedentary subjects. The active orthostatic test induced an increase in LFnu and a reduction in HFnu similar in both groups (Table 3). Heart rate recovery was not significantly correlated with HFnu in sedentary individuals (r=048, $p=0.19$) and in athletes (r=- 0.61, $p=0.19$).

Discussion

The major finding of the present study was that the heart rate recovery did not differ between soccer players and sedentary individuals during a competitive season. This finding is contrary to previous studies that showed a faster heart rate recovery in athletes than in sedentary individuals [13,26]. However, high-intensity exercise training during a competitive season could shift the cardiovascular autonomic modulation from a parasympathetic toward a sympathetic predominance [17-20]. In this study heart rate recovery in athletes was similar to sedentary individuals, suggesting that vagal reactivation after exercise was impaired in athletes during a competitive season.

The lower resting heart rate found in our athletes could be suggestive of increased vagal tone [13,20,27,28], although athletes and sedentary showed a similar heart rate variability. These findings are in agreement with a previous study that showed that five months of seasonal training and competitions reduced resting heart rate, but did not changed any index of the heart rate variability in young swimmers at resting and orthostatic test [2].

	Athletes (n = 7)	Sedentary (n = 9)	*p*
Age (years)	23 ± 5	26 ± 1	0,16
Weight (kg)	69 ± 8	72 ±11	0,54
Height (m)	173 ± 6	175 ±9	0,77
BMI (kg/m²)	23 ±2	23 ± 2	0,57
SBP (mmHg)	108 ± 4	118 ± 6	0,001*
DBP (mmHg)	65 ± 6	74 ± 3	0,08
Resting HR (bpm)	55 ± 3	72 ± 10	0,001*
FIT índex	100 ± 2	1 ± 0	0,001*
VO^2max (mL.kg^1 m^{i}n1	63 ± 5	47 ± 5	0,001*

Values are expressed as mean ± SD. SBP=Systolic blood pressure; DBP=Diastolic blood pressure; HR=Heart rate; BMI=Body mass index; FIT (Frequency Intensity Time) Index of Kasari; VO^2max = maximal oxygen uptake *Student's t-test different from athletes group. $p < 0.05$.

Table 1: Baseline characteristics of individuals.

Exercise Testing	Athletes (n=7)	Sedentary (n=9)
SBP, mmHg		
Warm up	119 ± 11	119 ± 6
1º stage	134 ± 10*	137 ± 15*
2º stage	151 ± 12*	149 ± 15*
3º stage	171 ± 16*	154 ± 13*≠
4º stage	185 ± 14*	163 ± 11*≠
5º stage	193 ± 9	-
Peak systolic pressure (mmHg)	194± 9*	169 ± 7*≠
DBP, mmHg		
Warm up	77 ± 7	79 ± 7
1º stage	81 ± 5*	83 ± 7*
2º stage	82 ± 9	82 ± 7
3º stage	86 ± 9*	82 ± 9*
4º stage	91 ± 6*	86 ± 7*
5º stage	100 ± 10	-
Peak diastolic pressure (mmHg)	101 ± 8*	87 ± 6*
Heart Rate, bpm		
Warm up	67 ± 13	88 ± 17≠
1º stage	92 ± 14*	107 ± 15*
2º stage	110 ± 14*	120 ± 15*
3º stage	132 ± 7*	145 ± 20*
4º stage	158 ± 10*	168 ± 20*
5º stage	179 ± 12*	-
Peak HR (bpm)	182 ± 10*	176 ± 6*

Values are expressed as mean ± SD. SBP= Systolic blood pressure; DBP= Diastolic blood pressure; HR= Heart rate. * ANOVA different from rest. ≠ Different from athletes group. $p < 0.05$.

Table 2: Hemodynamic Responses during the Exercise Testing.

