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Correlates of body fat and waist circumference in children from São Caetano do Sul, Brazil

Correlatos da gordura corporal e circunferência da cintura em crianças de São Caetano do Sul, Brasil

Gerson Luis de Moraes Ferrari (https://orcid.org/0000-0003-3177-6576) [1,2]
Dirceu Solé (https://orcid.org/0000-0002-3579-0861) [2]
Carlos Pires (https://orcid.org/0000-0001-9190-1119) [3]
Victor Matsudo (https://orcid.org/0000-0003-3552-486X) [4]
Peter T. Katzmarzyk (https://orcid.org/0000-0002-9280-6022) [5]
Mauro Fisberg (https://orcid.org/0000-0003-2992-3215) [2]

Abstract *The purpose of this study was to examine potential correlates of body fat (BF) and waist circumference (WC) in children. The sample included 328 children (169 boys) aged 9-11 years. BF (%) was measured using a bioelectrical impedance scale. WC measurements were made on exposed skin at the end of a normal expiration using a non-elastic anthropometric tape. Moderate-to-vigorous physical activity (MVPA) and sedentary behavior were measured using accelerometers. Participants with complete individual, family and home, and school environmental data were included in the analysis. Children averaged 21.3% in boys and 25.8% in girls for BF and 68.0 cm in boys and 67.2 cm in girls for WC. There was higher BF among girls (p<0.001), but no significant sex differences with respect to WC. In boys, breakfast consumption, bad sleep quality, and MVPA were associated with BF. Among girls, the only variables associated with BF were breakfast consumption and bad sleep quantity. Bad sleep quality and MVPA were associated with WC in boys. Among girls, WC was associated with breakfast consumption and bad sleep quantity. We identified correlates of BF and WC in children; however, few correlates were common for both BF and WC, and for both boys and girls.*

Keywords *Body fat, Waist circumference, Child.*

Resumo *O objetivo deste estudo foi examinar os potencias correlatos da gordura corporal (GC) e da circunferência da cintura (CC) em crianças. A amostra incluiu 328 crianças (169 meninos) de 9-11 anos. A GC (%) foi avaliada usando a bioimpedância elétrica e a CC (cm) usando uma fita antropométrica não elástica. A atividade física de moderada à vigorosa (AFMV) e o tempo sedentário (TS) foram mensurados usando acelerômetros. Os participantes que tinham informações completas individuais, familiares, e de ambiente da moradia e escolar foram incluídos nas análises. As médias das crianças foram 21,3% nos meninos e 25,8% nas meninas para GC e 68,0 cm nos meninos e 67,2 cm nas meninas para CC. A média das meninas foi maior do que nos meninos para GC (p<0.001). Não encontramos diferença significativa entre os sexos para CC. Nos meninos, o consumo de café da manhã, qualidade de sono ruim e AFMV foram associados com GC. Nas meninas, as únicas variáveis associadas foram o consumo do café da manhã e qualidade de sono ruim. Qualidade de sono ruim e AFMV foram associadas com CC nos meninos. Nas meninas, CC foi associada significativamente com consumo de café da manhã e qualidade do sono ruim. Identificamos correlatos da GC e da CC em crianças, no entanto, poucos correlatos foram comuns para GC e CC e em ambos os sexos.*

Palavras-chave *Tecido adiposo, Circunferência da cintura, Crianças.*

[1] Centro de Investigación en Fisiologia del Ejercido-CIFE, Universidad Mayor. José Toribio Medina 29. Estacion Central Santiago Chile. gersonferrari08@yahoo.com.br
[2] Disciplina de Alergia, Imunologia Clínica e Reumatologia do Departamento de Pediatria, Universidade Federal de São Paulo. São Paulo SP Brasil.
[3] Centro de Matemática da Universidade de Trás-os-Montes e Alto Douro (CM-UTAD). Vila Real Portugal.
[4] Centro de Estudos do Laboratório de Aptidão Física de São Caetano do Sul (CELAFISCS). São Caetano do Sul SP Brasil.
[5] Pennington Biomedical Research Center. Baton Rouge Louisiana United States.

