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Increase in the prevalence of abdominal obesity in Brazilian school children (2000–2015)

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ABSTRACT

Introduction: The prevalence of overweight and obese children and adolescents is a public health concern. Few studies have critically evaluated this problem in a Brazilian population, despite the growth of community-based programs to combat childhood obesity in this country.
Objective: To study the anthropometrics of Brazilian adolescents over a fifteen-year period.
Methods: In a cross-sectional analysis, we investigated the anthropometric status of male and female adolescents in Brazil. The anthropometric data and nutritional status of 595 schoolchildren in the year 2000 were compared to 636 schoolchildren in 2015.
Results: We found a significant increase in the prevalence of overweight or obese adolescents in 2015 compared to 2000 (23.4% vs. 18.3%, $p = .027$). A sub-analysis stratified by sex showed that this increase only occurred in females. No statistically significant difference was observed in body mass index between the groups. Waist circumference (73.5 cm vs. 77 cm, $p < .001$) and the prevalence of abdominal obesity (30% vs. 47.9%, $p < .001$) were significantly greater in 2015, regardless of sex.
Conclusion: Overweight or obese children, as well as abdominal obesity were more prevalent in 2015 than in preceding decades. This is a worrying trend as abdominal obesity increases the risk for cardiometabolic morbidity and mortality in adult life.

1. Introduction

Over the past several decades, the prevalence of obesity has increased in epidemic proportions, particularly in developed and developing countries. Data from the World Health Organization (WHO) revealed that 1.9 billion adults were overweight in 2014 and at least 600 million were obese. Given the health risks associated with obesity, it is estimated that excessive body weight is the underlying cause of approximately 2.8 million deaths per year [1].

Regional data from Brazil points to a similar scenario. Between 2002 and 2009, data from the Brazilian Institute of Geography and Statistics (IBGE 2009) [2] showed an increase in the prevalence of overweight or obese adults. Prevalence in males increased to 50.1% (from 41.4% in 2002) and prevalence in females increased to 48% (from 40.9% in 2002). For Brazilian individuals between 10 and 19 years old, the prevalence increased from 20.8% to 27.6% for males and from 18.1% to 23.4% for females over the same 7-year period. More recent data from the Brazilian Ministry of Health [3] showed that 52.5% of Brazilians over 18 years of age are overweight and 17.9% are obese.

Although childhood obesity is associated with poor health outcomes, 70%–80% of obese adolescents become obese adults. This can have sustained and negative implications on their future quality of life and overall life expectancy. Obesity is associated with many comorbidities, including type 2 diabetes mellitus (DM2), dyslipidemia, hypertension, cardiovascular disease and cancer and is the third costliest health condition in the world [4]. In Brazil alone, costs attributed to obesity-related disabilities were Brazilian Real billion per year, which is equivalent to 2.4% of the country's Gross Domestic Product [5].

In the past two decades, the Brazilian government has adopted public policies to promote healthy eating to combat childhood obesity, but the effects of these policies are not yet known [6].

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Therefore, the primary purpose of this study was to evaluate body mass and abdominal obesity of schoolchildren from Marília, Brazil, over a fifteen-year period. We hypothesized that despite efforts to promote healthy eating habits and physical activity, excessive body weight and abdominal obesity would still be more prevalent than in recent years.

2. Methods

We analyzed cross-sectional anthropometric data of schoolchildren from Marília, Brazil, that were collected in 2000 and 2015. The city of Marília is located in the state of São Paulo, in the southeastern region of Brazil. It has a human development index of 0.798 and an estimated population of 230 thousand inhabitants (9976 adolescents enrolled in high school in 2015) [7].

All reasonable efforts were made to identify a sample of schoolchildren that was representative of the whole population. Schoolchildren between 12 and 18 years of age of both sexes were included in this study. Parents or guardians of all children signed the Free and Informed Consent Form (Termo de Consentimento Livre e Esclarecid; TCLE) prior to participating in any facet of this study. Adolescents were excluded if they presented with debilitating chronic diseases that affected physical function, type 1 diabetes mellitus, physical or mental disability that prevented participation, systemic conditions that affected general health, or if they were pregnant.

