

Cardiac Autonomic Modulation Behavior in Community Men with Hypertension on rest and Effort Condition

Comportamento da Modulação Autonômica Cardíaca de Hipertensos Comunitários na Condição de Repouso e Após Esforço

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Abstract

Heart rate variability (HRV) analysis is an important method to evaluate the modulation of autonomic nervous system on cardiac activity. The goal was to evaluate the heart rate variability behavior in hypertensive middle-aged men at rest, before and after submaximal physical test. It is a cross-sectional, analytical study with sedentary men, middle-aged (mean 48 years) and owners of clinical diagnosis of hypertension who underwent to a physical therapy evaluation, and obtainment of HRV at rest in the supine position, sitting position and before a 6-minute walk test and after it. The values of HRV indexes on time and frequency domain showed low and statistically significant ($p < 0.05$) when analyzed and compared at rest and after the execution of the test. Conclusion: The data suggest that the studied hypertensive volunteers showed a reduction of HRV immediately after the 6-minute walk test, implying a reduction in parasympathetic modulation during this period and the consequent increase in cardiovascular risk after physical exertion, even being a submaximal test.

Keywords: Physical Exertion Heart. Hypertension. Autonomic Nervous System.

Resumo

A análise da variabilidade da frequência cardíaca (VFC) é um importante mecanismo para a avaliação da modulação do sistema nervoso autônomo sobre a atividade cardíaca. O objetivo do estudo foi avaliar o comportamento da variabilidade da frequência cardíaca de homens de meia-idade e hipertensos na condição de repouso antes e após serem submetidos a esforço físico submáximo. Trata-se de um estudo analítico transversal, em que foram estudados homens, sedentários de meia idade (média de 48 anos) e possuidores de diagnóstico clínico de hipertensão arterial sistêmica, submetidos à avaliação fisioterapêutica e captação da VFC na condição de repouso em supino, sedestação e antes de realizar teste de caminhada de 6 minutos (TC6) e após sua execução. Os valores dos índices de VFC nos domínios de tempo e frequência estudados apresentaram-se reduzidos e estatisticamente significantes ($p < 0.05$) quando analisados e comparados em repouso e após a execução do teste. Os dados sugerem que os hipertensos estudados apresentaram uma redução da VFC imediatamente após o TC6, inferindo uma diminuição da modulação parassimpática neste período e consequente aumento no risco cardiovascular após o esforço físico, ainda que submáximo.

Palavras-chave: Esforço Físico. Hipertensão. Sistema Nervoso Autônomo.

1 Introduction

It is defined as hypertension (HTN) the clinical condition determined by high and maintained levels of systemic blood pressure (SBP), defined by values higher than 130mmHg and 90mmHg systolic and diastolic blood pressure, respectively¹⁻³. In the year of 2001, approximately 7.6 million deaths worldwide were associated with hypertension, being the majority after stroke, followed by ischemic heart diseases².

The practice of physical activity is of great importance for the hypertensive population by hypotensive mechanisms triggered by means of the exercise, which promotes the reduction of the levels of plasma norepinephrine, reduction of renal sympathetic tonus, muscle and the attenuation of the sympathetic response after physical conditioning. There is also an increase of blood volume and consequent increase of cardiac ejection volume, which explains the decrease in heart rate (HR) through the mechanism of Frank Starling, after

physical conditioning^{4,5}. For the beginning of the practice of physical activity, the assessment of the physical fitness of the individual becomes essential for the detection of any amendment or possible complication that can be triggered by physical exertion. The analysis of heart rate variability (HRV) is a mechanism for evaluating and reporting on the integrity of the modulation of the autonomic nervous system on the heart⁶, which may indicate through their indexes the fitness level of an individual.

The heart rate variability describes the oscillations of cardiac R-R intervals, related to the autonomic nervous system, being a High HRV sign of good physiological adaptation of the organism and its maintenance, indicating a condition of stability of the system, while its decrease is directly related to higher rates of cardiovascular morbidity and mortality. The reduction of expressed HRV increases 3 to 5 times the relative risk of mortality by cardiovascular event⁷⁻¹⁰. HRV can be

analyzed through two linear methods in the domains of time and frequency, and there are protocols and variables specific to the study of each one of them.

