ISSN 1413-3555
Rev Bras Fisioter, São Carlos, v. 12, n. 1, p. 7-12, jan./fev. 2008

Evaluation of autonomic heart rate modulation among sedentary young men, in sitting and supine postures

Avaliação da modulação autonômica da freqüência cardíaca nas posturas supina e sentada de homens jovens sedentários

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Abstract

Objective: To evaluate and compare the autonomic heart rate (HR) modulation, under resting conditions in relation to body posture, in sedentary young adults. **Methods:** Twenty young healthy and sedentary men aged 22.6 ± 2.5 years participated in the study. The HR and R-R intervals (in ms) of the electrocardiogram (EKG) were obtained in real time using the modified DII derivation, with the volunteers at rest in the supine and sitting positions, for 15 minutes. The R-R data were analyzed in the time domain, by means of the RMSSD, RMSM and pNN50 (%) indices; and in the frequency domain, by means of spectral analysis and fast Fourier transforms (FFT), using low frequency (LF) and high frequency (HF) bands expressed as normalized units and as the LF/HF ratio. The statistical analysis consisted of the Spearman test for correlation analyses and the Wilcoxon test for paired samples, with significance of α= 5%. **Results:** In the time domain, the RMSSD and pNN50 indices demonstrated statistically significant differences between the supine and sitting positions ($p< 0.05$). The RMSM index did not showed any statistically significant difference between the positions ($p> 0.05$). In the frequency domain, the LF and HF bands and the LF/HF ratio demonstrated statistically significant differences between the supine and sitting positions ($p< 0.05$). **Conclusions:** The results demonstrated that, by changing the posture, autonomic adjustments were produced to the parasympathetic and sympathetic nervous systems with regard to HR control. This can be attributed to the integrity of the neurocardiac system.

Key words: heart rate variability; resting; young men; body posture; autonomic nervous system.

Resumo

Objetivo: Avaliar e comparar a modulação autonômica da freqüência cardíaca (FC) em repouso em relação à postura corporal em jovens sedentários. **Métodos:** Foram estudados 20 homens jovens (22,6 ± 2,5 anos), saudáveis e sedentários. A FC e os intervalos das ondas R (iR-R em ms) do eletrocardiograma (ECG) foram captados em tempo real na derivação DII modificada, com os voluntários em repouso nas posturas supina e sentada, durante 15 minutos. Os dados dos iR-R foram analisados, no domínio do tempo (DT), pelos índices RMSSD, RMSM e pNN50 (%); e no domínio da freqüência (DF) pela análise espectral, transformada rápida de Fourier (FFT), pelas bandas de baixa freqüência (BF) e alta freqüência (AF), expressas em unidades normalizadas (un) e a razão BF/AF. Para análise estatística foi utilizado o teste de correlação Spearman e o teste de Wilcoxon para amostras pareadas com significância de α= 5%. **Resultados:** No DT, os índices RMSSD e pNN50 apresentaram diferenças estatisticamente significantes na comparação entre as posturas supina e sentada ($p< 0,05$), e o RMSM não apresentou diferença estatisticamente significante na comparação entre as posturas ($p> 0,05$). No DF, as bandas de BF, AF e a razão BF/AF apresentaram diferença estatisticamente significante na comparação entre as posturas supina e sentada ($p< 0,05$). **Conclusões:** Os resultados mostraram que, com a mudança postural, ocorreram ajustes autonômicos do sistema nervoso parassimpático e simpático sobre o controle da FC, o que pode ser atribuído à integridade do sistema neurocárdico.

Palavras-chaves: variabilidade da freqüência cardíaca; repouso; homens jovens; postura corporal; sistema nervoso autônomo.

Recebido: 6/11/2006 – **Revisado:** 20/06/2007 – **Aceito:** 9/10/2007

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Financial support: CNPq, FAP/UNIMEP

Introduction

Homeostasis of the cardiovascular system is carried out by efficient control and feedback mechanisms that seek to maintain the mean arterial blood pressure and the central venous volume within a relatively narrow range. This is achieved by constant regulation of the heart rate (HR) and vascular tonus, which are primarily modulated by the autonomic nervous system (ANS)[1,2].