Anthropometric measurements were performed by trained evaluators at each time point. Body weight was obtained using a calibrated digital scale. During the weight acquisition, subjects stood with their arms at the side of their body, did not wear shoes and were instructed to wear light clothing. Subjects fasted prior to the weight assessment. Height was measured using a ruler fixed to the wall above a smooth floor. All subjects were barefoot during the height measurement and were instructed to stand in an upright position with their backs to the wall and heels together. Height was recorded in centimeters. Body mass index (BMI) was calculated using the conventional formula BMI = weight(kg)/height(m) [2]. Waist circumference (WC) was measured at the end of a non-forced expiration at the midpoint between the lower edge of the last rib and the iliac crest. A non-elastic anthropometric tape with an accuracy of 0.1 cm was used for all WC measurements [8].

Anthropometric status was determined from each BMI using the WHO criteria for underweight (<3rd percentile), overweight (≥85th to <97th percentile) and obese (≥97th), after adjusting for sex and age [9]. The presence of abdominal obesity was defined according to the International Diabetes Federation (IDF) criteria for adolescents aged from 12 to 16 years old (≥90th percentile), adjusted for age and sex. For adolescents older than 16 years, cut-offs for abdominal obesity were derived from adult IDF criteria (≥80 cm for women and ≥90 cm for men) [10]. Prevalence as total numbers and percentages was calculated for those who were underweight, overweight, obese, overweight or obese, or had abdominal obesity.

Statistical analyses were performed using StatView 5 software (SAS Institute Inc., Cary, NC). Analyses of variance (ANOVA) were used to compare continuous variables of age, height, weight, BMI, and WC between the 2000 and 2015 samples. Chi-square and Fisher tests were used to compare dichotomous variables (sex), as well as proportional variables (prevalence) between the 2000 and 2015 samples. Analyses were conducted for the whole sample, as well as stratified by sex. For all the variables tested, statistical significance was pre-defined as $p < .05$.

This study was authorized by the Municipal Secretary of Education of Marília and approved by the Committee of Ethics in Research in Human Beings of the Faculty of Medicine of Marília.

3. Results

A total of 1231 adolescents participated in the study, 595 in 2000 and 636 in 2015. The mean age (15.5 ± 1.1 vs. 15.3 ± 1.1 years), as well as the sex distribution (male:female ratio, 54.1:45.9 in 2000 vs. 60.7:39.3 in 2015, $p = .317$) did not differ between the groups. Height and waist circumference were greater in the 2015 group (Table 1). There was a significantly greater prevalence of overweight individuals (10.2% vs. 14.8%, $p = .020$) and overweight or obese individuals (18.3% vs. 23.4%, $p = .027$) in 2015 compared to 2000. There was also greater prevalence of abdominal obesity (30.0% vs. 47.9%, $p < .001$) in the 2015 sample (Table 1).

In a sex-stratified analysis (Table 2), females had greater height, weight, and WC in 2015 than in 2000. For males, height and WC were larger in 2015. There was no difference between the 2000 and 2015 groups for prevalence of overweight adolescents or obese adolescents; however, when overweight and obese individuals were grouped together there was a significantly larger prevalence for females in 2015 (25.6%) compared with 2000 (19.2%) ($p = .043$). The prevalence of abdominal obesity was larger in 2015 than in 2000 for both males (17.5% vs 33.6%, $p < .001$) and females (40.6% vs. 57.3%, $p < .001$). The 2015 sample also had a greater prevalence of underweight females (1.0% vs. 3.5%, $p = .003$), but not males (Table 2).

There was a significant positive linear correlation between BMI and WC in the two samples ($p < .0001$) (Fig. 1).