Due to its ease of measurement, the behavior of HR has been widely studied in different conditions at rest and during exercise^{8,11,12}. Although they are not definitely proved, the evidences suggest that the changes resulting from the SAH trigger in the individual an imbalance in cold-vagal balance with increase from the first in relation to the second, modifying the variability in heart rate and blood pressure control^{13,14}. It is suspected that these changes are associated with the increase in sympathetic activity in the vascular bed, occurring in situations of hypertension^{15,16}. Taking into account these changes, the need is intensified to assess if there are changes in HRV of hypertensive individuals, for determination of the degree of dynamics and regulation of autonomic system existing in those individuals^{12,17}, considering this need, the objective of this study was to evaluate the cardiac autonomic control of middle-aged hypertensive patients and check whether there is a difference in the values found at rest and after submaximal effort by the individuals.

2 Material and Methods

It is a sectional and analytical study performed at an event open to the community offered by the course of physiotherapy, which occurred at University of Brasília, Ceilândia Campus with the goal of screening individuals for inclusion in a cardiovascular rehabilitation program. The study has the approval by the Research Ethics Committee of the College of Health Sciences CEP/FS UnB (no. 1.166.770). All participants were informed about the research and signed the Informed Consent Form prior to their inclusion.

The non-probabilistic sample and selected by convenience, included in the present study was composed by male participants, sedentary (do not reach at least 150 minutes per week of physical activity considering the leisure, work and travel), middle age (mean age of 48 years) and the possessors of clinical diagnosis of hypertension stage I and II¹. Individuals with diabetes, uncontrolled blood pressure, orthopedic or cognitive problems were excluded that made the evaluation impracticable and regular physical activity practitioners for more than three months.

After the systematization and application of eligibility

criteria and agreement, all individuals underwent physiotherapy assessment which consisted of general anthropometric inspection and measurement of cardiac frequency and PAS before, during and after the completion of the test. TC6 was carried out in a 20-meter corrido, marked and free of traffic from other people. For its implementation, the patient was asked to walk from one extreme to the other part of the corridor for six minutes, with the largest walking speed that he could¹⁸. The variables were collected at the beginning and end of the test. HR was measured for 10 minutes at rest in supine position, 10 minutes on sitting position on a chair, 5 minutes in orthostatism, throughout the implementation of the TC6 and 5 minutes immediately after the test, totaling 36 minutes of collection. The systemic arterial pressure was measured before and after each position contained in the test. All tests and evaluations were performed by the same examiner, previously trained.

For the abstraction of HRV, it was placed on the patient's chest at the sternal region, the raising range of the Polar S810 heart rate monitor ®, the signal captured was processed by *software Polar Pro Trainer 5*® and transformed into text files. The values recorded for the analysis of the HRV in the time domain were obtained in the indices rMSSD and pNN50, whereas in the frequency domain the indices of low and high frequency were analyzed (LF, HF) and LF/HF ratio. The data were treated by means of *software Kubius HRV*.

2.1 Statistical analysis

It was verified the normality in the distribution of data through the Shapiro-Wilk test and homogeneity of variances by the Levene test. Later for comparison of median values found in the supine position and sitting position and before and after physical exertion, the non-parametric test of Wilcoxon paired with dependent samples was used. All statistical analysis was performed using the *SPSS software* version 22 (IL, USA) and the established level of significance was 5%.

3 Results and Discussion

10 participants were evaluated whose average age was 48 years. Considering the body mass index (BMI), 50% of the subjects were in the obesity range of grade I¹⁹, the characteristics of the participants are described in Table 1.

Table 1 - General characteristics of the participating sample.

(n=10)	Age (Years)	Weight (Kg)	Height (cm)	BMI (%)	PASr (mmHg)	PADr (mmHg)
Mean ±sd	48 ± 6.7	91.8 ± 10	175 ± 6.4	29.36 ± 3.8	143 ± 13.3	90 ± 7.1
Min/Max	42-58	76-98	164-186	20-32	120-160	78-100

BMI: body mass index; PARr: diastolic blood pressure at rest; PASr: systolic blood pressure at rest.

