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original article

Cardiovascular indicators at rest, and during an incremental test in young males

Indicadores cardiovasculares em repouso e durante um teste incremental em jovens do sexo masculino

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Abstract – The present study compared blood glucose levels, heart rate (HR) at rest and during exercise, besides body composition between hypertensive and normotensive individuals. The sample consisted of 32 young males with an average age of 22.6 years. Initially, the blood pressure was measured to split the sample into two groups: hypertensive and normotensive. Subsequently, fasting blood glucose, bioelectrical impedance, anthropometry, and resting heart rate, heart rate during maximal effort test and recovery phase were measured. Statistical analysis was composed of a Student *t* test and two-way repeated measures analysis. The significance adopted was p = 0.05. The analyzed data showed that hypertensive patients have higher metabolic rates and hemodynamic values than normotensive individuals, which are indicators of cardiovascular risk.

Key words: Hypertension; Risk factors; Young adult.

Resumo – *O presente estudo comparou valores de glicemia, frequência cardíaca em repouso e durante exercício, além da composição corporal entre hipertensos e normotensos. A amostra foi composta por 32 jovens do sexo masculino, com média de idade de 22,6 anos. Inicialmente, aferiu-se a pressão arterial, para divisão em dois grupos: hipertensos e normotensos. Posteriormente foram mensurados, glicemia em jejum, impedância bioelétrica, antropometria, e a frequência cardíaca no repouso, durante o teste de esforço máximo e na fase de recuperação. A análise estatística foi composta pelo teste t- Student e análise de variância para medidas repetidas two-way, entre os grupos. O valor de significância adotado foi p = 0,05. Os dados analisados mostraram que indivíduos hipertensos apresentam maiores índices metabólicos e valores hemodinâmicos do que indivíduos normotensos, sendo estes indicadores de risco cardiovascular.*

Palavras-chave: *Adulto jovem; Fatores de risco; Hipertensão.*

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INTRODUCTION

Among adult populations, throughout recent decades, a large increase in obesity, diabetes mellitus II and arterial hypertension has been noted. Consequently, there has been an increase in the occurrence of cardiovascular diseases such as arteriosclerosis and myocardial infarction, leading to an increase in the mortality rate and expenses associated with these diseases[1].

In turn, among the pathologies mentioned, arterial hypertension has been growing in importance. Arterial hypertension is a chronic degenerative disease of genetic and behavioral origin, characterized by the excess pressure which the blood exerts upon the walls of the blood vessels, or arteries and veins[2]. In a recent telephone study, it was found that 21.6% of the Brazilian populations living in the capitals and federal district reported the condition of being hypertensive[3].

As well as the blood pressure values, the heart rate (HR) is also controlled by the action of the autonomic nervous system and, as a result, for a long time it was thought that the HR was an indicator of risk solely due to its association with the blood pressure values. However, current studies have indicated that the HR can be used as an indicator of risk to health[4], as well as death regardless of the blood pressure[5]. In this respect, a line of investigation suggests that tachycardia at rest can be a health risk index in adults.

On the other hand, taking physical exercise is directly associated with greater production / bioavailability of vasodilatory substances (less damage to the endothelial cell), better autonomic control (reduction of catecholamines circulating or modifications in the density of the receptors), and, possibly to lower blood pressure and HR values.

In pathological situations, where determined modifications have already occurred in the functioning of the organism, observing the response of the HR and other risk indicators, both at rest and in situations of taking exercise, can provide information which allows this index to be used as an indicator of risk to health.

Thus, the study aimed to (i) compare values of blood glucose, HR and body composition between hypertensive and normotensive subjects, as well as, (ii) compare values of HR at rest, during exercise and recovery between hypertensive and normotensive subjects.

