Metabolic syndrome’s risk factors and its association with nutritional status in schoolchildren

Fabiana Costa Teixeira a,*, Flavia Erika Felix Pereira b, Avany Fernandes Pereira c, Beatriz Gonçalves Ribeiro d

a Programa Pós Graduação em Nutrição, Instituto de Nutrição UFRJ, Laboratório Integrado de Pesquisa em Ciências do Esporte, UFRJ Campus Macaé, RJ, Brazil
b Programa Pós Graduação em Alimentação, Nutrição e Saúde, Universidade do Estado do Rio de Janeiro UERJ, RJ, Laboratório Integrado de Pesquisa em Ciências do Esporte, UFRJ Campus Macaé, RJ, Brazil
c Prof. Curso de Nutrição, Universidade Federal do Rio de Janeiro, Brazil
d Prof. Curso de Nutrição, Laboratório Integrado de Pesquisa em Ciências do Esporte, UFRJ Campus Macaé, RJ, Brazil

ARTICLE INFO

Article history:
Received 31 October 2016
Received in revised form 22 January 2017
Accepted 6 February 2017
Available online 8 February 2017

Keywords:
Children
Metabolic syndrome
Abdominal obesity
Dyslipidemia
Hypertension

ABSTRACT

The metabolic risk factors (RF) to the diagnosis of metabolic syndrome (MetS) have been evidenced at early ages, including children. The aim of the present study was to identify the prevalence of RF to the diagnosis of MetS and its association with nutritional status of schoolchildren from 6 to 10 years old. A cross-sectional study was carried out in 505 students of municipal schools in Macae, Brazil, conducted from 2013 to 2014. The RF evaluated were: blood pressure (mm Hg), triglycerides (mmol/L), HDL-cholesterol (mmol/L), fasting glucose (mmol/L) and waist circumference (cm). At least one RF was present in 61% (n = 308) of the sample. By nutritional status, there was higher prevalence of RF in overweight/obese schoolchildren compared to those with normal weight, except in the concentration of HDL-c. The prevalence of one, two and three RF (MetS) were 34.7% (n = 175), 21.0% (n = 106) and 5.3% (n = 27), respectively. Two RF were more present in overweight (28.2% 95%CI 19.0; 39.0) and obese (41.5% 95%CI 31.4; 52.1) compared to normal weight children (13.5% 95%CI 9.9; 17.8). Three or more RF were more frequent among obese (25.5% 95%CI 17.0; 35.5) in relation to overweight (2.4% 95%CI 0.2; 8.2) and normal weight children (0.3% 95%CI 0.1; 1.7). The data indicate high prevalence of RF and its relationship with the magnitude of body weight excess. Therefore, the identification and early treatment of these RF might minimize the risk of MetS and related diseases.

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1. Introduction

Metabolic syndrome (MetS) can be defined as the co-occurrence of metabolic risk factors (RF) that contributes to the development of cardiovascular disease (CVD) and type 2 diabetes mellitus (DM2) (Alberti et al., 2009). The RF, as insulin resistance (IR), hypertension (HAS), hyperglycemia, hypertriglyceridemia, low high density lipoprotein cholesterol concentration (HDL-c) and excess waist circumference (WC), have been identified at earlier ages, including children (Agirbasli et al., 2016).

There is no consensus for the diagnosis of MetS in children (Corte and Nobili, 2015; D’Adamo et al., 2011; Pergher et al., 2010). Some criteria have been suggested and differentiated for RF as their cutoffs (Ford and Li, 2008). However, regardless of the criteria, commonly it is required at least three RF for the diagnosis of MetS in children (D’Adamo et al., 2011). When RF is present during childhood, it tends to persist through adolescence and adulthood (Magnussen et al., 2014); thus, it has been suggested that the focus of research in children be in the RF of MetS regardless of its diagnosis (D’Adamo et al., 2011; Faienza et al., 2016; Kassi et al., 2011; Sinaiko, 2015).