Introduction

Obesity is an important lifestyle-related public health problem worldwide[1]. The prevalence of obesity in children has risen significantly during the past few decades not only in high-income countries but also in low- and middle-income countries[2]. One recent review has reported that the prevalence of childhood overweight and obesity rose by 47.1% between 1980 and 2013 worldwide[3].

The association between obesity, defined by various assessment methods, and comorbidities/mortality is considered to be strong and causal[4]. Even though body fat (BF) is associated with an increased health risk, abdominal fat mass has proved to be an independent risk factor for the development of comorbidities such as stroke, type II diabetes, hypertension, and cancer[4]. In adults, markers of central BF distribution are associated with visceral fat and components of the metabolic syndrome[5]. Waist circumference (WC) is also associated with cardiovascular disease risk factors in children[6].

The prevalence of overweight and obesity among Brazilian children may have increased during the last decades leading to concern among public health authorities. In 2010, the National School of Health (Pesquisa Nacional de Saúde do Escolar) reported that 33.5% of Brazilian children were overweight, and 16.6% of boys and 11.8% of girls were obese[7]. Strategies implemented to reduce overweight/obesity in children, especially at the school level, have reported inconclusive outcomes - some showed significant results[8], while others did not[9]. A better understanding of lifestyle characteristics associated with obesity is needed to reduce the negative behavioural and health effects of excessive weight in childhood. Further, as children spend most of their daily time at school, where healthy behaviours are learned[10], the school environment may promote healthy habits that positively affect children's weight status[11]. Thus, the aim of this study was to examine potential individual (demographic and behavioral), family and home, and school environmental correlates of BF and WC in children aged 9-11 years from São Caetano do Sul, Brazil.

Methods

Data source

The International Study of Childhood Obesity, Lifestyle and the Environment (ISCOLE) aimed to determine the relationships between lifestyle behaviours and obesity in a multi-national, cross-sectional sample of 9-11 year-old children[12]. Data collection for this study was conducted in the Brazilian city of São Caetano do Sul.

A complete list of public and private schools enrolling 5th grade students in São Caetano do Sul was assembled. Public and private schools were sampled separately and schools were selected from each list at a ratio of 4 (public) to 1 (private). All schools were placed in random order within each stratum and each school was approached according to the established order. This 80% public to 20% private schools ratio was purposely implemented to maximize socioeconomic status (SES) distribution. In total, 20 schools (16 public) were sampled in order to generate a sample of 25–30 children from each school with a stipulation that each sex comprise approximately 50% of the selected sample, resulting in a minimum enrollment of 500 5th grade children. Additional details on study design, sample size, and full methodology have been published elsewhere[12]. This project was approved by the research ethics board at the Federal University of São Paulo, Brazil and the participating school boards. Written informed parental consent and child assent were obtained for all participants.

Anthropometric variables

Data were collected by trained ISCOLE data collectors during an in-school visit according to standardized procedures[12]. Anthropometric variables included body height, body weight, body mass index (BMI), body fat percentage (BF%), and WC. Body height (cm) was measured without shoes using a Seca 213 portable stadiometer (Hamburg, Germany), with the head in the Frankfort plane. Body weight and BF% were measured using a portable Tanita SC-240 body composition analyzer (Arlington Heights, IL, United States) after all outer clothing, heavy pocket items and shoes and socks were removed[13]. WC measurements were made on exposed skin at the end of a normal expiration using a non-elastic anthropometric tape midway between the lower rib margin and the iliac crest[12].

Each measurement was repeated and the average was used for analysis (a third measurement was obtained if the first two measurements were >0.5 cm apart for body height and WC, 0.5 kg apart for body weight and 2.0% for BF%, respectively). The mean value of the two closest measurements was used for analysis.

Potential correlates

Demographic correlates. Parents were asked about the child's age, sex and ethnicity (white/caucasian, black, mixed, other) in the ISCOLE Demographic and Family History Questionnaire.

Behavioral correlates. Participants completed the ISCOLE Diet and Lifestyle Questionnaire, containing questions asked to the child related to dietary intake, physical activity and sedentary behaviors[12]. Children completed a Food Frequency Questionnaire (FFQ) which asked how often participants consumed 23 food and beverage items in a usual consumption[12]. In the present paper, we use standardized principal component scores for these two patterns as the dependent variables "unhealthy diet pattern" (characterized by high intakes of fast foods, and fried food) and "healthy diet pattern" (including fruits and vegetables).