METHODOLOGICAL PROCEDURES

Sample

A descriptive/analytical cross-sectional study, which analyzed 32 university students of the male sex (Physical Education course) who, after becoming aware of the project (announcements on the campus), expressed interest in taking part in the study and who, in turn, fulfilled the criteria of inclusion previously established based upon three items of information: (i) Being of the male sex and being duly enrolled; (ii) Not having any special need or cardiopathy which could interfere in executing the physical test; (iii) Signing the free informed term of consent. The study followed the directives and standards which regulate research with human beings (law 196/96) and was approved by the Research Involving Human Beings Ethics Committee which is linked to the university where the study was made (Process 280/2008).

Data Collection

The data presented in this study were collected in two laboratories linked to the Department of Physical Education of the higher level institution responsible for the research. Initially, all those evaluated appeared in the first laboratory, where, at a controlled temperature (22°C), evaluations were made referring to fasting blood glucose, bioelectrical impedance, anthropometry and blood pressure at rest. Soon after this initial evaluation, those evaluated had a light meal and, after a rest period of 30 minutes, were taken to the second laboratory, again at a controlled temperature, in which the treadmill test was performed to estimate the maximum consumption of oxygen (VO_{2max}).

Anthropometry

The body mass was measured using a Filizola brand digital scale, with accuracy of 0.1 kg and maximum capacity of 180 kg. The height was measured using a fixed stadiometer made of wood with accuracy of 0.1 cm and maximum extension of two meters. The body mass index (BMI) was calculated by dividing the body mass by the height value squared and was expressed as kg/m^2. The waist circumference (WC) value was adopted as indicating excess abdominal fat tissue, the measures being taken twice at the minimum circumference between the iliac crest and the last rib, using an anthropomorphic metal tape measure with accuracy in millimeters (mm). All the anthropomorphic measures were taken following the recommendations of the relevant literature[6].

Bioelectrical Impedance

The resistance and corporal reactance (ohm) were obtained using a portable analyzer (BIA Analyzer -101Q, RJL Systems, Detroit, United States). On each day of evaluation, the appliance was calibrated before the evaluations using a resistor of 500 ohm, furnished by the manufacturer itself. The BIA was performed only after emptying the bladder. The procedures were executed with the individual lying on a flat surface of material not conducting electricity (a stretcher) and after removing shoes, socks and any type of metal attached to the body (rings, bracelets, necklaces, etc.).
The transmitter electrodes were placed on the back of the right hand, at the distal phalange of the third metacarpal and on the front surface of the right foot, at the distal phalange of the second metatarsal, and at least 5 cm from the receptor electrodes, which were placed between the styloid process of the radius and the ulna and between the lateral and medial malleolus of the ankle.[7] The body fat percentage (BFP%-BIA) was calculated using a specific equation for the male sex devised by Sun et al.[8].

Blood Pressure

A previously validated[9] *Omron* brand oscillometric appliance, model HEM-742, was used to check the blood pressure. The blood pressure was checked in the right arm with the individuals seated for at least 5 minutes of rest. The individuals taking part in the study were told not to take physical exercise prior to the day of the evaluation and analyses, and not to have any drinks containing caffeine. A two-minute interval was standardized between each one of the three measures of the blood pressure and the values of systolic blood pressure (SBP) and diastolic blood pressure (DBP) were estimated by taking the average of the three evaluations. The presence of arterial hypertension was defined as values of SBP ≥140 mmHg and/or DBP ≥90 mmHg, and diagnosed in 22.6% of the sample (n= 7).

Fasting Blood Glucose

The blood was taken in the university unit itself by the researcher responsible for the study, and to perform the analyses there was a fast of 10-12 hours. A *Johnson & Johnson* brand portable appliance, model *One Touch Ultra* 2, with disposable *One Touch Ultra Soft* lancets and One *Touch Ultra* reagent strips, was used for the glucose dosage . Before taking the blood samples, there was asepsis of the skin surface using cotton wool soaked in alcohol.

Heart Rate

The heart rate was measured continuously at rest (lying on a stretcher in the dorsal decubitus position for 5 minutes) and during the maximal effort test, using a heart rate monitor (Polar brand - Heart Rate Monitor, model S810, Finland).