The RF in children are more common in the obese population (Abrams and Levitt Katz, 2011; Ode et al., 2009), which increased significantly in recent years, representing a serious public health problem in Brazil and worldwide (IBGE BRASIL, 2010; Gupta et al., 2013; Marie et al., 2014). Although studies to evaluate the nutritional status, blood pressure (BP), lipid profile and blood glucose levels in the juvenile group are growing (Kuschnir et al., 2016; Onzuz and Demir, 2015; Strufaldi et al., 2009; Wee et al., 2011), they are not so frequent in children especially in developing countries (Gupta et al., 2013). Early identification of the presence of RF predictors of MetS enables the planning and implementation of programs for the prevention of CVD and DM2 in...
adulthood. Thus, the aim of this study is to identify the prevalence of RF to MetS and its association with nutritional status in schoolchildren from 6 to 10 years old in the city of Macae, Brazil.

2. Methods

2.1. Study design and sample population

This investigation was a cross-sectional study conducted from March 2013 to November 2014 in schoolchildren (6–10 years) from public schools in the city of Macae, located in the state of Rio de Janeiro, Brazil, with 1219.8 km² of area and about 217,000 inhabitants. It has the petroleum as main economic activity, being the low social class prevalent among schoolchildren of municipal schools. The city is divided into 9 administrative sectors, with 52 schools and 10,247 schoolchildren (6–10 years). For the reference population, by logistical issues, it was selected one school of each sector, totaling 1553 schoolchildren, who were invited to participate. A simple random sample size was carried based on the national prevalence of obesity in the study age group (14.2%) (IBGE 2010), 95%CI, maximum error 2.5% and the population (1553). The final sample size was 502 schoolchildren.

The exclusion criteria were: children who had physical impairment that prevented the evaluations, with diabetes mellitus and/or hypothyroidism and/or use of medications that could interfere in the results. Of the 1553 schoolchildren, one was exclude due to dwarfism. Were not authorized for biochemical examination 936 schoolchildren. The total of children evaluated in all parameters was 505 (Fig. 1).

2.2. Data collection

Data were collected in schools under the supervision of responsible research including: body weight, height, WC, BP and biochemical examination. The team that carried out the collection was properly trained.

2.3. Anthropometry

Body weight and height were measured in duplicate according to the technique proposed by Lohman et al. (1988), through electronic and portable scale Tanita® platform (Illinois, USA) with capacity of up to 150 kg and range of 50 cm and anthropometer Height Exata® (Minas Gerais, Brazil) with a 0.1 cm. The children were evaluated with light clothing without shoes and without headress. The value of the average of the two measurements was used to calculate body mass index (BMI) in kg/m². The schoolchildren were classified in four categories: underweight, normal weight, overweight and obese by z-score as the criteria proposed by WHO (2007). Waist circumference (cm) was measured at the midpoint between the last rib and the upper edge of the iliac crest as recommended by WHO (2014) in duplicate and the average of the measurements was calculated. It was considered excess abdominal fat WC value above the 90th percentile according to sex and age (Maffeis et al., 2001), obtained from the sample data that consists of all schoolchildren who had WC measured (Dias et al., 2014).

2.4. Blood pressure

The procedures for measuring BP of the schoolchildren were based on the guidelines of the Brazilian Society of Cardiology (SBC, 2005), without having done exercise for an hour before the procedure and after 5 min of rest, sitting, reclining in chair and legs uncrossed. It used validated digital equipment OMRON HEM-705 CP® (G-Tech International– Republic of Korea) and the cuffs were adequate to arm size. The measurements were performed in duplicate and with an interval of 2 min between them. To classify, the PA was considered the average value of the measures. The cutoff point used were the suggested by the Brazilian Society of Cardiology (high BP ≥ 95 percentile for age, sex and height percentile for age) (SBC, 2005).

