Association of body mass index and aerobic physical fitness with cardiovascular risk factors in children

Reginaldo Gonçalves*, Leszek Antony Szmuchrowski, Vinicius Oliveira Damasceno, Marcelo Lemos de Medeiros, Bruno Pena Couto, Joel Alves Lamounier

Universidade Federal de Minas Gerais (UFMG), Belo Horizonte, MG, Brazil
Universidade Federal de Pernambuco (UFPE), Recife, PE, Brazil
Universidade Federal de Lavras (UFLA), Lavras, MG, Brazil
Universidade Federal de São João del-Rei (UFSJ), São João del-Rei, MG, Brazil

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Abstract

Objective: To identify the association between both, body mass index and aerobic fitness, with cardiovascular disease risk factors in children.

Methods: Cross-sectional study, carried out in Itaúna-MG, in 2010, with 290 school children ranging from 6 to 10 years-old of both sexes, randomly selected. Children from schools located in the countryside and those with medical restrictions for physical activity were not included. Blood sample was collected after a 12-hour fasting period. Blood pressure, stature and weight were evaluated in accordance with international standards. The following were considered as cardiovascular risk factors: high blood pressure, high total cholesterol, LDL, triglycerides and insulin levels, and low HDL. The statistical analysis included the Spearman’s coefficient and the logistic regression, with cardiovascular risk factors as dependent variables.

Results: Significant correlations were found, in both sexes, among body mass index and aerobic fitness with most of the cardiovascular risk factors. Children of both sexes with body mass index in the fourth quartile demonstrated increased chances of having high blood insulin and clustering cardiovascular risk factors. Moreover, girls with aerobic fitness in the first quartile also demonstrated increased chances of having high blood insulin and clustering cardiovascular risk factors.
Resumo

Objetivo: Identificar a associação do índice de massa corporal e aptidão física aeróbica com fatores de risco de doenças cardiovasculares em crianças.

Métodos: Estudo transversal realizado na cidade de Itaúna-MG no ano de 2010 com 290 escolares de 6 a 10 anos de ambos os sexos, aleatoriamente selecionados. Crianças de escolas da zona rural e aquelas com limitações médicas para prática de atividade física não foram incluídas. Coletou-se o sangue após jejum de 12 horas. A pressão arterial, a estatura e o peso foram avaliados segundo padrões internacionais. Foram considerados fatores de risco cardiovascular: hipertensão arterial, colesterol total, LDL, triacilgliceróis e insulinemia elevados e HDL baixo. A análise estatística incluiu a Correlação de Spearman e a Regressão Logística, com os fatores de risco cardiovascular como variáveis dependentes.

Resultados: Correlações significativas foram encontradas, nos dois sexos, entre índice de massa corporal e aptidão física aeróbica com a maioria dos fatores de risco cardiovascular. Crianças dos dois sexos com índice de massa corporal acima do percentil 75 apresentaram chances aumentadas para insulinemia alterada e agrupamento de fatores de risco cardiovascular. Meninas com aptidão física aeróbica no primeiro quartil apresentaram chances aumentadas para insulinemia alterada e agrupamento de fatores de risco cardiovascular.

Conclusão: As associações significativas e as chances aumentadas para presença de fatores de risco cardiovascular em crianças com menor aptidão física aeróbica e maior índice de massa corporal justificam o uso dessas variáveis no monitoramento da saúde em pediatria.

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Introduction

Diseases of the circulatory system have been the leading cause of death among the adult population over the last 30 years in Brazil.1 Cardiovascular diseases (CVD) are caused by the association between genetic and behavioral risk factors, and may originate in childhood.2-4 Among the major risk factors for CVD are hereditary factors, obesity, smoking, physical inactivity, dyslipidemia, hypertension, diabetes, insulin, and gender.5,6 The control of modifiable risk factors should begin in childhood, aiming to decrease cardiovascular morbidity and mortality in adulthood.7

For the diagnosis of overweight and obesity, the body mass index (BMI) is considered a good indicator of overall adiposity, as it is associated with subcutaneous fat.4 Both BMI and other measures of adiposity are related to aerobic fitness in children.4 Aerobic fitness is inversely associated with CVD risk factors in children and adults.5-11 Even among overweight or obese children, better aerobic fitness appears to have a protective effect on CVD risk factors.11

The associations between anthropometric variables, aerobic fitness, and CVD risk factors lack cross-sectional and longitudinal studies in Brazilian children, aiming to better understand their magnitude and mechanisms. Therefore, this study aimed to identify the association of BMI and aerobic fitness with CVD risk in children aged 6 to 10 years.