Children reported the frequency of breakfast consumption. Subsequently, weekly breakfast frequency (0-7 days per week) was calculated as the sum of weekday and weekend day breakfast frequency. Children were asked how many hours they typically watched television (TV) and played video game and/or computer per week day, and per weekend day[12]. Children were asked how many hours they typically watched TV, and how many hours they played video games and/or used computer on weekdays and on weekends days separately[12]. For analysis, this is presented as a screen time score. Children were asked how they traveled (e.g., walking, car), to school most days and these responses were re-coded as active or inactive transport. Children also reported the time that it usually took them to travel to school.

Children were asked to wear an ActiGraph GT3X+ accelerometer (ActiGraph LLC, Pensacola) at the waist on an elasticized belt, and positioned in line with the right mid-axillary line, for at least 7 consecutive days (plus an initial familiarization day and the morning of the final day). Children were asked to wear the accelerometer 24h/day (removing only for water-related activities). Children received instruction during the initial in-school assessment on how to wear the accelerometer.

Data reduction strategies limited the analytical dataset to participants who provided at least four days of valid measurements (including at least one weekend day), with at least 10 hours/day of waking wear time[14]. Data were collected at a sampling frequency of 80 Hz, and subsequently downloaded in 1-second epochs, and aggregated to 15-second epochs for analysis using ActiLife Software (version 6, Actigraph LLC)[15]. Time spent in moderate-to-vigorous physical activity (MVPA) and sedentary behavior (SB) were estimated using the Evenson et al.[15] cut points. To determine MVPA and SB, total sleep period time and non-wear time were identified using validated procedures[16].

Family and home environment correlates. A Demographic and Family History Questionnaire, and a Neighborhood and Home Environment Questionnaire contained questions for parents related to their home and neighborhood environment. Parents were also asked about the child's age, sex, number of siblings birth country, health history of the child, total annual household income, parental education level, parental employment status, and number of working motorized vehicles at the household. Combined parental education level (highest level of either parent) was used by considering both parents' responses. Many questions were asked separately about both maternal and paternal parents, but the identity of the familial relationship of the individual completing the questionnaire (mother or father) was not captured by the questionnaire.

School environment correlates. An ISCOLE School Environment Questionnaire captured information on school characteristics, policies, and practices that may influence healthy eating and activity behaviours of the children. This questionnaire was completed by a school administrator or teacher in each of the participating schools. Lastly, one school audit was completed for each participating school by the research study team. This questionnaire recorded directly observed information on the school's built and food environments. Full details of the questionnaires are provided in Katzmarzyk et al.[12].

Ferrari et al.[17] provides additional details on response categories and additional details on measurement and analysis of potential individual, family and home, and school environmental correlates of BF and WC. Additional details on analytical sample, complete data, missing data study design, participating countries, and full methodology can be found in Ferrari et al.[17].

Statistical analysis

Male and female samples were described separately using the mean and standard deviation, or frequencies, depending on the nature of the variables. For the comparison between the two groups, the Student T Test, the Chi-Square Test for independence, and Standardized Adjusted Residuals were used. The normality of the data was assessed with the Kolmogorov-Smirnov Test.

We used multilevel linear regression models, including school in the second level (random intercept), to examine the associations of potential correlates with BF% and WC. Due to the non-normal distribution, both variables were log-transformed for analysis and treated as continuous variables.

At first, univariate models, adjusted for age and ethnicity, with school as a random effect, were carried out for all potential correlates, separately in the boys and girls. The variables that were significant at $p<0.10$ in the univariate models, were included in multiple models (also adjusted for age and ethnicity, with school as a random effect) to determine the correlates of BF% and WC, among boys and among girls. Variables that were significant at $p<0.10$ in the multiple models were considered correlates of BF and WC. Data were analyzed using Statistical Package for the Social Sciences (SPSS) software, version 22.0.

Results

Complete data for the outcomes of interest and all investigated correlates were available for 328 children. Missing data were found for 256 participants of the original sample of participants[17].