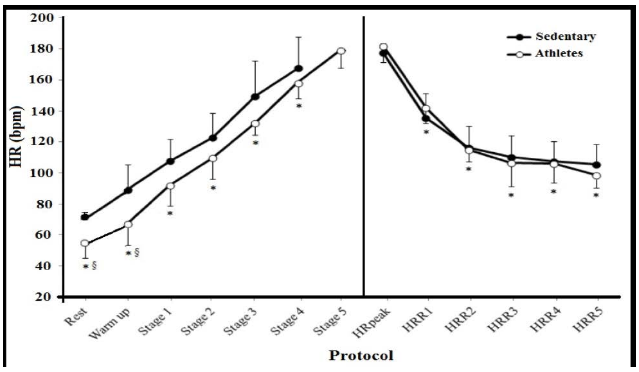

Figure 1: Mean ± SD during the rest, warm up, maximal exercise test and heart rate recovery period.
HR=Heart rate; HRR=Heart rate recovery. * Different from baseline. § Different from Sedentary group. ANOVA P<0.001.

	Athletes (n=7)		Sedentary (n=9)	
	Seated	Stand up	Seated	Stand up
Total Power (ms2)	5541 ± 3502	4699 ± 2822*	2656 ± 1398	2294 ± 1144*
LF power (nu)	72 ± 9	79 ± 7*	70 ± 11	77 ± 9*
HF power (nu)	25 ± 9	19 ± 7*	26 ± 10	20 ± 9*
LF/HF	3.4 ± 1.9	5.2 ± 4*	3.2 ± 1.9	5.2 ± 3.6*

Values are expressed as mean ± SD. LF = low frequency; nu = normalized units; HF = high frequency; LF/HF = low frequency/high frequency ratio. *ANOVA different from seated position. $p < 0.05$.

Table 3: HRV indexes recorded during Active Orthostatic Test in athletes and sedentary individuals.

Many studies have reported a relationship between heart rate recovery and physical activity [13,29,30]. Although our athletes showed higher VO_2 max and lower resting HR, indicating a good physical fitness, the heart rate recovery was about 40 beats in the first minute after the exercise for both athletes and sedentary. On the other hand, the specific modality of the exercise training could affect the heart rate recovery. In fact, athletes engaged in continuous endurance sports may have slower heart rate recovery than athletes engaged in intermittent endurance sports [31]. The soccer athletes enrolled in our study performed a high-intensity of continuous endurance exercise. Therefore, the exercise training modality likely explains the lack of a faster heart rate recovery in our athletes compared to sedentary individuals.

Our data is in agreement with a recent study that showed that heart rate recovery is not related to any index of heart rate variability in well trained athletes [32]. This suggests that vagal reactivation after exercise and vagal tone at rest represents different mechanisms for the autonomic control of the heart rate, since vagal reactivation could be impaired by high-sympathetic influences at the peak of the exercise.

Heart rate recovery is an important marker of physical fitness [29]. Clinically, a slow heart rate recovery is predictive of cardiovascular mortality [4,5,8]. Interestingly, regular exercise training improves heart rate recovery in cardiac patients [10,11,12]. In healthy individuals endurance and strength exercise training are effective in improving heart rate recovery. However, high-intensity exercise training associated with competitions could impair heart rate recovery, but the clinical implication of this finding is still unknown.

This study suggests that a competitive season may have potential effects on the heart rate recovery in athletes. However, this cross-sectional study has several limitations that we cannot potentially exclude from the finding results, as follows: 1) VO_2peak was assessed indirectly. However, sedentary individuals obtained the lowest score (~1), while the athletes achieved the highest score (~100) in the Physical Activity Index, proposed by Kasari [23], indicating that athletes were physically very active. 2) The sample size was relatively small. The athletes were submitted to hard daily exercise training associated with competition season that takes around 10 months in South America. This was the reason why we could not recruit more athletes for this study. 3) The resting SBP and HR had no normal distribution at baseline between groups. As knowing athletes had a lower SBP and HR in resting condition that shown a better autonomic modulation due the regular physical activity [13,14]. 4) We performed a cross-sectional study because a randomized clinical trial or an experimental trial could not be feasible. This study represents heart rate recovery and heart rate variability in soccer players in a real training and competition condition.

In conclusion, our data suggest that high-intensity exercise performed at the competition season, would explain in part, the blunted heart rate recovery in soccer athletes. Therefore, further studies could investigate the relationship between heart rate recovery and heart rate variability in soccer athletes before, during and after periods of competition.

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