2.5. Biochemical measurements

A venous blood sample was collected overnight past 12 h. To make sure about fasting, it was sent to the children’s parents a reminder the day before the procedure. It was also requested a signed confirmation of fasting state of each child delivered at the time of biochemical analysis. Approximately 10 mL blood sample was collected and centrifuged for 5 min. Then, the samples were placed in coolers and transported within a maximum of 2 h to the laboratory where they were frozen for later analysis. They were analyzed by enzymatic colorimetric method, kit LABTEST®: Glucose (mmol/L), HDL-c (mmol/L) and triglycerides (TG) (mmol/L).

For classification, were used the cutoff points suggested by the Brazilian Society of Cardiology (SBC, 2005): HDL-c (<1.16 mmol/L), TG (≥1.13 mmol/L) and fasting glucose was used to reference the Brazilian Diabetes Society (SBD, 2016) of ≥5.55 mmol/L. The diagnosis of MetS was based on the concurrent presence of three or more of RF cited as criteria proposed by the NCEP-ATPIII (Grundy et al., 2004) with cutoff points adapted for the child population.

2.6. Ethical aspects

The study was approved by the Research Ethics Committee of the University Veiga de Almeida (Number: 876333) and authorized by the Municipal Department of Education of the city of Macae, Rio de Janeiro and the direction of each participating school. Parents or guardians interested in their children’s participation in the study signed the free and informed consent. At the end of the investigation, participants received individual results of their assessments.
2.7. Statistical analysis

The mean and standard deviation were calculated for continuous variables and frequencies of categorical variables and their respective 95% confidence interval (95%CI). Quantitative variables were compared by sex using a Student’s t-test for independent samples. For the association between RF and nutritional status and gender, Chi-square and Fisher’s Exact tests were used. p value <0.05 for statistical significance was considered for all analysis. Data analysis was performed using the Statistical Program for the Social Sciences, version 21.0 (SPSS, Chicago, IL).

3. Results

The sample included 505 schoolchildren, 221 (43.8%) boys and 284 (56.2%) girls. Anthropometric, BP and biochemical data are presented in Table 1. There was no gender difference in any of the parameters evaluated.

Among the schoolchildren, 14 (2.8%), 312 (61.8%), 85 (16.8%) and 94 (18.6%) had underweight, normal weight, overweight and obesity, respectively. At least one RF included in the diagnosis of MetS was present in 308 (61%) children. The prevalences of RF in the total sample, according to sex and nutritional status, are shown in Table 2. The underweight schoolchildren were excluded from the analysis for nutritional status due to the reduced number of RF in this group.

Hypertriglyceridemia was the most prevalent RF, observed in 29.3% (n = 148) of the sample. The low HDL-c, more prevalent in males than in females, was the only RF that showed a significant difference between sexes (p = 0.03), and was not associated with nutritional status (p = 0.43). For other RF in schoolchildren, overweight and/or obesity had higher prevalence rates compared to normal weight (p < 0.05) (Table 2).

There were 175 (34.7%), 106 (21.0%) and 27 (5.3%) schoolchildren with one, two and three or more RF (MetS), respectively, without difference between the sexes. According to the nutritional status, there was no significative difference between the prevalence of one RF (p = 0.085) and significative difference was observed between 2, 3 or more RF (p < 0.001) (Table 2).

The concomitant presence of two RF was higher in overweight children and obese children compared to those with normal weight. Three or more RF (MetS) were more prevalent among obese in relation to overweight and normal weight (Fig. 2).

4. Discussion

In the present study conducted in Brazilian children, at least one RF for MetS was identified in more than half of the sample. It was shown that obese children have the highest prevalence of WC, TG and high BP in relation to normal weight, as well as WC and high BP relative to overweight. The concomitant presence of two RF was higher in overweight/obesity children, and three or more among obeses. Therefore, this study demonstrates the association of nutritional status of children with the RF that contributes to MetS.

