EXERCISE AND SPORTS MEDICINE CLINIC

HEART RATE VARIABILITY AND MAXIMUM WORKLOAD REACHED IN THE DYNAMIC PHYSICAL EXERTION TEST IN ELDERLY MEN

ORIGINAL ARTICLE

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ABSTRACT

Introduction: One of the benefits provided by regular physical activities seems to be the improvement of cardiac autonomic nervous system modulation. However, the role of physical activity as a determinant factor of the heart rate variability (HRV) is not well-established. Therefore, the aim of this study was to verify whether there was a correlation between resting heart rate and maximum workload reached in an exercise test with HRV indices in elderly men. Methods: A study was carried out with 18 elderly men between the ages of 60 and 70 years. The following evaluations were made: a) Maximal exercise test on a cycle ergometer using Balke treadmill protocol to evaluate the aerobic capacity; b) Heart Rate (HR) and RR Intervals (RRi) registered for 15 minutes at rest, in the supine position. After collection, data were analyzed by time domain (RMSSD index) and by the frequency domain (low (LF) and high (HF) frequency indices and LF/HF ratio). Pearson correlation test was used to verify whether there was a correlation between the maximum workload reached during the exercise test and the HRV indices ($p \leq 0.05$). Results: Demographic, physiological, and anthropometric characteristics and the maximum load achieved during exercise test: Age = 63 ± 3.0 years; BMI = 24 ± 2 kg/m2; HR = 63 ± 9 bpm; SBP = 123 ± 19 mmHg; DBP = 83 ± 8 mmHg; maximum workload = 152 ± 29 watts. No correlation was found between the HRV indices with the values of the resting heart rate and the maximum workload reached in the exercise test ($p > 0.05$). Conclusion: Temporal and spectral indices of heart rate variability are not indicators of aerobic capacity of elderly men evaluated on a cycle ergometer.

Keywords: heart rate variability, exercise test, resting heart rate, elderly.

INTRODUCTION

Heart rate variability (HRV) is an important marker of neural cardiac activity, where high values are a sign of good adaptation and they characterize a healthy individual, while low values are frequently sign of abnormal adaptation of the autonomous nervous system (ANS) and are associated with higher risk of cardiovascular diseases[1].

HRV, likewise aerobic capacity, decreases during the aging process due to alterations of the ANS[2]. However, behavior factors, including regular practice of physical exercise, seem to attenuate these adaptations[3].

On this matter, it has been reported that regular moderate practice of physical exercise may increase vagal modulation[4], which supports the idea that HRV may be associated with the level of maximal aerobic capacity[5].

Besides higher levels of HRV, trained individuals may present lower values of resting heart rate (HR)[6], possibly due to increase of vagal activity[7]. Therefore, some studies mention that aerobic performance positively correlates with parasympathetic activity[8]. However, other studies have observed that aerobic training did not alter the oxygen consumption peak in the same proportion that HRV[9], indicating that the other factors involved in the aerobic performance are independent from the alterations in HRV[10].

Additionally, some research did not find significant alterations of the ANS after aerobic training in men[9]. One of the explanations for these findings is that low intensity aerobic exercises would not be effective in altering the ANS from the extent to keep or increase the HRV in elderly individuals[11].

Therefore, the ANS abnormalities aggravated by the aging effects have been seen as an example of physical conditioning [12]. Thus, many studies have pointed regular practice of physical activity as the aim to attenuate such effects. Nonetheless, the investigations on the correlation between autonomic modulation of the heart and aerobic capacity are inconclusive[13].

Thus, the present study has tried to test the hypothesis that there is a correlation between maximal workload values reached in the ergometric test, resting heart rate with the HRV indices in elderly men.

METHODS

The present study was approved by the Ethics in Research Committee of the Philosophy and Sciences College of UNESP-Marília, according to legal opinion number 461/2009. All volunteers received information about the experimental procedures and after having read and agreed on it, they signed the Free and Clarified Consent Form according to resolution 196/96 and its complementary parts in the National Health Board.

The studied sample was composed of 18 men aged between 60 and 70 years, classified as elderly[14]. All of them practiced physical activity regularly. Inclusion criteria were: being healthy, non-smokers, non-obese and do not drink alcohol (body mass index lower than 30kg/m^2).