Pathological conditions such as diabetes, myocardial infarct and degenerative diseases promote alterations in the autonomic modulation of the HR and in the dynamics of the cardiovascular system. Thus, the rapid compensatory HR adjustments to ensure homeostasis that are determined by autonomic action on the sinus node become compromised[3].

The ANS of the heart regulates and modulates the responses and oscillations of the HR through its efferent, sympathetic and parasympathetic branches. Variations in the R-R interval (IRR) duration in milliseconds (ms), in eletrocardiogram (ECG), are dependent on autonomic modulation. These temporal variations between two consecutive ventricular contractions are called heart rate variability (HRV)[4,5].

From studying HRV at rest, indirect information on the integrity and disorders of the heart's autonomic modulation resulting from health conditions and physical fitness levels can be obtained at lower costs[4,5]. This method has been used by various professionals in different fields of healthcare, as a means of evaluation and reevaluation, both for prescribing medical treatment and for physical therapy. Thus, it is used in determining physical training protocols that are more effective for the evaluation of the degree of adaptation. Therefore, the aim of the present study was to evaluate autonomic HR modulation under resting conditions, among young healthy sedentary men in the supine and sitting postures.

Methodology

Sample calculations were carried out using the GraphPad StatMate application, version 1.01i (1998), with a confidence interval of 95% and power of 80%. This suggested that 14 volunteers would be needed. Twenty young (22.6 ± 2.5 years) male healthy sedentary volunteers were evaluated. They had "weak" aerobic capacity, according to the classification of the American Heart Association[6] (VO_2max: 30.2 ± 4.3 ml/kg/min^{-1}), obtained by means of a cardiopulmonary exercise test. They were non-smokers and were not taking any kind of medication.

The individuals were given explanations about the relevance of the study and the experimental procedures. After agreeing to participate, they signed an informed consent statement, in accordance with Regulation no. 196 of the National Health Council. The study was approved by the Ethics Committee of the Universidade Metodista de Piracicaba where it was carried out, with procedure no. 03/05.

The volunteers were considered to be healthy, according to the evaluations they underwent: anamnesis (collection of personal data, lifestyle and eating habits, family antecedents and present and previous history of diseases); complementary biochemical blood tests (glycemia, triglycerides, total cholesterol, urea, creatinine and uric acid); and physical therapy evaluation consisting of physical and general muscle inspection, heart and lung auscultation, heart rate measurement, arterial blood pressure measurement by means of the Korotkoff method (three measurements at rest in the supine and sitting postures), clinical and cardiovascular evaluation, and conventional 12-derivation ECG at rest and in the DI, DII and modified V2 derivations, under the following conditions: at rest in the supine and sitting postures; under hyperventilation for 30 seconds; and during the maximum ergospirometry exercise test. The research was carried out in a laboratory with an artificial climate-controlled environment at a temperature between 22°C and 24°C and relative air humidity between 40% and 60%, during the same period of the day (between 2:00 pm and 6:00 pm).

On the days before the tests, each volunteer received important instructions for ensuring the success of these tests, such as avoiding consumption of stimulating drinks (tea, coffee or alcoholic drinks), not performing physical activities, having light meals and having a night time sleep of at least eight hours. In addition, they were familiarized with the experimental procedures by means of a pilot test that was carried out one week earlier.

To collect HR and IRR data, the volunteers were monitored in relation to the modified DI derivation, with the negative electrode on the manubrium sterni, the positive electrode on the fifth space of the left anterior midaxillary line, relative to V5, and the neutral electrode on the fifth right intercostal space. The ECG signals were picked up by a single-channel cardiac monitor (Miniscope II, Instramed, Porto Alegre, RS, Brazil) and processed by means of an eight-channel analog/digital converter (Lab-PC+/National Instruments Co, Austin, TX, USA) that formed an interface between the cardiac monitor and the Pentium III microcomputer. The HR was obtained in real time, beat by beat at a sampling frequency of 500 Hz, and the IRR of the ECG was calculated using specific software[7]. During the data collection, the volunteers were instructed not to speak or move. To evaluate the autonomic HR modulation response in relation to the supine and sitting postures, data were recorded for a 15-minute period at rest for each condition respectively, with spontaneous breathing.

