Resting Heart Rate is Associated with Blood Pressure in Male Children and Adolescents

Rômulo Araújo Fernandes, PhD, Ismael Forte Freitas Júnior, PhD, Jamile Sanches Codogno, PhD, Diego Giulliano Destro Christofaro, PhD, Henrique Luiz Monteiro, PhD, and Dalmo Machado Roberto Lopes, PhD

Objectives To analyze the association between resting heart rate and blood pressure in male children and adolescents and to identify if this association is mediated by important confounders.

Study design Cross-sectional study carried out with 356 male children and adolescents from 8 to 18 years old. Resting heart rate was measured by a portable heart rate monitor according to recommendations and stratified into quartiles. Blood pressure was measured with an electronic device previously validated for pediatric populations. Body fatness was estimated by a dual-energy x-ray absorptiometry.

Results Obese subjects had values of resting heart rate 7.8% higher than nonobese ($P = .001$). Hypertensive children and adolescents also had elevated values of resting heart rate ($P = .001$). When the sample was stratified in nonobese and obese, the higher quartile of resting heart rate was associated with hypertension in both groups of children and adolescents.

Conclusions This study confirms the existence of a relationship between elevated resting heart rate and increased blood pressure in a pediatric population, independent of adiposity, ethnicity and age. *(J Pediatr 2011;158:634-7)*.

Resting heart rate (HR) is a simple measurement with important prognostic implications in cardiovascular events.[1] In patients with cardiovascular diseases (CVD), resting HR has been a predictor for mortality, independent of other risk factors.[2,3]

Despite evidence of an association between HR and cardiovascular events, some authors have not considered the elevated HR as a risk factor for CVD.[4,5] Recent epidemiologic studies have indicated that, in adults, the relationship between elevated HR and cardiovascular events is independent of high systolic blood pressure, level of physical activity, and increased waist circumference,[2] suggesting that HR could be considered as an independent cardiovascular risk factor.

Cardiovascular events are the consequence, mainly, of an unhealthy lifestyle that begin at an early age and culminate in the development of diseases such as arterial hypertension, obesity, and insulin resistance.[6,7] Thus, the analysis of the prognostic characteristics of resting HR during infancy may be important.

The purpose of the present study were (1) to analyze the association between elevated resting HR and elevated blood pressure (EBP) in male children and adolescents and (2) to identify covariates of this association.

Methods

This was a cross-sectional study carried out in the city of Presidente Prudente (Human Development Index = 0.846), in Southeastern Brazil, from July to November 2008. The initial sample was 358 male children and adolescents from 8 to 18 years (n = 92 from 8 to 10 years and n = 266 from 11 to 18 years). Two subjects did not follow the protocol and were excluded from the sample (n = 356). The sample was selected from three schools and three sports clubs in the city. In each school and sports club, all students/associates from 8 to 18 years were invited to participate as volunteers in the study. Inclusion criteria for participants consisted of a self-declaration of health and that they were neither taking any medication nor undergoing any regular medical treatment. Research participants and parents/guardians gave written informed consent after receiving a thorough explanation of the research project. The study was approved by the ethics committee on human experimentation of the institution involved.

Resting HR in beats per minute (beats/min) was measured by a portable HR monitor (S810; Polar Electro, Kempele, Finland). The measurements of HR were made during two 30-second periods (with 3 minutes in between). The HR was registered after 5 minutes with the sub-

CVD	Cardiovascular disease
DBP	Diastolic blood pressure
DXA-%BF	Dual-energy X-ray absorptiometry-percentage of body fat
EBP	Elevated blood pressure
HR	Heart rate
OR	Odds ratio
SBP	Systolic blood pressure

From the Institute of Bioscience (R.A.F., J.S.C., H.L.M.), UNESP Univ Estadual Paulista, Rio Claro, Brazil; the Department of Physical Education (I.F.F.J.), UNESP Univ Estadual Paulista, Presidente Prudente, Brazil; the Department of Public Health (D.G.D.C.), Universidade Estadual de Londrina, Londrina, Brazil; and the Department of Physical Education (D.M.R.L.), Universidade de São Paulo, Ribeirão Preto, Brazil

The authors declare no conflicts of interest.

 10.1016/j.jpeds.2010.10.007

jects in a sitting position.[4] All HR measures were made at a university laboratory in a quiet room with constantly controlled temperature.