4. Discussion

Over a fifteen-year period, there was a significant and meaningful increase in the prevalence of overweight and obese schoolchildren in the city of Marília, Brazil. The difference was most dramatic for the rates of abdominal obesity, which showed a 60% increase in prevalence between 2000 and 2015. The result is alarming as it is well-known that children and adolescents are particularly vulnerable to deleterious cardiometabolic effects associated with obesity, including DM2, dyslipidemias, arterial hypertension, non-alcoholic fatty liver disease and atherosclerosis [11].

Our findings suggest a potential underlying cause for the increase in DM2 among young people aged 10–19 years that has been reported in the last two decades [12]. Approximately 85% of DM2 cases in this age group are associated with obesity and/or being overweight [13]. This is particularly concerning as recent studies have shown that many of these young people present with micro- and macrovascular dysfunction, which is a significant predictor of reduced life expectancy [13]. Beyond physiological complications, childhood obesity is associated with psychosocial problems, such as self-image disorders, attention deficit hyperactivity disorder, social isolation and discrimination, low self-esteem and depression [14].

Table 1
Anthropometric and clinical characteristics between groups.[a]

	2000 N = 595	2015 N = 636	*P* Value
Height, cm	164 (0.1)	166 (0.1)	.0003[a]
Weight, kg	58.8 (13.1)	59.8 (13.0)	.151[a]
BMI, kg/m^2	21.6 (4.2)	21.5 (4.2)	.822[a]
WC, cm	73.5 (10.0)	77.0 (10.0)	< .001[a]
Low weight, n (%)	6 (1.0)	22 (3.5)	.003[c]
Overweight, n (%)	61 (10.2)	94 (14.8)	.020[b]
Obese, n (%)	48 (8.0)	55 (8.6)	.757[c]
Overweight or Obese, n (%)	109 (18.3)	149 (23.4)	.027[b]
Abdominal obesity, n (%)	179 (30)	305 (47.9)	< .001[b]

Data expressed as mean (SD), except for prevalence, which is presented as number of individuals (percentage). BMI: body mass index; WC: waist circumference.
[a] Analyses of variance (ANOVA).
[b] Chi-square.
[c] Fisher test.

Table 2
Anthropometric and clinical characteristics of the students according to sex**.

	Male			Male		
	2000 N = 322	2015 N = 386	*P*-value	2000 N = 273	2015 N = 250	*P*-value
Height, cm	160 (0.06)	163 (0.06)	< .001[a]	171 (0.08)	173 (0.07)	.004[a]
Weight, kg	55.5 (11.9)	57.8 (12.8)	.037[a]	62.4 (12.6)	63.1 (12.8)	.536[a]
BMI, kg/m^2	21.7 (4.7)	21.8 (4.5)	.827[a]	21.4 (3.6)	21.0 (3.6)	.299[a]
WC, cm	72.2 (10.2)	76.2 (10.3)	< .001[a]	74.9 (9.6)	78.2 (9.6)	.001[a]
Low weight, n (%)	3 (0.9)	15 (3.8)	.015[c]	3 (1.1)	7 (2.8)	.205[c]
Overweight, n (%)	36 (11.1)	59 (15.2)	.110[b]	25 (9.1)	35 (14.0)	.099[b]
Obese, n (%)	26 (8.0)	40 (10.3)	.297[c]	22 (8.0)	15 (6.0)	.396[c]
Overweight or Obese, n (%)	62 (19.2)	99 (25.6)	.043[b]	47 (17.2)	50 (20.0)	.413[b]
Abdominal obesity, n (%)	131 (40.6)	221 (57.3)	< .001[b]	48 (17.5)	84 (33.6)	< .001[b]

**Data expressed as mean (SD), except for prevalence, which is presented as number of individuals (percentage). BMI: body mass index; WC: waist circumference.
[a] Analyses of variance (ANOVA).
[b] Chi-square.
[c] Fisher test.

These conditions have negative implications on quality of life, socialization and school performance [14].