The IRR data series was initially inspected to assess its quality and then the intervals that showed greatest stability in the tracings were selected. Following this, the data were analyzed provided that they consisted of at least five minutes of recording or 256 points[8].

The analyses were carried out using routines in MatLab version 6.5. In the time domain (TD), the data were analyzed based on the RMSSD index of the IRR (ms) in ms, i.e., the square root of the sum of the squared difference between the recorded IRR, divided by the number of IRR (ms) in the selected data series minus one (RMSM, in ms), which corresponds to the square root of the sum of the squared difference of the individual values in relation to the mean value, divided by the number of IRR (ms) in the selected data series and the pNN50 of the IRR (ms) (the percentage in relation to the total of number of R-R intervals that have a difference greater than 50 milliseconds for each R wave interval in the ECG)[8].

The data analysis in the frequency domain (FD) was carried out on data that were collected under the same conditions and over the same intervals that were selected for time domain analysis. For the FD analysis, fast Fourier transforms was used, applied to a single window, after linear subtraction of the trend in the previously chosen R-R intervals. The total power component was obtained from the high frequency (HF: 0.04 to 0.15 Hz) and the low frequency (LF: 0.15 to 0.4 Hz), in absolute measurement units (ms^2), and the normalized units were calculated by dividing the absolute power of the HF or the LF component (ms^2) by the total power component and subtracting the very low frequency (VLF: 0.003-0.04 Hz) and then multiplying this ratio by 100. The LF band is modulated by the sympathetic and the parasympathetic nervous systems, the HF band is controlled by the vagus nerve and the LF/HF ratio represents the sympathetic-vagal balance[5,8].

The statistical analyses of the significance on the data were done using the non-parametric Wilcoxon test. This test was selected because the Kolmogorov-Smirnov test had shown that the data set distribution was not normal. The correlation test that was used was Spearman's, for given pairs of variables that were studied. The statistical significance level was established at 5% ($p< 0.05$).

Results

Table 1 shows the age values, anthropometric characteristics, HR, blood pressure (BP) at rest in the supine posture and biochemical blood tests. It could be seen that they were within the normal range.

Figure 1 A, B and C present the results of the analyses of R-R intervals (ms) in the TD are presented. It could be observed that the RMSSD (Figure 1A) and pNN50 (%) (Figure 1C) index were greater in the supine posture than in the sitting posture (p<0.05). However, the RMSM index during the R-R intervals (ms) (Figure 1B) were similar (p>0.05).

Through the FD analysis of the periodic variations in the RR intervals (ms), by means of band power spectrum decomposition, it could be observed (Figures 2A, 2B and 2C) that for the supine posture in relation to the sitting posture, the HF (units) were greater, the LF (units) were lower and the LF/HF ratio was lower. This reflected the finding that the HRV decreased significantly from the supine posture to the sitting posture (p< 0.05).

It could be seen that the correlations between the RMSM (ms) and LF (units) indexes were moderate (r = 0.51; p< 0.05) in the supine posture.

Discussion

The HR at rest is influenced by different factors, such as: genetic characteristics, anthropometrics (body mass and height), age, gender, hormonal and emotional factors, level of physical fitness and state of health, among others[9]. The influence of these factors can be analyzed through postural tests[10,11].

It has been reported in the literature that adjustments in HR modulation from the supine posture to the sitting posture are due to hydrostatic deviations caused by the displacement of blood from the central region to the lower regions, thereby reducing the cardiac debit, systemic arterial pressure and activation of the arterial and cardiopulmonary receptors[12,13]. Siebert et al.[14] evaluated the sympathetic-vagal balance at the

Table 1. Ages, anthropometric characteristics, heart rate (HR) at rest, systolic arterial pressure (SAP), diastolic arterial pressure (DAP) at rest and biochemical blood tests on the volunteers studied (n=20). Values expressed as means and standard deviations.