Methods

The study population consisted of schoolchildren aged 6 to 10 years enrolled from first to fifth grade in public schools in the urban area of Itaúna, state of Minas Gerais, Brazil. A total of 4,649 students were assessed. To determine the minimum sample size, a survey (pilot study) was conducted with 25 students aged 6 to 10 years of both genders, in whom the variables systolic blood pressure (SBP), diastolic blood pressure (DBP), high-density lipoprotein (HDL) cholesterol (mg/dL), low-density lipoprotein (LDL) cholesterol (mg/dL), total cholesterol (mg/dL), triglycerides (mg/dL), and insulin (µIU/mL) were measured, and their respective means and standard deviations were obtained. A maximum
tolerance error was established for estimating the population mean for each variable that did not compromise result reliability.

To calculate the minimum sample size for each variable, the respective sample's standard deviation was used as a population estimate at a significance level of 5%. Thus, it was decided to presuppose the maximum sample size as between the minimum obtained values, resulting in 228 individuals related to the variable insulinemia, which, in turn, was limiting for the sampling, as it showed the highest variability. Therefore, the sample size was set at 228 students as the minimum to meet the margin of error in population measurements for all variables of interest. However, after estimating a loss of 50%, the final sample consisted of 456 children. Stratification by gender and age was performed in each school so that the proportion of age and gender was maintained. With the data obtained in each school, students were numbered in each series in sequence. Then, using a table of random numbers generated by Excel 2003 (Microsoft Corporation, Washington-USA), the corresponding number of children was selected in the list created in each series, until the number necessary to constitute the sample for that age and gender at each school was reached.

Inclusion criteria were children aged between 6 and 10 years, enrolled in state or municipal schools from the first to the fifth grade. Exclusion criteria were clinical and/or motor limitations to undergo the physical testing and enrollment in rural schools, which represented 6% of students in the municipality.

Children were included only after their parents or guardians agreed to their participation by signing the informed consent. The project was approved by the Departmental Board of Pediatrics of Faculdade de Medicina da UFMG (Edict No. 93/2009) and by the Research Ethics Committees of UFMG (Edict No. 0040.0.203.000-10) and of Universidade de Itaúna (Edict 012/10).

Body mass was measured with children wearing light clothing, on a digital Seca electronic scale (Scales Galore, New York - USA), with maximum capacity of 150 kg and precision of 0.1 kg. The weight corresponding to clothing was not subtracted from the measured weight. Height was measured in an Alturaexata vertical stadiometer (Alturaexata, Minas Gerais - Brazil) calibrated in centimeters (cm) with precision of 0.001 m. Body weight and height were measured twice, and the mean value was considered. BMI was previously calculated at each age of BMI and aerobic fitness with each of the CVD risk factors. The BMI z-score was previously calculated at each age for each gender and used to make the association with risk variables. Three or more factors present in the same child were considered for the clustering of risk factors.

The cutoffs used for the risk variables were: blood pressure and insulin levels > 80th percentile for age and gender, HDL-cholesterol < 45 mg/dL, and LDL-cholesterol, triglycerides, and blood glucose > 100 mg/dL. The logistic regression analysis estimated the odds ratio for arterial hypertension, low HDL, high LDL, high triglycerides, high insulin, and clustering of CVD risk factors in children above the 75th percentile and below the 25th percentile for BMI, and above and below the 25th percentile for aerobic fitness. Data were analyzed using the SPSS software for Windows, release 17.0 (SPSS Inc. Released 2008. SPSS Statistics for Windows, Chicago - USA). A probability level of p<0.05 was used to indicate statistical significance.

Results

The sample's descriptive characteristics are shown in Table 1. The intraclass correlation coefficient for the two measures of height and weight were, respectively, 0.997
and 1.0 (p<0.001). Regarding the socioeconomic status, the sample was classified as 0.7% in class B1, 9.7% in B2, 35.9% in C1, 35.2% in C2, 17.9% in D, and 0.7% in E. Spearman’s correlation coefficients between BMI and aerobic fitness in both genders are shown in Table 2.