Characteristics of participating children and their parents are summarized in Table 1. The sample included 328 children aged from 9 to 11 years old (M = 10.4; SD = 0.5), and 169 (51.5%) were boys. The majority (75.9%) was white/caucasian (73.4% of the boys and 78.6% of the girls). The comparison between boys and girls showed significant higher percentage of BF among girls ($p<0.001$), but no significant differences with respect to WC, height, weight, or BMI ($p>0.05$). However, the percentage of overweight was higher among girls (30.8% vs. 17.2%), and the percentage obese was higher among boys (33.1% vs. 22.6%).

Boys had a higher healthy diet score ($p=0.024$) and ate breakfast more often than girls ($p=0.042$). They also had higher screen time ($p=0.053$), which is explained by more time spent playing videogames/computer ($p=0.007$), since there were no differences between boys and girls in TV time ($p=0.616$) (Table 1).

More than half of boys and girls spent less than 15 minutes to travel to school and did it in an inactive mode. More than 90% of boys and of girls classified their sleep quality and quantity as very good/fairly good. There were no significant differences between boys and girls with respect to these variables ($p>0.05$) (Table 1).

Mean MVPA time was 71.2 min/day for boys and 46.6 min/day for girls ($p<0.001$). More than half of boys (63.9%) met MVPA guidelines. Among girls, only 25.1% met MVPA guidelines[18]. On the other hand, SB was higher among girls than among boys ($p=0.005$) (Table 1).

There were no significant differences between boys and girls with respect to the family, home and school environment characteristics ($p>0.05$) (Table 1). On average, each family had 2.3 TVs at home and more than 70% of children have a TV in the bedroom. More than half of the parents have completed high school or some college. About half of the mothers and two-thirds of the fathers work full time.

Results from the multiple models (Table 2) showed that, among boys, breakfast consumption and MVPA were negatively associated with BF%. Sleep quality was positively associated with BF%. Sedentary behavior and TV in bedroom were not associated with BF%.

Among girls, the only variable negatively associated with BF% was the breakfast consumption. Sleep quantity was positively associated with BF%. Time to travel to school was not associated with BF% (Table 2).

Results from the multiple models for WC (Table 3) showed a positive association of sleep quality with WC in boys. MVPA was negatively associated with WC. Screen time, TV in bedroom and policies or practices oh healthy eating were not associated with WC.

Among girls, WC was negatively associated with breakfast consumption. Sleep quantity was positively associated with WC.

Discussion

The aim of this study was to examine potential correlates of BF and WC in Brazilian children. In boys, breakfast consumption, bad sleep quality, and MVPA were associated with BF%. Among girls, the only variables associated with BF% were

Table 1. Demographic, anthropometric, behavioral, family, home and school environment characteristics in children from São Caetano do Sul, Brazil by sex.