	Values	Reference values
Age (years)	22.6 ± 2.5	-
Massa corpórea (kg)	79 ± 6.1	-
Height (cm)	176.5 ± 5.8	-
BMI (kg/m^2)	24.9 ± 1.7	-
HR (bpm)	66.7 ± 6.2	-
SAP (mmHg)	119.5 ± 2.2	-
DAP (mmHg)	79.5 ± 2.2	-
Glucose (mg/dl)	87 ± 4.6	70 to 100
Urea (mg/dl)	31.8 ± 3.3	10 to 45
Creatinine (mg/dl)	0.9 ± 0.1	0.6 to 1.4
Total cholesterol (mg/dl)	178.6 ± 32	<200
Triglycerides (mg/dl)	79.7 ± 16	30 to 150
Uric acid (mg/dl)	5.4 ± 0.5	2.5 to 7.0

kg: kilograms; cm: centimeters; BMI: body mass index; HR: heart rate; bpm: beats per minute; SAP: systolic arterial pressure; DAP: diastolic arterial pressure; mmHg: millimeters of mercury; kg/m^2: kilograms per square meter; mg/dl: milligrams per deciliter.

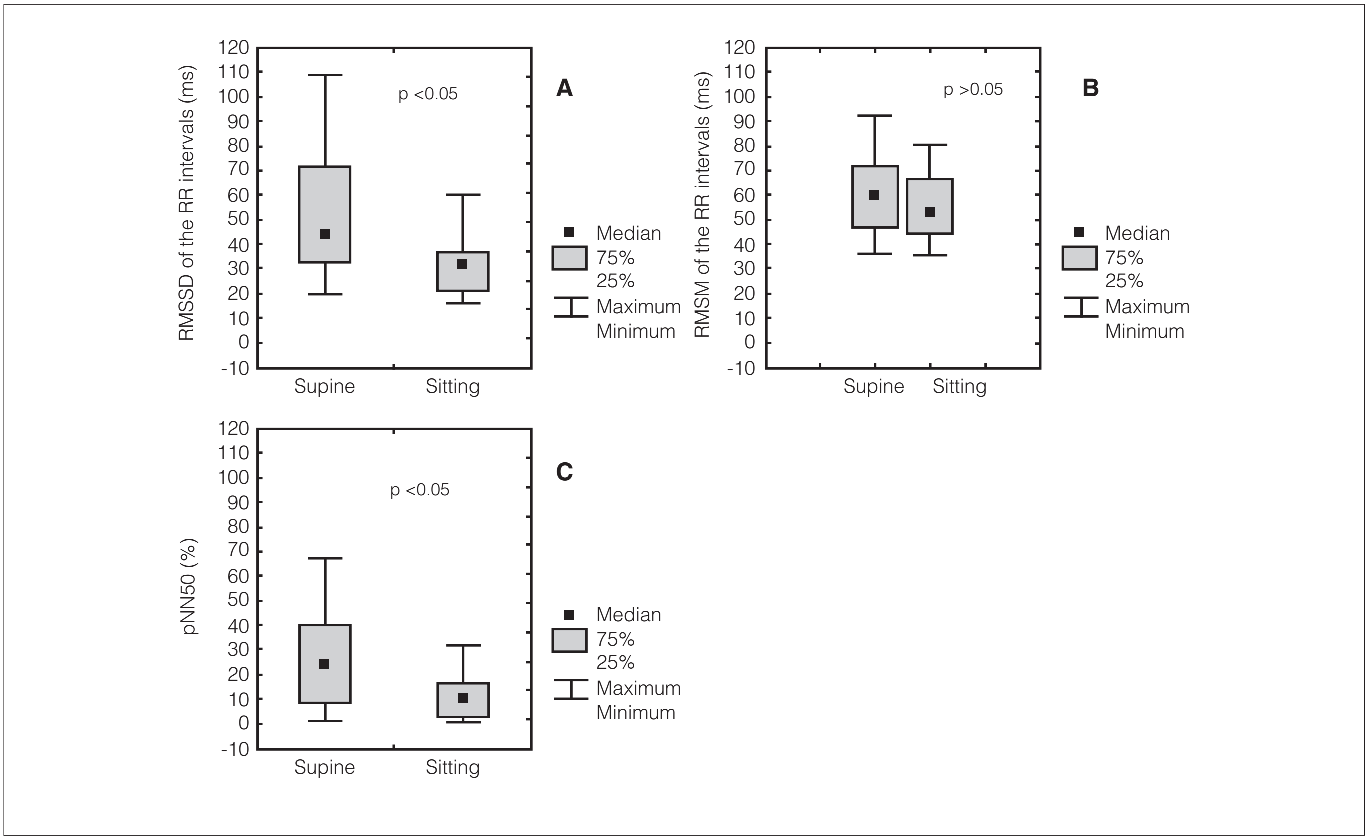

Figure 1. RMSSD (A), RMSM (B) and pNN50 (C) values of R-R intervals in ms, for the volunteers studied (n=20), in the supine and sitting posture. Significance level α= 5%.