| Variável   | Females (n=132) Mean | Females (n=132) SD | Males (n=158) Mean | Males (n=158) SD |
|------------|----------------------|-------------------|-------------------|-----------------|
| Age (years)| 8.3                  | 1.6               | 8.3               | 1.3             |
| Height (m) | 1.3                  | 0.1               | 1.3               | 0.1             |
| Body mass (kg) | 30.0       | 8.9               | 31.6              | 8.9             |
| BMI (kg/m²) | 16.9                | 3.6               | 17.5              | 3.3             |
| VO₂ max (mL/kg/min) | 49.9       | 3.1               | 52.0              | 3.6             |
| SBP (mmHg) | 94.8                | 9.9               | 95.8              | 11.4            |
| DBP (mmHg) | 59.3                | 8.5               | 57.5              | 8.9             |
| Total cholesterol (mg/dL) | 171.4  | 30.4              | 169.3             | 27.9            |
| LDL (mg/dL) | 103.7              | 27.0              | 100.3             | 28.0            |
| HDL (mg/dL) | 50.2               | 10.6              | 53.1              | 10.9            |
| Triglycerides (mg/dL) | 87.4      | 39.5              | 79.8              | 33.5            |
| Glycemia (mg/dL) | 88.7      | 7.9               | 88.3              | 8.2             |
| Insulinemia (µIU/mL) | 5.8       | 5.4               | 4.8               | 4.0             |

Increased odds ratios for clustering of CVD risk factors in both genders were shown in Table 3.

| BMI > 75th percentile versus < 75th percentile | Females (n=138) | Males (n=152) |
|-----------------------------------------------|----------------|--------------|
| Odds ratio | 95% CI | Odds ratio | 95% CI |
| SBP 6.79 | 0.99 | 0.07 - 57.51 |
| DBP 4.38 | 0.35 - 54.44 | 1.27 | 0.07 - 22.56 |
| Triglycerides 2.80 | 1.16 - 6.72 | 2.55 | 0.98 - 6.66 |
| HDL 2.49 | 1.07 - 5.80 | 1.55 | 0.60 - 4.0 |
| LDL 1.72 | 0.73 - 4.01 | 1.34 | 0.58 - 3.0 |
| Insulinemia 11.81 | 4.33 - 32.23 | 3.62 | 1.48 - 8.84 |
| Cluster 4.70 | 1.98 - 11.19 | 5.25 | 2.08 - 13.23 |
| VO₂ max < 25th percentile versus > 25th percentile | Females (n=138) | Males (n=152) |
| Odds ratio | 95% CI | Odds ratio | 95% CI |
| SBP 0 | 2.14 | 0.07 - 61.68 |
| DBP 4.38 | 0.35 - 54.44 | 1.36 | 0.08 - 24.21 |
| Triglycerides 3.50 | 1.46 - 8.34 | 1.95 | 0.74 - 5.14 |
| HDL 0.97 | 0.40 - 2.35 | 1.18 | 0.45 - 3.11 |
| LDL 0.88 | 0.39 - 2.02 | 1.55 | 0.66 - 3.61 |
| Insulinemia 4.88 | 1.86 - 12.78 | 2.99 | 1.21 - 7.37 |
| Cluster 2.48 | 1.04 - 5.94 | 1.58 | 0.61 - 4.11 |

Both genders showed a significant positive correlation between the BMI z-score and SBP, DBP, triglycerides, and insulinemia. The correlations between the BMI z-score and total cholesterol, HDL, and LDL levels were not significant in either gender. Aerobic fitness in female was negatively and significantly correlated with DBP, total cholesterol, triglycerides, and insulinemia. In boys, a strong negative and significant correlation (p<0.01) was found between aerobic fitness and SBP, DBP, total cholesterol, LDL, triglycerides, and insulinemia.

In the present study, BMI was positively associated in both genders with SBP, DBP, triglycerides, and insulinemia. Children with BMI above the 75th percentile had increased odds ratio for CVD risk factors, when compared with children below the 75th percentile. Aerobic fitness was negatively associated in both genders with DBP, total cholesterol, triglycerides, and insulinemia. Increased odds ratio for altered insulinemia in both genders and for clustering of CVD risk factors in girls were found when comparing aerobic fitness below and above the 25th percentile. Mean values of the CVD risk variables found in this study for both genders, except total cholesterol (171.4 mg/dL) and LDL (103.7 mg/dL) in females, are within the range considered “desirable” according to the I Guideline for the Prevention of Atherosclerosis in Childhood and Adolescence and are in the present study, BMI was positively associated in both genders with SBP, DBP, triglycerides, and insulinemia. Children with BMI above the 75th percentile had increased odds ratio for CVD risk factors, when compared with children below the 75th percentile. Aerobic fitness was negatively associated in both genders with DBP, total cholesterol, triglycerides, and insulinemia. Increased odds ratio for altered insulinemia in both genders and for clustering of CVD risk factors in girls were found when comparing aerobic fitness below and above the 25th percentile. Mean values of the CVD risk variables found in this study for both genders, except total cholesterol (171.4 mg/dL) and LDL (103.7 mg/dL) in females, are within the range considered “desirable” according to the I Guideline for the Prevention of Atherosclerosis in Childhood and Adolescence and are in females and males aged 6 to 10 years (n = 290)
similar those found in the Belo Horizonte Heart Study (Estudo do Coração de Belo Horizonte). 17