We observed a significant increase in the prevalence of overweight or obese children between 2000 and 2015 (Table 1), even though obesity rates remained stable. These data are similar to those reported in other Brazilian studies, in which the prevalence of overweight and obese children and adolescents ranged from 3.8% to 24% [15]. However, according to IBGE data, these results are lower than the national average of 47.8% [16]. Our sex-stratified analysis found that there was a significant increase in the prevalence of overweight or obese females, but not males. This differs from the study by Leal et al. [17], which observed that the prevalence of overweight or obese children occurred only in boys when using a similar study design. One likely explanation for these divergent findings is the differences in ages of the study samples. In this study, we included schoolchildren aged 12–18 years, while Leal et al. [17] evaluated a younger cohort of children aged 7–10 years. While there are a variety of societal and participatory differences between these age groups; the younger group may also not have reached puberty, a time at which hormonal changes can dramatically influence body size and shape. Greater total body fat and peripheral adiposity in females can be explained by increased estrogen synthesis during adolescence [18].

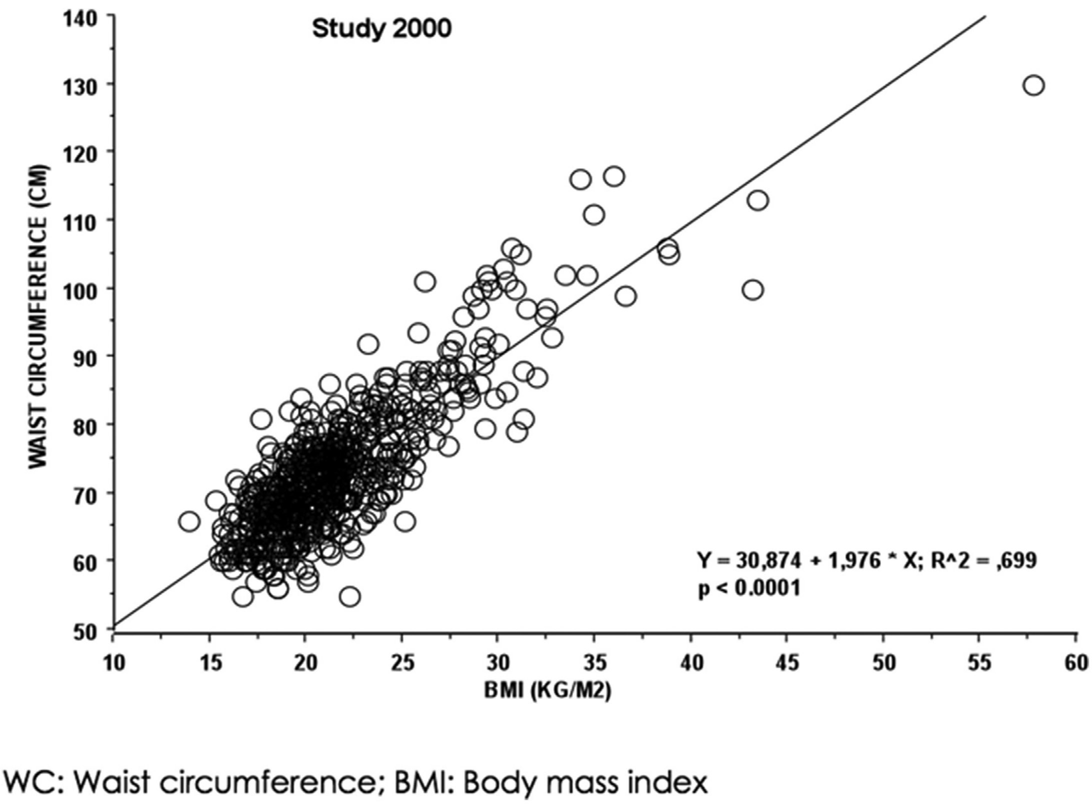
Although there was increased prevalence of individuals in the overweight or obese category, greater mean WC in the 2015 group, and a strong and positive correlation between WC and BMI (Fig. 1), we did not observe a significant difference in BMI between the two samples. BMI is a useful and practical tool to define obesity, but it is limited by not considering the distribution or location of fat, nor does it differentiate lean mass from fat mass [19]. Intra-abdominal adiposity (visceral fat), in particular, has been associated with increased insulin resistance, metabolic syndrome, DM2, and increased risk of cardiovascular morbidity and mortality [20]. Thus, for two individuals with the same BMI, one may have a higher cardiometabolic risk, depending on the amount of intra-abdominal fat [21]. Measures of body mass and fat other than BMI should be considered when evaluating overall health risk due to excessive adiposity.