Maximum Oxygen Consumption

The direct measure test of the VO_{2max} was executed on an Inbrasport brand treadmill. The ventilator variables were obtained directly every 20 seconds by the gas analyzer VO2000; to do so, a silicone mask connected to the analyzer was used. Prior to the warm-up, the silicone mask was placed upon the subject, who remained passively resting so that the value of the respiratory exchange ratio, or respiratory quotient (RQ), attained a value of 0.70 and 0.90. After the stabilization of RQ, a warm-up of 3 minutes started, on the treadmill, at a speed of 5 $km \cdot h^{-1}$. After this warm-up, the incremental test started, beginning at a speed of 6 $km \cdot h^{-1}$, in which each period lasted one minute and at the end of it there was a load increment of 1 $km \cdot h^{-1}$. There was no increase of inclination during the test. The VO_{2max} was defined as the highest value of oxygen consumption attained in the last complete stage by the evaluated subject.

The criteria for interrupting the test were (i) voluntary exhaustion; (ii) maximum heart rate attained (estimated by the formula HR_{max}= 220 - age); (iii) RQ equal to 1.15. During the test, the subjects received oral encouragement from the valuators.

Statistical Procedures

In the statistical analysis, to check the normality of the data, a Shapiro-Wilks test was used, which confirmed the normal distribution of the variables. Thus, the mean and standard deviation were used as indicators of central trend and scattering, respectively. The Student *t* test for independent samples was used in the comparisons between normotensive and hypertensive subjects for the sample characterization variable (Table 1). Finally, the analysis of variance for repeated measures (moment by moment of the test) and two-way (distinguishing the group effect) established comparisons between the heart rate values during the effort test and recovery after it.

All the statistical analyses were performed in the statistical software SPSS (in its version 13.0), assuming a statistical significance of 5%.

RESULTS

The mean age of the group analyzed was 22.6 (minimum: 19.8 and maximum: 32) and when the comparison was established between the two groups in accordance with the presence of arterial hypertension, there was no statistical difference. In the comparisons between the hypertensive and normotensive subjects, as expected, the SBP (14% higher) and DBP (16% higher) values were higher for the hypertensive group (Table 1). On the other hand, there was no statistical difference for any of the adiposity indicators analyzed, whether anthropometric (BMI and WC) or based upon the quantity of body water (BFP%-BIA).

Table 1. General characteristics of the sample stratified in accordance with the presence of arterial hypertension.

Variables	Normotensive (n= 24)	Hypertensive (n= 7)	P
Age (years)	22.5 (3.5)	23 (5.2)	0.809
BMI (kg/m^2)	23.6 (2.8)	25.2 (4.5)	0.284
WC (cm)	79.1 (5.4)	81.4 (12.6)	0.489
WC%-BIA	19 (4.5)	20.4 (7.8)	0.533
SBP (mmHg)	124.6 (8.8)	142.4 (9.1)	0.001
DPB (mmHg)	72.7 (7.2)	84.6 (5.9)	0.001
HR_{rest} (beats/min)	64.4 (11)	77 (10.6)	0.015
VO_{2max} (ml/kg/min)	53.6 (7)	48.6 (4.7)	0.047
Blood Glucose (mg/dl)	86.5 (5.5)	96.5 (17)	0.023

SD= standard deviation; BMI= body mass index; SBP= systolic blood pressure; DBP= diastolic blood pressure; WC= waist circumference.

The group analyzed had a mean value for VO_{2max} of 52.8 ml/kg/min, there being a significant difference ($P < 0.05$) between the hypertensive and normotensive groups, where normotensive individuals had values 9% higher than the hypertensive ones. In the case of fasting blood sugar, the fasting values for the hypertensive individuals were 11.5% higher when compared with the normotensive individuals. The resting HR values indicated that hypertensive individuals had values 19% higher than the normotensive ones.