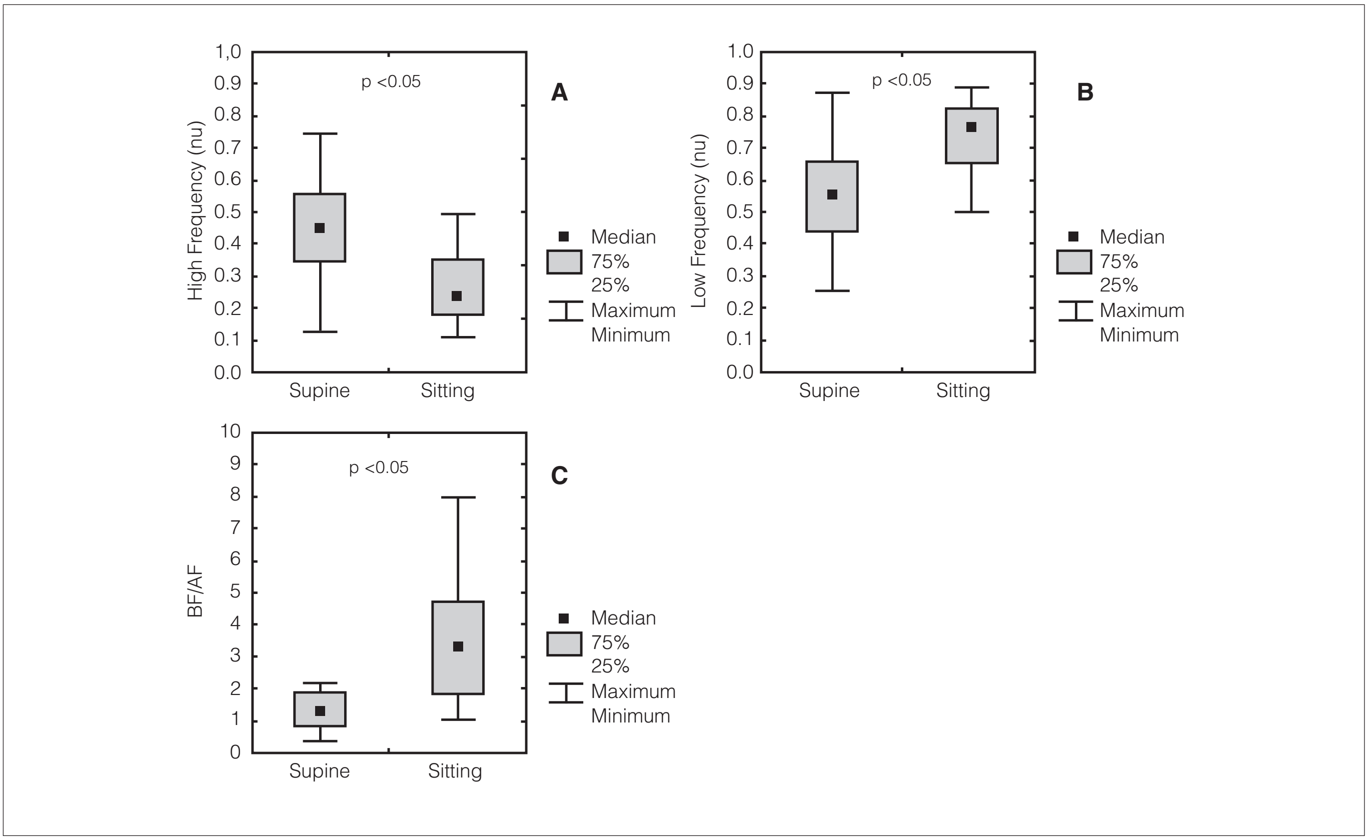

Figure 2. HF (A), LF (B) and LF/HF (C) values of R-R intervals in milliseconds, for the volunteers studied (n=20), in the supine and sitting posture. Significance level α= 5%.

sinus node, by analyzing the HRV in the FD, in relation to the transition from the supine posture to standing up, and observed an increase in LF band values. However, these authors reported that the predominance of sympathetic activation was due to adrenergic stimulation, Frank-Starling mechanisms, activation of the rennin-angiotensin-aldosterone system and other neurohormones.

Under resting conditions, there is a sympathetic-vagal interaction, but the predominance of one in relation to the other can vary according to postural changes. Thus, studying the HRV at rest in the supine and sitting postures enables identification of sympathetic-vagal balance alterations at the sinus node[11]. It has been reported that, in the supine posture, there is greater parasympathetic activation at the sinus node, in relation to the sitting posture[15]. In the present study, decreased sympathetic action in relation to the parasympathetic system was observed in the supine posture, with higher HRV. Acharya et al.[12] found that young women and men presented higher values for the RMSSD (ms) and pNN50 (%) indices and lower values for the LF/HF ratio in the supine posture, in relation to the sitting posture. The results from the present investigation are in agreement with their findings.

The LF spectral component represents the activation of sympathetic and parasympathetic activity, modulated by the baroreflex and by the cyclic oscillations in blood pressure, or Meyer waves. The HF component represents the efferent vagal activity, and the LF/HF ratio indicates the relationship in the sympathetic-vagal balance, since the higher this value is, the more the sympathetic predominance will be[16]. The results from the present study were similar to those of other authors[3,14], i.e., the HF component was greater in the supine posture (indicating parasympathetic predominance in relation to the sitting posture) and the LF component and LF/HF ratio were greater in the sitting posture.