In order to guarantee health conditions and diagnose possible alterations which could contraindicate their participation in the research, the following procedures were followed: initial interview and from it, a subsequent individual form with personal information, anamnesis (life habits, previous and current history of pathologies, family history); physiotherapeutic clinical examination of the locomotor and cardiorespiratory systems; anthropometric evaluation (body mass, stature and body mass index calculation); conventional electrocardiogram of 12 derivations, blood pressure record (BP) and HR performed at rest at supine position, ergometric test and laboratory tests (hemogram, complete lipid profile, glycemia, type I urine, uric acid, creatinine and urea) was filled out.

Those individuals with blood pressure above 139 x 89mmHg, classified as borderline[15]; patients with cardiovascular, respiratory or metabolic diseases; smokers and users of any kind of medication or drug were excluded from the study.

Heart rate and R-R intervals recording and analysis of heart rate variability (HRV)

Heart rate was recorded with a cardio frequency meter (Polar, S810i, Kempele, Finland). The volunteers did not intake coffee, tea, soda or alcohol and kept the activities of daily living 48 hours before the recording. The subject was positioned at dorsal decubitus and remained at rest, with minimal movement and quiet, until the physiological variables were steady; that is to say, BP and HR. From that moment on, heart rate, R-R intervals beat by beat were recorded during 15 minutes. Subsequently, the data were transferred to the computer with an infrared interface. Data transfer and analysis were done with the Heart Rate Variability Analysis (University of Kuopio, Finland) program. The most stable segment was selected for analysis, always considering 256 points. For time domain analysis, the RMSSD (root mean square of successive differences) index was calculated, which represents the vagal activity. For analysis in the frequency domain the spectrum was decomposed in the following bands: high frequency (HF – 0.15 to 0.4Hz) and low frequency (LF – 0.04 to 0,.5Hz). From these two bands, the LF/HF ratio was calculated[16]. The HF represents the parasympathetic activity, the LF represents an association of the sympathetic and parasympathetic activities, with predominance of the sympathetic one, and the BF/AF ratio represents the sympathovagal balance[17].

The resting HR was obtained through the calculation of the mean of the collection period.

Physical exercise test

The maximum physical exercise test was performed in a vertical cycle ergometer of electromagnetic braking (Lion Fitness, LF 300, Pompeia, Brazil). The seat height was individually set so that the knee was at kept at an angle between 5 and 10º at the highest extension point of the lower limb.

Balke[18] protocol was applied. It consists of increment of 25w of overload at every two-minute stage, until voluntary fatigue, or until the individual reached maximum heart rate (HR) and/or any other signo r symptom of physical fatigue which hampered the test continuity, such as: precordial pain, whiteness and excessive sweating, or any other signs identified by the researcher or by the volunteer himself[19].

Statistical Analysis

Kolmogorov-Smirnov normality test was applied and data normal distribution was verified.

In order to test the hypothesis of association between the HRV indices and resting HR and the maximum load reached in the exercise test, Pearson correlation test was applied ($p \leq 0.05$). The significance level adopted was 5% ($p < 0.05$). The analysis software used was the GraphPad InStat®.

The sampling calculation was based on the correlation value between HRV and VO_2 found in the study by Hägglund *et al.*[20]. Thus, the correlation coefficient value used in this statistical procedure was of 0.64, a statistical power of 80% and alpha of 0.05 was considered. The Ene® software version 3.0 was used (Barcelona, Spain) for statistical processing. The sampling size suggested was of 14 volunteers.

RESULTS

Demographic, anthropometric and physiological characteristics, as well as maximum workload reached in the ergometric test are presented in table 1. Table 2 presents the statistical data of correlation analysis between the time (milliseconds) and spectrum (normalized units) indices, HR (beats per minute) and maximum workload (watts) reached in the ergometric test.

Table 1. Demographic, antrhopometric, physiological characteristics and maximum load reached in the ergometric test.

	Mean	Standard deviation
Age (years)	63	3
BMI (kg/m2)	24	2
HR (bmp)	63	9
SBP (mmHg)	123	19
DBP (mmHg)	83	8

BMI= body mass idex; kg/height2= kilograms per meters to the square; HR= heart rate; bpm = beats per minute; SBP = systolic blood pressure; DBP = diastolic blood pressure; mmHg= merceury millimeters.