The significant increase in the prevalence of underweight females may have contributed to the fact that mean BMI values did not differ between the 2000 and 2015 samples. Despite the reduction of poverty and hunger in the last several decades in Brazil, there has been a concurrent increase in the frequency of eating disorders, such as anorexia nervosa and bulimia among females between the ages of 13 and 18 [22]. A concomitant increase in prevalence of eating disorders may have negated the larger body weights of the overweight or obese groups when average values were examined. This highlights the importance of measuring the prevalence of different BMI categories, not just mean values, in cross-sectional and longitudinal studies. In this study, the increase in the prevalence of underweight females (Table 2) agrees with the previously reported rates of 0.5%–3% [23].

In the present study, the rate of abdominal obesity more than doubled to 47.9% (Table 2) by 2015. This high prevalence is comparable to other Brazilian studies, in which the frequency of abdominal obesity in children and adolescents was found to range from 30.5% to 47.6% [24]. Our study revealed that not only are the prevalence rates high, but there has also been a significant uptick in the rates of abdominal obesity over time for adolescents with similar ethnic characteristics and environmental factors. This suggests that the problem of increased abdominal obesity may be a systemic problem. Contrary to our findings, Leal et al. [17] did not find an increase in abdominal obesity in children 7–10 years between 2002 and 2007, but as previously mentioned, there was a large difference in the age of the samples between these studies.

In this study, the WC of the adolescents evaluated in 2015 was 4 cm greater than those evaluated in 2000. This is not only statistically different, but also clinically meaningful. There is a 2% increase in the risk of future cardiovascular events for every 1 cm change in WC, so the difference seen in our samples may indicate a much greater level of risk [25]. Abdominal fat is more metabolically active than subcutaneous fat and secretes a range of lipoxins that have deleterious effects on the body, including increasing the inflammatory response and enhancing insulin resistance [26]. A recent study of 182 Brazilian children and adolescents found a significant association between greater abdominal obesity and a higher risk of elevated blood pressure, dyslipidemia, metabolic syndrome, and non-alcoholic fatty liver disease [27].

Our results are relevant to public health because we compare two samples of adolescent students exposed to the same socioeconomic and environmental conditions over a period of 15 years. The first sample was evaluated in 2000, when data from the Life Standards Survey [28] showed a progressive increase in the prevalence of overweight and obesity in Brazilian children and adolescents. This finding set the stage for public policies aimed at preventing obesity and its associated complications. Since that time, several government programs were implemented to reduce childhood obesity, including the Healthy School Project (2001), the Ten Steps to Promote Healthy Eating in Schools (2004), the Promotion of Healthy Eating (2006), the Health in School Program (2007), the Regulation of Foods Marketed in School Cafeterias (2007), the National School Feeding Program (2009), and the Food Advertising and Publicity Regulation (2010) [29]. Our results suggest that these programs may not have had the intended effect in the municipality of Marília. It is also likely that the failure of these programs may be more systemic