According to Maia[16], under physiological conditions, the RMSSD (ms) and pNN50 indices represent vagal activity, whereas the RMSM index represents the sympathetic-vagal modulation. Maia reported that RMSSD values lower than 30 ms and pNN50 lower than 4% should be considered to be a risk factor for triggering arrhythmia, with an indication for using beta-blockers. In the present investigation, it was found that, although the volunteers were sedentary, they demonstrated RMSSD indices of 45 and 35 ms and pNN50 of 28 and 11% in the supine and sitting postures, respectively, which were within the normal values according to data in the literature[8,16]. Our RMSSD indices were close to those of Paschoal et al.[17] and Mello et al[18]. In the literature, it is stated that the RMSM rate represents the sympathetic-vagal balance and that there is a correlation between RMSM and LF. Our data are in agreement with those findings.

FD analysis has been considered to be a more robust tool than TD analysis for investigating HRV and identifying HR response variations. Although our results showed a correlations between the RMSM and LF indices[19], there was no statistically significant differences in RMSM. This was because modifications in the autonomic modulation may occur without any HRV response variations, as observed in TD analysis[11].

Conclusion

From the results of this study, it can be concluded that postural changes led to autonomic adjustments of the parasympathetic and sympathetic nervous system relating to HR control, which can be attributed to the integrity of the neurocardiac system.

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