Straight after the warm-up and just before starting the test (Moment 0, in Figure 1 and 2), the HR values rose in both the groups compared with the resting values (increase of 70% in the normotensive group and 66% in the hypertensive group) (Figure 1). The HR response continued being similar for both the groups throughout the test and, in a linear manner, increased until the end of the incremental test (*P* = 0.001 for both the groups in the ANOVA of repeated measures). On the other hand, in the five minutes of the recovery period, among the normotensive subjects there was a more pronounced reduction of the HR values.

When comparisons were made between hypertensive and normotensive individuals (Figure 2), the HR values differed between the groups up to the fourth minute of the test, when they remained similar until the end of it. At the end of the test, it can be seen that from the third to the fifth minute the values differed again between the groups (less for the normotensive individuals).

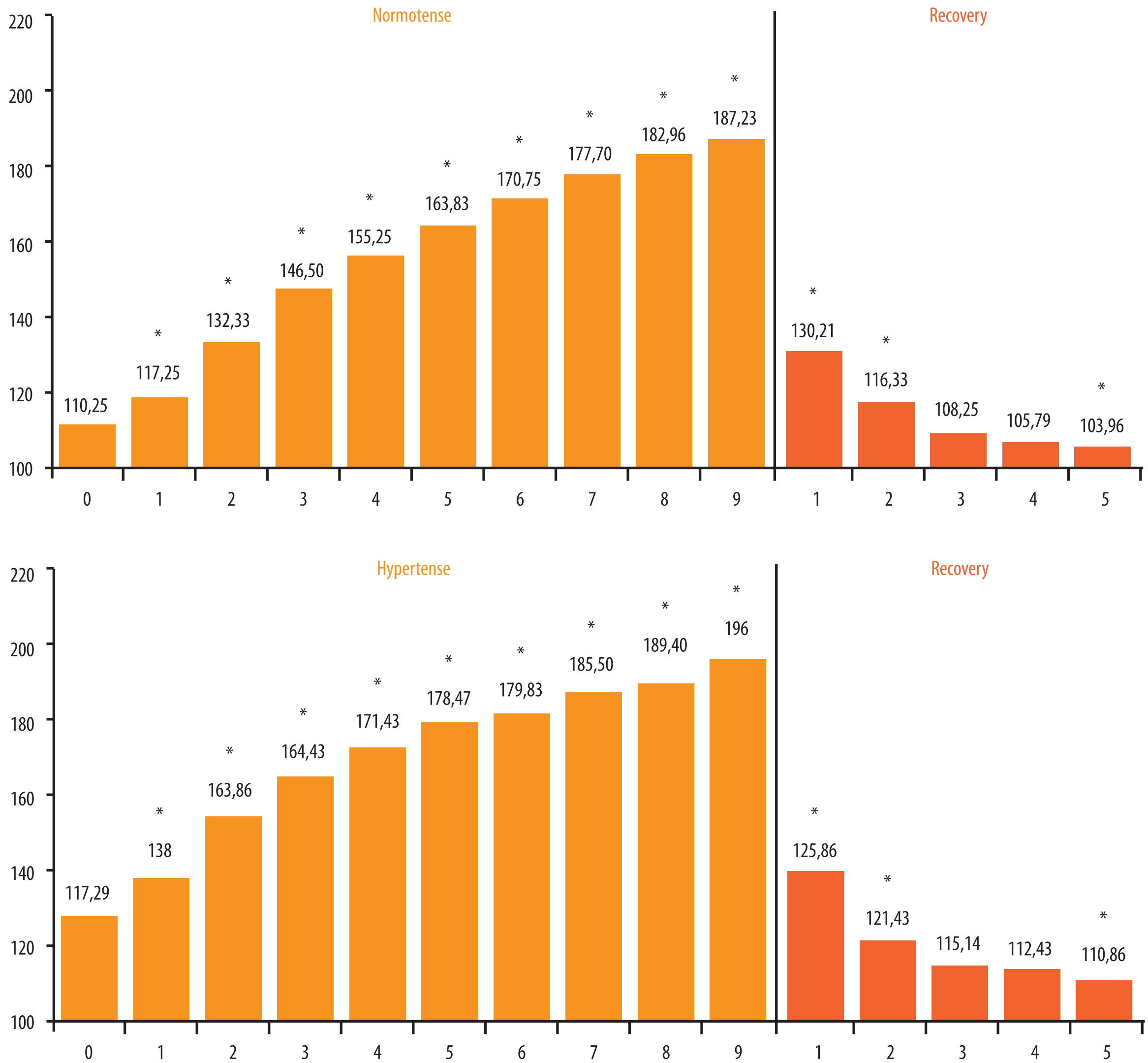

Figure 1. Heart rate response during exercise in hypertensive and normotensive individuals. *= $P<0.05$ compared with the moment zero.

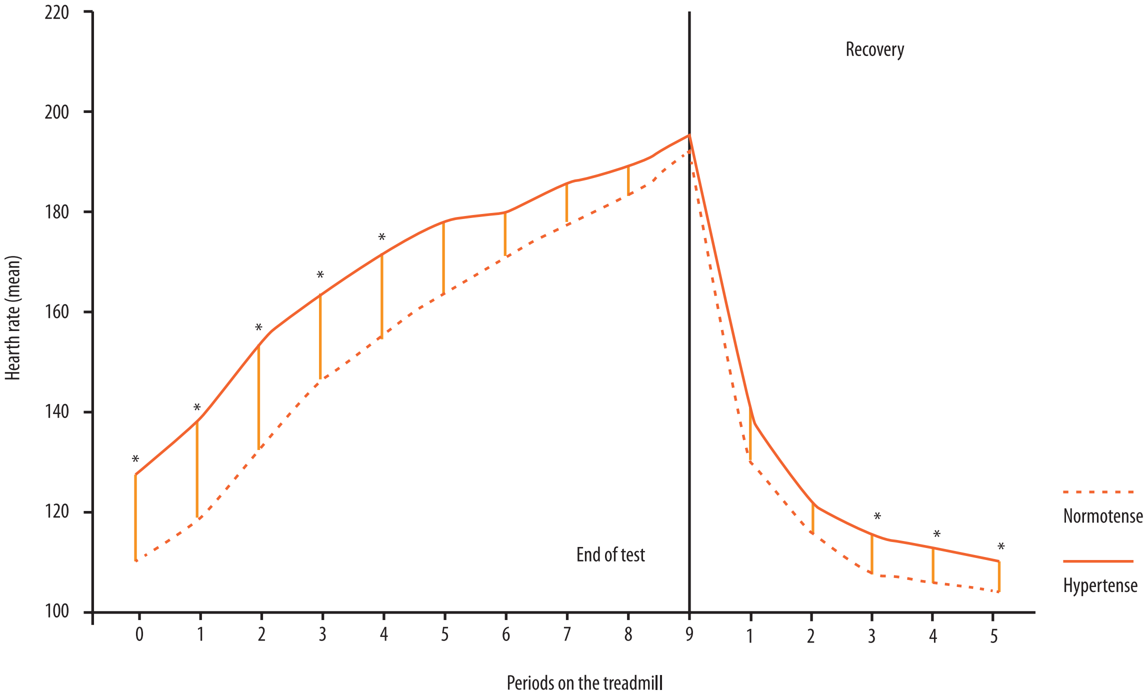

Figure 2. Heart rate response during exercise in accordance with the presence of arterial hypertension.
*= *P*<0.05 in the comparison between normotensive and hypertensive.

DISCUSSION

This was a cross-sectional study performed upon young adults without a history of heart disease, in which it was found that, at rest, when compared with normotensive individuals, the hypertensive subjects had greater tachycardia and high blood glucose value, as well as less cardiorespiratory aptitude in a maximum effort test. Moreover, it was found that the HR response standard differed between the two groups regarding the period of recovery, in which the hypertensive subjects had higher values.