Studies in different countries also demonstrate the occurrence of RF for CVD and DM2 in children, especially among the overweight/obese ones (Adair et al., 2014; Freedman et al., 2007; Holst-Schumacher et al., 2009; l’Allemand et al., 2008; Kuschinri et al., 2016; Rosini et al., 2015; Seki et al., 2001; Van Vliet et al., 2009). In children born after the 2000s, obesity was observed to be three times prevalent as compared to those of the same age born in the 80’s (Gupta, 2015; Marie et al., 2014). Despite being stabilized in some countries, the prevalence of obesity remains high (Dietz and Economos, 2015; Ogden et al., 2016). In Brazil, the last national survey data showed overweight/obesity in 33.5% of children aged 5 to 9 years of age. Obesity was present in 16.6% of the girls and 11.8% of the boys (IBGE, 2010). High BMI in childhood is related to metabolic changes, including changes in the lipid profile, BP elevation and insulin resistance (Abrams et al., 2011; Han et al., 2010; Freedman et al., 1999). In this sense, the high prevalence of overweight/obesity observed in this study may explain, in part, the frequency of RF in the sample.

Associated with the occurrence of obesity or overweight diagnosed by BMI, it was shown the prevalence of the 80% of excess WC among obese, which was compatible with other national studies such as those conducted by Ricco et al. (2010) and Pretto et al. (2015) who observed, respectively, 50% and 84.7% excess WC among obese children. In a study conducted in Turkey in about 4000 schoolchildren, excess WC was also observed in those with high BMI (Inanc, 2014). Although it is not a consensus in children, it has been shown that excess abdominal fat, estimated by WC, is a better predictor of metabolic alterations compared with BMI (McCarthy, 2006), that can indicate the impact of the distribution of body fat in the cardiovascular risk (Goran and Gower, 1999; Spolidoro et al., 2013). There is no universal cutoff point for WC associated to cardiometabolic RF, but it has been suggested that children with a WC > 90th percentile are at higher risk of having multiple cardiometabolic RF than those with lower WC percentiles (Maffeis et al., 2001). Considering the lack of such reference curves in Brazil, the classification of risk in this study was WC > 90th percentile according to values of its sample. Despite the difficulty in comparing with other studies, the results showed excess of central adiposity, with possible repercussions on the health of these children.

Hypertriglyceridemia and low HDL-c were the most common abnormal biochemical parameters, as observed by Tavares et al. (2010) in a systematic review of MetS in Brazilian children and adolescents. Rosini et al. (2015) also identified a high prevalence of these RF between Brazilian schoolchildren 6–14 years old. The process of atherosclerosis may begin in childhood (Arnaiz et al., 2013; Magnussen et al., 2014) and is associated with changes in lipid profile, including the rise of low-density cholesterol and TG (Berenson et al., 1998), and the low concentration of HDL-c, which is also included in MetS’s diagnosis (Ford and Li, 2008). In a 26-year cohort study with 770 schoolchildren from 5 years old, Morrison et al. (2012b) observed that children with persistent hypertriglyceridemia from childhood to adulthood had a higher prevalence of CVD compared to those without this RF.

According to the nutritional status, there was no difference in prevalence in low HDL-c concentration, corroborating to Pereira et al. (2009) in a Brazilian study. Moreover, hypertriglyceridemia was higher in obese than normal weight children, as reported by Seki et al. (2001) and Inanc (2014) in Brazilian and Turkish schoolchildren, respectively. Data from large longitudinal studies such as the Bogalusa Heart Study American (Freedman et al., 1999) and European cohort on cardiovascular risk factors (l’Allemand et al., 2008) also showed significantly higher prevalence of hypertriglyceridemia in overweight/obese children as compared to normal weight.

The prevalence of high BP was 16.4% and was also associated with nutritional status, with prevalence among obese four times higher.
Table 2
Prevalence of metabolic risk factors for metabolic syndrome according to gender and nutritional status in children aged 6–10 years, Macae, Brazil, 2013/14.