Body weight (with the subjects wearing light clothing) and height were measured with an electronic scale (precision, 0.1 kg) and a wall-mounted stadiometer (precision, 0.1 cm), respectively. Body mass index was calculated with the values of weight divided by height squared (kg/m^2). All anthropometric measurements were performed by the same researcher, according to standardized techniques.[8]

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) values were measured with an electronic device (MX3 Plus; Omron Corporation, Kyoto, Kansai, Japan), previously validated for pediatric populations.[9] After 5 minutes of resting in a sitting position, two measures were taken on the right arm, with a 2-minute interval between them. The mean value was used. For the blood pressure measurement, two types of cuffs were used according to the arm circumference (6 mm × 12 mm for children and 9 mm × 18 mm for adolescents age 14 to 18 years and for those children with a large arm size). Blood pressure was measured according to the recommendations of the American Heart Association.[10] To determine which cuff would be used, the circumference of the arm of each child was measured, and the cuff that had approximately 40% of the width of arm circumference and 80% of length was used. The 95th percentile of the National High Blood Pressure Education Program[11] cutoffs adjusted by age and height percentile were applied to indicate EBP.

Body composition was estimated by a dual-energy x-ray absorptiometry (DXA) scanner (Lunar DPX-NT; General Electric Healthcare, Little Chalfont, Buckinghamshire, United Kingdom). The software provided measurements of dual-energy X-ray absorptiometry-percentage of body fat (DXA-%BF) and the presence of obesity has been identified as DXA-%BF ≥25%.[12] All DXA measurements were made at the laboratory of the university, in a room with controlled temperature. Each morning before beginning the measurements, the DXA equipment was calibrated by the same researcher and according to the reference values provided by the manufacturer.

Statistical Analysis

The Kolmogorov-Smirnov test was used to confirm the normality of the numerical data in each quartile HR group. Mean and standard deviations were used as indicators of central tendency and dispersion measurements, respectively. The resting HR values were stratified into quartiles: 1st quartile (<percentile 25 [<70 beats/min]), 2nd quartile (≥percentile 25 and <percentile 50 [70 to 77.4 beats/min]), 3rd quartile (≥percentile 50 and <percentile 75 [77.5 to 85.9 beats/min]), and 4th quartile (≥percentile 75 [≥86 beats/min]). Analyses of variance (one-way), with the post hoc Tukey test, was used to compare the mean values of resting HR according to each quartile. Pearson product-moment correlation coefficients indicated the linear relationship between numerical variables. Linear regression was performed to explain HR as a function of the variables evaluated. For categorical variables, Pearson χ^2 test was used to compare rates according to the quartiles for resting HR. In contingency tables 2 × 2, the Yates correction was applied. Logistic regression (odds ratio [OR] and 95% confidence interval [$OR_{95\%CI}$]) was used to construct a multivariate model, in which EBP was the dependent variable and age, ethnicity, and DXA-%BF were included as independent variables. Significance (P) was set at 5%. All analyses were performed using SPSS version 13.00 (SPSS Inc, Chicago, Illinois).

Results

The sample included white (64.3%), black (19.1%), and other (16.6%) subjects. There were no associations between skin color and either obesity (P = .628) or EBP (P = .229). There also were no differences for mean values of resting HR (P = .449), SBP (P = .117), DBP (P = .478), and DXA-%BF (P = .080) by skin color.

The group with the lowest HR had higher age, lower DBP, and lower DXA-%BF (Table I). The prevalence of obesity and EBP were positively associated with higher quartiles for resting HR. Obese subjects presented values of resting HR

Table I. General characteristics of children and adolescents grouped into quartiles for resting heart rate (n = 356)

	Quartiles for resting heart rate				
	<70 beats/min	70 to 77.4 beats/min	77.5 to 85.9 beats/min	≥86 beats/min	
Variables	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	*P*
n	83	91	88	94	
Skin color (white)	61.4%	69.2%	62.5%	63.8%	.988
Age (years)	14.9 (2.9)	13.2 (3.1)*	12.3 (2.7)*	11.7 (2.6)*	.001
BMI (kg/m^2)	19.8 (3.2)	19.1 (3.8)	19.3 (4.7)	19.8 (6.4)	.677
DXA-%BF	15.1 (9.8)	17.1 (8.4)	18.2 (10.2)	20.9 (10.4)*†	.001
SBP (mm Hg)	118.7 (12.4)	119.1 (14.9)	118.4 (12.6)	121.2 (14.8)	.501
DBP (mm Hg)	65.8 (9.5)	66.3 (9.8)	64.1 (8.6)	69.8 (9)*†	.001
EBP	14.5%	23.1%	23.9%	41.5%	.001
Obesity	15.7%	18.7%	20.5%	39.4%	.001

SD, standard deviation; *BMI*, body mass index; *DXA*, dual-energy x-ray absorptiometry; *DXA-%BF*, percentage of body fat measured by DXA; *SBP*, systolic blood pressure; *DBP*, diastolic blood pressure; *EBP*, elevated blood pressure.
*Significantly different compared with 1st quartile (<70 beats/min).
†Significantly different compared with 2nd quartile (70 to 77.4 beats/min).