Table 2. Statistical data of the analysis of correlation between the time and spectrum indices, heart rate and maximum load reached in the ergometric test.

	HR rest (bpm)		Maximum load (watts)	
	p	r	p	r
LF (un)	0.88	-0.03	0.52	-0.15
HF (un)	0.51	0.16	0.78	0.06
LF/HF	0.49	-0.17	0.67	-0.1
RMSSD (ms)	0.08	-0.42	0.23	-0.29

HR= heart rate; bpm= beats er minute; LF= low frequency index; HF= high frequency index; un= units normalized; RMSSD= root mean square of the successive differences between normal adjacent RR intervals (represents parasympathetic activity); ms= milliseconds.

DISCUSSION

In the present study, in which healthy elderly men and practitioners of regular physical activity were evaluated, correlation of the maximum workload reached in the egometric test and resting HR with the HRV values was not found.

These results clash with other investigations which verified direct correlation between the level of aerobic capacity and HRV, especially by the high frequency index, which reflects the parasympathetic activity[21]. According to other authors, the training is responsible for conditioning sufficient to increase the cardiac vagal activity[4]; however, the low intensity exercises do not seem to have the same effect [22]. In addition to the intensity, training engagement and regularity should also be considered, a fact which can be observed in the work by Galetta *et al.*[23], in which endurance elderly athletes submitted to many years of training were evaluated. In that investigation, positive correlation between HRV indices in the time domain and maximum workload reached in the exercise test was verified.

Nevertheless, other studies[24,25] corroborate our findings when verify that, after a significant period of aerobic training, the HRV indices were not proportional to the oxygen consumption peak in elderly men. These results evidence that the HRV may not be necessarily a direct consequence of engagement and regularity of physical exercises practice, considering other factors, such as genetic characteristics[25] and the other systems besides the cardiac, which determine the aerobic functional capacity during a physical exercise test, such as the respiratory and musculoskeletal.

Concerning the results of the correlation test between resting HR and HRV indices, some findings are also contradictory to the results in the present study. For instance, in the study by Yamamoto *et al.*[26], training significantly decreased the resting HR and increased the indices related to the parasympathetic modulation, demonstrating hence that the ANS alterations partially contribute to the bradycardia. Likewise, the study by McLachlan *et al.*[27], which compared two groups, one with normal sinus rhythm and another with sinus bradycardia, presented HRV values for the individuals with bradycardia compared with the individuals with normal sinus rhythm. However, the authors state it is incorrect to suppose that the increase of parasympathetic activity is responsible for all the cases of sinus bradycardia, since the vagal activity reinforcement do not explain the bradycardia induced by training when control groups paired by age are compared.

Thus, as in the present study, there seems to be additional factors involved in the bradycardia caused by training[28] , as reported in another work which verified increase of 12% in oxygen consumption and decrease of resting HR after a period of aerobic training, without alteration in the vagal activity, though[28]. Similar results were obtained by Catai *et al.*[29] who studied the effects of aerobic physical training in young individuals and middle-aged men and concluded that the bradycardia caused by training is related to the intrinsic adaptations in the sinus node. Reland *et al.*[30] strengthen this hypothesis when state that active elderly subjects present lower resting HR with none alteration in HRV, indicating that the effects of the physical activity on the HR and HRV are dissociated and the sinus node may be more sensitive to the adaptations verified.

Therefore, we concluded that the time and spectrum HRV indices studied are not indicators of the level of aerobic capacity of elderly men evaluated in cycle ergometer. However, it is worth mentioning that despite being independent, these variables are essential factors related to the population survival, which enables the stratification of the risk for cardiovascular diseases.

Finally, we highlight that in this study careful triage of the volunteers was conducted in order to obtain homogeneity concerning the demographic and anthropometric data, physiological variables and health conditions. Nevertheless, this methodological severity despite being necessary, limits the number of volunteers. Therefore, further studies able to recruit a larger number of volunteers and guarantee the most possible control of variables are suggested.

All authors have declared there is not any potential conflict of interests concerning this article.

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