| Risk factors                  | Male (n = 221) | Female (n = 284) | p-Value |
|-------------------------------|----------------|------------------|---------|
| Excess WC (cm)                |                |                  |         |
| 58 (11.5)                     | 28 (12.7)      | 30 (10.6)        | 0.46    |
| 8.8–14.6                      | 8.6–17.8       | 7.2–14.7         |         |
| Hypertriglyceridemia          |                |                  |         |
| 148 (29.3)                    | 60 (27.1)      | 88 (30.9)        | 0.35    |
| 25.4–33.5                     | 21.4–33.5      | 25.6–36.7        |         |
| Low HDL-c                     |                |                  |         |
| 133 (26.3)                    | 69 (31.2)      | 64 (22.5)        | 0.3     |
| 22.5–30.4                     | 25.2–37.8      | 17.4–27.8        |         |
| High BP                       |                |                  |         |
| 83 (16.4)                     | 39 (17.6)      | 44 (15.5)        | 0.51    |
| 13.3–19.9                     | 12.9–23.3      | 11.5–20.2        |         |
| Hyperglycemia                 |                |                  |         |
| 49 (9.7)                      | 25 (11.3)      | 24 (8.5)         | 0.28    |
| 7.3–12.6                      | 7.4–16.2       | 5.5–12.3         |         |

Number of risk factors

|   | 1 risk factor | 2 risk factors | 3 or more risk factors (MetS) |
|---|---------------|----------------|-------------------------------|
|   | 175 (34.7)    | 106 (21.0)     | 27 (5.3)                      |
|   | 83 (37.6)     | 50 (22.6)      | 12 (5.4)                      |
|   | 92 (32.4)     | 56 (19.7)      | 15 (5.2)                      |
| p-Value | 0.23 | 0.42 | 0.94 | 0.085 | 0.001 | 0.001 |

n = number of children, NS (nutritional status), BP (blood pressure), WC (waist circumference), TG (triglycerides), HDL-c (cholesterol HDL), 95%CI (95% confidence interval), MS children (metabolic syndrome).

Chi-square test/Fisher’s Exact test for nutritional status p < 0.05.

Compared to normal weight. The association between childhood overweight/obesity and high BP has been reported in different studies (Onzuz and Demir, 2015; Tornquist et al., 2015; Wang et al., 2015). Rosner et al. (2000) had collected data from eight American longitudinal studies, covering >45,000 children of different ethnic groups and identified increased risk of high BP as increased BMI, regardless of sex, race or age. In a systematic review of HAS in Brazilian schoolchildren aged 6 to 10 years, Pereira et al. (2015) showed higher prevalence in overweight/obese children and highlighted the association between nutritional status and the BP values. However, to consolidate the diagnosis of HAS in children it is necessary that the BP average is above the cutoff established in at least three days (SBC, 2005). In this sense, the results should be interpreted only as a risk. Nevertheless, the high prevalence of this RF in the study group is relevant, considering that BP values can be elevated since their childhood and it can also be related to arterial stiffness and HAS in adults (Li et al., 2004; SBC, 2005).

The insulin resistance (IR), other RF associated with MetS results in hyperglycemia, what is a risk for the development of DM2 (Junior Montenegro et al., 2013). The IR during childhood and adolescence corresponds to a cardiovascular RF independent of the DM2 development and is associated with the increased rate of cardiovascular events in adults (Steinberger et al., 2009). Hyperglycemia, parameter used in the study to evaluate the glucose metabolism, was present in 9.7% of the sample, and it has been also the less frequent FR in other

![Fig. 2. Prevalence (%) of number of risk factors for diagnosis of metabolic syndrome by nutritional status in children aged 6–10 years, Macae, Brazil, 2013/14.](image-url)
Whereas the results of prevalence of RF depend, among others, on the resulting in the lack of standardization between different studies. Advocated for child population, they do not always represent consensus, of the most recent systematic review of MetS in children also identi_9 years of age (3.2%). However, the prevalence was close to the average observed by Seki et al. (2001) in Brazilian schoolchildren aged 6 to 9 years of age (3.2%). However, the prevalence was close to the average of the most recent systematic review of MetS in children also identified by NCEP-ATPIII adaptations (4.2%) (Friend et al., 2013). It must be emphasized that, regardless of the MetS, the concomitant presence of RF was present in approximately 26% of the schoolchildren. Loureiro et al. (2015) identified in Chilean children and adolescents progressive increase in cardiovascular risk, including inflammation of the endothelium, as the presence of each RF. Barja et al. (2009) and Arnaiz et al. (2013) complemented these findings by identifying the individual carotid intima thickening in the co-occurrence of RF in children. The results of this study indicated the presence of associated RF, which may promote physiological changes, independent of MetS diagnosis (Berenson et al., 1998).