Variables	Boys (n=169)	Girls (n=159)	p-value
Demographic			
Age (years)	10.4 (0.5)	10.4 (0.5)	0.844(1)
Ethnicity			0.091(2)
White/Caucasian	124 (73.4%)	125 (78.6%)	
Black	13 (7.7%)	11 (6.9%)	
Mixed	28 (16.6%)	14 (8.8%)	
Other	4 (2.4%)	9 (5.7%)	
Anthropometric			
Body fat percentage (%)	21.3 (9.6)	25.8 (9.0)	<0.001(1)
Waist circumference (cm)	68.0 (11.7)	67.2 (9.8)	0.544(1)
Height (cm)	143.3 (7.1)	144.4 (8.2)	0.187(1)
Weight (kg)	41.7 (12.9)	42.6 (12.2)	0.528(1)
Body mass index (BMI) (kg/m^2)	20.1 (4.7)	20.2 (4.5)	0.713(1)
BMI weight status[19]			0.014(2)
Underweight	3 (1.8%)	1 (0.6%)	
Normal weight	81 (47.9%)	73 (45.9%)	
Overweight	29 (17.2%) (-)	49 (30.8%) (+)	
Obese	56 (33.1%) (+)	36 (22.6%) (-)	
Behavioral			
Unhealthy diet score	0.021 (1.025)	-0.022 (0.976)	0.697(1)
Healthy diet score	0.120 (1.087)	-0.128 (0.883)	0.024(1)
Breakfast consumption (days/week)	5.4 (2.1)	4.9 (2.2)	0.042(1)
Screen time score (hour/day)			
Total screen time	4.1 (2.2)	3.7 (2.1)	0.053(1)
TV	2.3 (1.4)	2.3 (1.3)	0.616(1)
Video game/computer	1.8 (1.3)	1.4 (1.2)	0.007(1)
Travel mode to school			0.566(2)
Active	67 (39.6%)	68 (42.8%)	
Inactive	102 (60.4%)	91 (57.2%)	
Time to school			0.054(2)
≤15 minutes	102 (60.4%)	116 (73.0%)	
>15 - <30 minutes	39 (23.1%)	25 (15.7%)	
>30 minutes	28 (16.6%)	18 (11.3%)	
Sleep quality			0.361(2)
Fairly bad, very bad	6 (3.6%)	9 (5.7%)	
Very good, fairly good	163 (96.4%)	150 (94.3%)	
Sleep quantity			0.698(2)
Fairly bad, very bad	9 (5.3%)	7 (4.4%)	
Very good, fairly good	160 (94.7%)	152 (95.6%)	
Physical education classes			0.715(2)
≤2 days	141 (83.4%)	135 (84.9%)	
≥3 days	28 (16.6%)	24 (15.1%)	
Mean (SD)	2.1 (1.1)	2.1 (0.9)	0.400(1)
Physical activity (min/day)			
MVPA	71.2 (27.0)	46.6 (18.6)	<0.001(1)
MPA	48.4 (16.5)	34.0 (12.9)	<0.001(1)
VPA	22.8 (12.7)	12.6 (6.8)	<0.001(1)
Meeting MVPA guidelines (≥60 min/day)[18]	108 (63.9%)	40 (25.1%)	<0.001(2)
Sedentary behaviour (min/day)	489.7 (69.2)	511.1 (67.3)	0.005

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Table 1. Demographic, anthropometric, behavioral, family, home and school environment characteristics in children from São Caetano do Sul, Brazil by sex.

Variables	Boys (n=169)	Girls (n=159)	p-value
Family and home environment			
Siblings	1.3 (1.1)	1.3 (1.1)	0.979[(1)]
Total annual household income (Brazilian Real)			0.099[(2)]
Less than R$ 19,620	59 (34.9%)	57 (35.8%)	
R$ 19,621 to <32,700	54 (32.0%)	33 (20.8%)	
R$ 32,701 to 58,860	35 (20.7%)	41 (25.8%)	
R$ 58,861 and above	21 (12.4%)	28 (17.6%)	
TVs in home	2.3 (1.0)	2.3 (0.9)	0.558[(1)]
TV in bedroom			0.663[(2)]
Yes	124 (73.4%)	120 (75.5%)	
No	45 (26.6%)	39 (24.5%)	
Automobiles	1.0 (0.8)	1.0 (0.8)	0.628[(1)]
Combined parental educational level			0.970[(2)]
Did not complete high school	38 (22.5%)	34 (21.4%)	
Completed high school or some college	94 (55.6%)	90 (56.6%)	
Completed bachelor or postgraduate degree	37 (21.9%)	35 (22.0%)	
Maternal characteristics			
Employment status			0.190[(2)]
Part-time or less	93 (55.0%)	76 (47.8%)	
Full-time	76 (45.0%)	83 (52.2%)	
Paternal characteristics			
Employment status			0.964[(2)]
Part-time or less	57 (33.7%)	54 (34.0%)	
Full-time	112 (66.3%)	105 (66.0%)	
School environment			
Type of school			0.667[(2)]
Public school	165 (97.6%)	154 (96.9%)	
Private school	4 (2.4%)	5 (3.1%)	
Children in schools that has in practice policies about physical activity	82 (48.5%)	94 (59.1%)	0.054[(2)]
Children in schools that has in practice policies about healthy eating	71 (42.0%)	76 (47.8%)	0.292[(2)]

Results presented as mean (standard deviation) or n (%);
[(1)] Student T Test; [(2)] Chi-square Test; [(-)] standardized adjusted residuals < 1.96; [(+)] standardized adjusted residuals > 1.96.
MVPA: moderate-to-vigorous physical activity; VPA: vigorous physical activity; MPA: moderate physical activity.

breakfast consumption and a bad sleep quantity. Bad sleep quality and MVPA were associated with WC in boys. Among girls, WC was associated with breakfast consumption and bad sleep quantity. Correlates identified here are similar to those identified in previous studies[20,21].