In the present study, the hypertensive subjects had higher blood glucose levels. Indeed, the relevant literature shows that AH is related to diabetes mellitus type 2[10]. The appropriate functioning of the connection between insulin and its receptor in the vascular endothelium activates two cascades of parallel chemical reactions, having as end products the release of nitric oxide and endothelin, which are powerful vasodilators and constrictors, respectively[11,12]. In situations of resistance to the action of insulin, the cascade of chemical reactions which leads to vasodilation is impaired; nevertheless, what encourages vasoconstriction does not undergo modifications. This process, over time, can aid in developing endothelial dysfunction, which in turn leads to AH[11,12]. Moreover, even in cases of resistance to the action of insulin, the insulin stimulates the reabsorption of sodium by the kidneys, as well as activating the sympathetic nervous system[11]. Although a causal line cannot be clearly identified, these mechanisms could explain the higher values of fasting blood glucose in the hypertensive subjects.

On the other hand, physical exercise is an important agent associated with prevention and treatment, as it stimulates the increase of the blood flow in the vessels, activates receptors in the membrane of the endothelium which, in turn, activate oxidizing enzymes responsible for producing nitric acid, through the oxidation of the terminal nitrogen present in the amino acid L-arginine[13,14]. Zaros et al.,[15] after 24 weeks of aerobic training in hypertensive women, identified an increase in the values of circulating nitrite and nitrate (subproducts of the use of nitric oxide)[15]. The aforementioned mechanisms could help to explain the maximum greater consumption of oxygen observed for the normotensive subjects, as physical aptitude is a strong indicator of the practice of physical activities and many of the benefits of practicing physical activities are measured by the increments on physical aptitude.

The present study found that, at rest, the hypertensive individuals had a higher heart rate than the normotensive ones. According to the study of Almeida and Araújo[16], the lower resting heart rate is associated with greater vagal action and less sympathetic action at rest. Nevertheless, in a study made by Uusitalo et al.[17] it was found that the reduction of the resting heart rate in nine athletes undergoing aerobic training did not occur by autonomic modification and, according to Almeida and Araújo[16], greater venous return and systolic volume arising from physical training can cause alterations in the resting HR.

The data showed that, in both the groups, the HR from exercise increased in a linear manner up to the end of the incremental test, only differing in the initial stages of the increment, becoming similar at the end of it. However, there was a difference in the recovery of the heart rate between the groups. For Lahiri et al.[18], the heart rate recovery can be used as a means of evaluating the autonomic nervous system. Concerning the recovery HR, Almeida and Araújo[16] establish that it evaluates the sympathetic withdrawal and return of the vagal tonus after the exercise. The present study found that in hypertensive individuals, the vagal re-establishment was slower compared with the normotensive ones. This result was expected, as the hypertensive individuals have greater sympathetic action at rest, when compared with normotensive ones.[16] It was found that the HR after the effort differed between the two groups from the third minute of recovery, a finding which corroborates the suggestion of Lahiri et al.[18] that the quick drop in the HR is due to vagal reactivation and, later, there is the influence of sympathetic withdrawal.

Finally, the present study contributes to the relevant literature by showing that hypertensive individuals have higher metabolic indices and hemodynamic values than normotensive ones. In our study, the behavior of the HR after the end of the exercise shows that using simple ergometric tests, together with employing the HR, can be useful in the early diagnosis of people with some cardiovascular complication. However, it was limited to the cross-sectional analysis of the sample population, ensuing observations not being made, thereby characterizing its greatest limitation. Moreover, the differences observed regarding to the maximum consumption of oxygen must be treated as a limitation, and so taken into account when analyzing the findings of this study. Thus, to overcome this shortcoming, it is suggested that future studies are developed in groups with similar values of maximum consumption of oxygen.

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