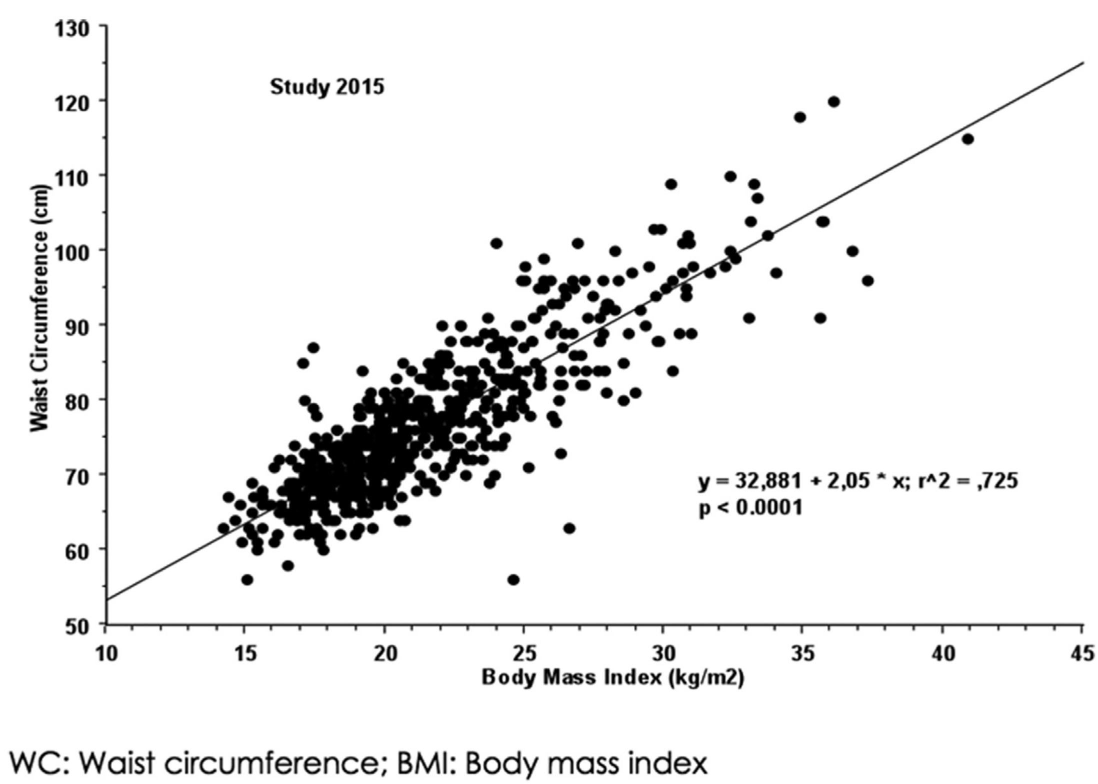


Fig. 1. Relationship between body mass index (BMI) and waist circumference (cm) in sample 2000 (a) and 2015 (b).

throughout Brazil, since Marília has better infrastructure and resources when compared to other Brazilian municipalities. Marília is in the top 50 municipalities with the highest HDI in Brazil [30].

Despite the important implications of this study, it is not without limitations. The cross-sectional design of this study precludes potential associations of causality, outcome analysis, and prognosis. The anthropometric measures were obtained by different evaluators at each testing time, but we do not believe this compromised data quality because all evaluators were trained by the same team at both time points. We leveraged the limitations against the strengths of this study, which included representative samples of the target population who had similar ages and ethnic characteristics, and were exposed to the same environmental factors at each time period. We also included anthropometric measures other than BMI. Using BMI alone may produce biased results that are not reflective of changes in fat distribution in the body. Including CA allowed for a more consistent analysis of the body fat distribution of the students.

5. Conclusion

This study shows a worrisome increase in the prevalence of overweight or obese individuals and abdominal obesity in Brazilian adolescents over a 15-year period, despite public policies to fight obesity that were enacted over the same period.

Author contributions

- Daniela Casagrande (primary author)
- Paulo Henrique Waib (co-author)
- José Augusto Sgarbi (co-author)

Conflicts of interest

Nothing to declare.

Ethical clearance

Ethical approval and prior permission were obtained from the institutional Ethics Committee before commencement of the study.

Institution at which work was performed

Marília Medical School, SP. Brazil.

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