Other studies corroborate the present investigation with significant and positive correlations between BMI and SBP, DBP, 2,18 triglycerides, and insulin. 3,19 However, the non-significant correlations found in this study between BMI and total cholesterol, HDL, and LDL in both genders are not in agreement with the results of the aforementioned studies. As in the present study, Sinaiko et al 20 also found no significant correlation between BMI and HDL \((p=0.07)\), nor between BMI and LDL \((p=0.48)\) in males, whereas this correlation was significant in females. In the present study, females above the 75th BMI percentile in comparison to those below the 75th percentile had odds increased by 2.8, 2.5, and 11.8 fold for altered triglycerides, HDL, and insulinemia, respectively. In males, the odds for those with a BMI above the 75th percentile were 3.6 fold higher for elevated insulinemia.

The odds of having a clustering of CVD risk factors for females and males, respectively, were 4.7 and 5.3-fold higher for those above the 75th percentile. Falaschetti et al 21 studied 5,002 children aged 7 to 12 years and found significant odds ratios among those below the 85th percentile and those above the 95th percentile of BMI in both genders, for hypertension, high triglycerides, and low HDL levels. The Belo Horizonte Heart Study found, in 1,450 children and adolescents aged 6-18 years, significant odds ratios for CVD risk variables when comparing students with BMI below and above the 85th percentile. 17 In that study, the odds for altered HDL and elevated SBP and DBP were, respectively, 2.2, 3.6, and 2.7 fold higher for students with a BMI above the 85th percentile. Perhaps no increased odds for elevated SBP and DBP were observed for both genders in the present study because the cutoff point was established above the 75th percentile for BMI, rather than above the 85th percentile, as in the Belo Horizonte Heart Study.

Although BMI does not discriminate abdominal from visceral obesity, the latter is associated, through several mechanisms, to some risk factors for CVD. Visceral adipose tissue secretes larger amounts of adipocytokines compared to subcutaneous fat. The adipocytokines have inflammatory and immune functions that mediate insulin resistance, cardiovascular complications, and especially the atherrogenic process via inflammatory biomarkers such as TNF-alpha, IL-6, and C-reactive protein (CRP). 21,22 The adipocytokines indirectly mediate lipolysis and increase hepatic fatty acid synthesis, thus increasing serum levels of fatty acids and triglycerides. 21

The high correlations between BMI, insulinemia, and triglycerides for both genders in the present study corroborate the aforementioned studies.

Aerobic fitness showed a significant and negative correlation with DBP, total cholesterol, triglycerides, and insulinemia in girls in the present study. In boys, the correlations were stronger \((p<0.01)\) and also more significant with SBP and LDL-cholesterol. These results are similar to several other studies in the pediatric population. 10,11,21,22 Kriemler et al 23 used analysis of variance to compare the means of variables of CVD risk among the four quartiles of aerobic fitness. Significant differences were observed between the first and fourth quartiles of aerobic fitness for insulin resistance in both genders, and between the first and fourth quartiles for triglycerides and total cholesterol/HDL ratio in girls. Males and females in the first quartile of aerobic fitness also had lower metabolic risk in relation to other children.

Aerobic fitness can be assessed in a running test in which the body mass of the assessed individual directly affects test performance or in cycle ergometer tests, in which body mass may or may not be considered. As the present study used a running test to evaluate aerobic fitness, overweight and obese children probably had worse results, which may explain the poorer risk profile of children below the 25th percentile of aerobic fitness. Although the physical fitness test used is strongly corre-
lated with laboratory measures of aerobic fitness and has been used in recent studies with children, motivation-al factors can affect test results, and perhaps this may explain the inconsistencies in the odds of cardiovascular risk between the genders observed here.

Even in overweight children, better aerobic fitness attenuates the metabolic and CVD risk by mechanisms that possibly involve genetic factors, adipocytokines, and oxidative capacity of skeletal muscle. The benefits of aerobic fitness may involve improved insulin action, improved glucose transport, improved fat metabolism, increased levels of HDL-cholesterol, and decreased sympathetic tone and blood pressure. Therefore, the association between aerobic fitness and CVD risk factors justifies the inclusion of aerobic fitness assessment, especially in the school environment, as part of children’s health monitoring.

Possible limitations of this study include its cross-sectional design, which prevents establishing a causal association between the variables and the generalization of these data to other regions of the country due to possible ethnic, cultural, and socioeconomic differences. Despite these limitations, the results reinforce the contribution of high BMI and a low level of aerobic fitness to the presence of clustering of cardiovascular disease risk factors in children.

Conflicts of interest
The authors declare no conflicts of interest.

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