Source: Research data.

In Table 2, it can be observed that despite the decrease in the values of all the analyzed indices, except for the LF/HF ratio,

there is no statistically significant difference when compared to the HRV in the supine and sitting position, both in rest condition.

Table 2 - Comparison of median values of HRV indices obtained at rest in the supine sitting position

	Supine	Sitting	<i>p</i>
rMSSD (ms)	15.200	11.500	0.06
pNN50 (%)	0.3500	0.000	0.23
LF (%)	73,450	77.300	0.13
HF (%)	26,450	22.650	0.13
LF/HF	2.750	3.350	0.07

HF: high frequency; LF: low frequency; LF/HF ratio, low frequency and high frequency; *p*: Index of significance; pNN50: percentage of adjacent R-R intervals with duration greater than 50ms; rMSSD: root mean square of the difference among the normal adjacent R-R intervals.

Source: Research data.

In the comparison between rest and after physical effort (Table 3), the values found in the time domain of indices rMSSD and pNN50 showed reduced median values and statistically significant after performing the test. The values found in the frequency domain, despite also presenting reduction, after the statistical analysis showed no statistical significance.

Table 3 - Comparison of median values of HRV indices of participants at rest and after the 6-minute walking test.

	Pre-effort	Post-effort	<i>p</i>
rMSSD (ms)	12.800	8.600	0.01
pNN50 (%)	1.200	0.1000	0.03
LF (%)	74.050	81,900	0.10
HF (%)	18.950	18.100	0.32
LF/HF	3.050	4.550	0.43

HF: high frequency; LF: low frequency; LF/HF ratio, low frequency and high frequency; *p*: Index of significance; pNN50: percentage of adjacent R-R intervals with duration greater than 50ms; rMSSD: root mean square of the difference among the normal adjacent R-R intervals.

Source: Research data.

The analysis of the indices of HRV performed in the present study observed reduction of their indices in hypertensive individuals after the completion of the TC6, corroborating studies found in the literature^{13-15,20-23} that analyzed this population in similar conditions. The reduction of the indices pNN50 and rMSSD reflect the parasympathetic modulation found in hypertensive patients studied and are in accordance with what is observed in the literature. Huikuri²² upon comparing normotensive and hypertensive male subjects and mean age of 50 years, found reduced values in both areas, concluding that long-time hypertensive patients, have alteration in their autonomic modulation, reflecting on the HRV. Result also found in another comparative study of the HRV in hypertensive patients, with the same distribution of age and sex as their control group¹³. In the present study, the variables, both in the time domain and frequency recorded in hypertensive individuals, present values significantly lower than those observed in normal individuals.

Hypertensive patients have an imbalance in the cold-vagal balance characterized by increased sympathetic activity to the detriment of parasympathetic activity. In the frequency domain the low frequency index corresponds to interference

predominantly sympathetic, while the high-frequency response indicates parasympathetic influence. Even though not statistically significant in our study, it was observed an increase in the HF band, also being in favor of sympathetic activity to the detriment of the vagal activity²¹. A systematic review²¹ gathered 17 studies being one of its aims to analyze the relationship between the autonomic dysfunction in hypertension by means of comparison of HRV between normotensive and hypertensive individuals. The completion of the review also notes that there is a reduction in the baroreflex sensitivity on the part of the hypertensive and this decrease is believed to be secondary to increased arterial stiffness, a characteristic triggered by SAH^{13,15}.

Another study found in the literature had as objective to evaluate and compare the HRV at rest in the supine and seated position in healthy middle-aged men, hypertensive and after acute myocardial infarction, being participants in the last two groups aerobic physical training (TFA) practitioners for approximately 3 years. The analysis of the indices of HRV in time domain and frequency domain showed no intergroups statistically significant differences. It is possible to associate this lack of difference between the groups, to the effects of TFA performed by the two groups, recognizing that physical activity promotes readjustment in the vagal balance of heart with a gain of the vagal modulation and consequently adjust in HRV¹⁴.