The presence of two RF was higher among overweight/obese children compared to normal weight and three or more RF among obese compared with others. The data corroborate the literature and suggest that overweight/obesity and its magnitude may increase the risk of the association of RF, hence the presence of metabolic disorders (Friend et al., 2013; l’Allemend et al., 2008; Rosini et al., 2015).

There was no difference in having one RF by nutritional status. It shows that even those with adequate weight have already one RF. Besides the excess weight, RF such as high BP, hyperglycemia, low HDL-c may be associated with genetics, physical activity level, diet, birth weight, among others (Loureiro et al., 2015, Weiss et al., 2004). In this sense, studies have also demonstrated RF in normal weight children (Seki et al., 2001; Dias et al., 2014).

Noteworthy, the early treatment of metabolic RF and overweight/obesity does not imply a worse prognosis for CVD in adulthood when compared to those who never had such complications (Magnussen et al., 2014). Moreover, the persistence of these RF into adulthood relates to the substantial increase cardiovascular risk (Magnussen et al., 2014). In this sense, once overweight/obesity or the presence of any of the RF of MetS is identified, immediate intervention strategies as nutrition education, regular physical exercise in addition to more active behavior in daily activities are suggested, regardless of the diagnosis of MetS (Faienza et al., 2016; Magnussen et al., 2013; Owens and Galloway, 2014).

Although previous studies have demonstrated the presence of RF in the pediatric population, the present study demonstrates in early ages not only the RF, but also the concomitant presence of two or more RF for MetS and its association with nutritional status, investigations that are scarce in Brazil (Seki et al., 2001; Rosini et al., 2015). In this sense, it may contribute to the gap in the literature in developing countries, especially in Brazil. However our findings should be interpreted considering its limitations. Although using cutoffs of different RF previously advocated for child population, they do not always represent consensus, resulting in the lack of standardization between different studies. Whereas the results of prevalence of RF depend, among others, on the values established by different researchers, the interpretation and comparison of the occurrence of the different parameters become difficult (Van Vliet et al., 2011). In addition, the parameters evaluated as RF are influenced by the behavior, genetics, ethnicity and may have more significance than others depending on the population studied (Loureiro et al., 2015). In this sense, the data in this specific group of children may not represent other groups even if they are the same age and nationality and should not be extrapolated.

5. Conclusions

The data indicated high prevalence of RF of MetS among schoolchildren, mainly influenced by nutritional status. The potential impact of excessive body weight in the concomitant presence of RF and its magnitude in the presence of three or more RF observed in the study reinforce the importance of prevention and treatment of overweight/obesity in order to reduce the likelihood of MetS and related diseases in adults.

Financial support

This work was supported by the Foundation of Research Support of the State of Rio de Janeiro (PAPER number E-26/110,487/2010), National Counsel of Technological and Scientific Development (CNPQ number 19011).

Conflict of interest

None declared.

Authors’ contributions

Study concept and design: B.G.R. Acquisition of data: F.C., F.P.P. Analysis and interpretation of data: B.G.R., A.F.P., F.C.T., F.P.P. Drafting of the manuscript: F.C.T., F.P.P. Critical revision of the manuscript: B.G.R., A.F.P. Funding acquisition: B.G.R. Study supervision: B.G.R. All authors read and approved the final version of this manuscript.

Acknowledgments

The authors thank Professor Dr. Ronir Ragio (Postgraduate program in public health at the Federal University of Rio de Janeiro) for his assistance with statistical analysis, Dr. Jackson de Souza Menezes and Dr. Anderson Morales for biochemical analysis. We also thank the Municipality of Macae (Municipal Department of Education and the Municipal Health Department) for permission to access the schoolsand technical support, respectively.

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