Killit²³ in his study used the HRV as one of the instruments for investigation of autonomic modulation of hypertensive patients not bearers of other cardiac dysfunctions and normotensive individuals, both with equal distribution of age and sex. Using the variables in the time domain, there was reduction in the values of HRV of hypertensive individuals when compared to normotensive individuals. The study also emphasizes that hypertensive grade I and II not bearers of other comorbidities, are not commonly associated with increased cardiovascular risk, requiring methods that estimate their existing risk, the HRV analysis is a tool that can be used with this purpose²⁴.

In relation to the anthropometric profile of the participants in our study, the sample was composed predominantly by individuals classified as obese grade I according to BMI. Obesity is an important risk factor for the development of SAH, being associated with elevated blood pressure. Prospective studies emphasize that the increase in body weight throughout life is an important predictor for the development of hypertension¹⁹. The main hemodynamic findings that confirm this association are the increase of extracellular volume, increased regional blood flow, which lead to an increase in cardiac debit. Just as the weight gain during life is a predictor for the incidence of hypertension, weight loss is commonly related to a reduction in the levels of arterial pressure. BMI as a way of measuring the anthropometric index, also has a direct relationship with the blood pressure. When comparing different anthropometric indicators of

obesity, BMI allows consistently to be associable with the prevalence of hypertension²⁵.

In this study, the reduction of the values of systolic and diastolic arterial pressure after physical exercise when compared with those measured in rest condition, may be associated with acute hypotensive mechanism triggered by physical exertion, whose extension is directly related to the duration of physical effort and its intensity, which may justify its discreet reduction by the short duration of physical effort carried out^{5,20}.

The studies on the relationship between the sympathetic and parasympathetic nervous system and mortality due to cardiovascular disease encourage the investigation of quantitative markers of cardiac autonomic modulation, being the heart rate variability the most promising marker^{10,26,27}. HC can be captured by different instruments, and the electrocardiogram despite still being widely used, has its application limited by the high cost, complexity by specific positioning of numerous electrodes in addition to demanding outpatient physical space. Polar heart rate monitor provides accuracy in its records, it is easy to apply, allowing its use in studies outside the hospital context^{9,10,12,28}.

The use of heart rate variability and cardiovascular therapy allows a large growth, expanding new horizons for clinical practice, and its study of great value for the safe application of physical exercise in specific populations^{12,28,29}, especially the holders of complications or cardiovascular dysfunctions as the bearers of SAH. The reduction of HRV found in hypertensive individuals reflects the degree of impairment of cardiac autonomic modulation, which mediated by baroreflexes, corroborate the diagnosis of SAH^{13,15}. Emphasizing the importance of the inclusion of physical activity practice in the life habits of this population¹⁴.

In addition to simple and reproducible, TC6 becomes safe by the self-limitation capacity of the individuals themselves during their execution. TC6 has a higher correlation with the demands of daily activities when compared to the ergometer cycle, besides presenting also relationship with other variables of physical capacity before the effort¹⁸ becoming an alternative for the evaluation of tolerance and physiological behavior before physical exercise.

The analysis of the HRV characterizes a simple method, demonstrating that the heart rate can be determined at any moment in time between the RR intervals, being able to reveal the behavior of the autonomic nervous system, thus favoring their clinical interpretation, exercise prescription and possible care and prevention before the cardiovascular risk factors triggered by effort.

Because it is a cross-sectional study conducted in a restricted period, the reduced sample size in the present study may be appointed as a limiting factor, because they do not reflect the current prevalence of hypertensive middle-aged individuals in the Brazilian population in addition to reducing

the statistical power of the analysis performed. However, relevant information was observed about the variable studied, aiding in the visualization of the HRV behavior in hypertensive patients and contributing to new studies and questionings about the prescription and monitoring during the practice of physical activity in this population.

4 Conclusion

The findings of the present study, through the analysis of the indices of HRV in hypertensive men showed a reduction of its values after the completion of physical effort, suggesting an increase in cardiovascular risk after the completion of immediate effort, even if the effort is characterized as a submaximal test. The results found, added to those of the literature, reinforce the use of HRV as an important tool for the study of cold-vagal modulation in cardiac activity.

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