There is a clear link between intra-abdominal fat and metabolic abnormalities, such as plasma cholesterol, triglyceride, insulin concentrations[22] and cardiovascular risk factors in children[6]. In adults, central (intra-abdominal) distribution of BF increases risk of the metabolic syndrome more than peripheral distribution[5] and it is well established that a more central fat distribution is associated with an increased risk of ill health[23]. WC measurements have been used to estimate intra-abdominal fat in children[24]. Pediatric studies consistently show strong correlations of WC with components of the metabolic syndrome, including dyslipidemia and fasting insulin[22]. Studies in children have also showed that a greater deposition of central fat is correlated with less fa-

Table 2. Final multiple models for correlates with the logarithm of body fat percentage in in children from São Caetano do Sul, Brazil[a]

Variables	Boys (n=169)		Girls (n=159)	
	β coefficient (95% CI)	p-value	β coefficient (95% CI)	p-value
Behavioral correlates				
Breakfast consumption (days/week)	-0.0131 (-0.027, 0.001)	0.065	-0.0107 (-0.023, 0.001)	0.075
Time of travel to school (>15 - <30 min)	-		0.0472 (-0.034, 0.128)	0.250
Time of travel to school (≥ 30 min)	-		-0.0066 (-0.106, 0.093)	0.897
Sleep quality (fairly bad, very bad)	0.1356 (-0.012, 0.283)	0.071	-	
Sleep quantity (fairly bad, very bad)	-		0.1179 (-0.006, 0.241)	0.061
Physical education classes	-		-	
MVPA (minutes)	-0.0023 (-0.004, -0.001)	<0.001	-	
Sedentary behavior (minutes)	-0.0001 (-0.0005, 0.0004)	0.826		
Family and home environment correlates				
TV in bedroom (yes)	0.0415 (-0.022, 0.105)	0.199	-	

[a] Multilevel linear regression model including all significant variables from the full model, controlling for ethnicity and age, with school as a random effect (2nd level); unstandardized beta coefficients are presented; 95%CI: 95% confidence intervals; Independent variables with p-value <0.10 in the univariate models (Table 4);
Reference categories in categorical variables: time of travel to school: ≤15 min; sleep quality and sleep quantity: very good, fairly good; TV in bedroom: no.

Table 3. Final multiple model for correlates with the logarithm of waist circumference in children from São Caetano do Sul, Brazil.[a]

Variables	Boys (n=169)		Girls (n=159)	
	β coefficient (95% CI)	p-value	β coefficient (95% CI)	p-value
Behavioral correlates				
Breakfast consumption (days/week)	-		-0.0123 (-0.024, -0.001)	0.039
Screen time - Video (hour/day)	0.0134 (-0.008, 0.035)	0.211	-	
Sleep quality (fairly bad, very bad)	0.1310 (-0.017, 0.279)	0.082	-	
Sleep quantity (fairly bad, very bad)	-		0.1178 (-0.005, 0.240)	0.059
MVPA (minutes)	-0.0021 (-0.003, -0.001)	<0.001	-	
Family and home environment correlates				
TV in bedroom (yes)	0.0420 (-0.022, 0.106)	0.194	-	
School environment correlates				
Policies or practices on healthy eating (no)	-0.0460 (-0.128, 0.035)	0.252	-	

[a] Multilevel linear regression model including all significant variables from the full model, controlling for ethnicity and age, with school as a random effect (2nd level): unstandardized beta coefficients are presented; 95%CI: 95% confidence intervals; Independent variables with p-value < 0.10 in the univariate models (Table 6);
Reference categories in categorical variables: sleep quality and sleep quantity: very good, fairly good; TV in bedroom: no; policies or practices on healthy eating: yes.

vorable patterns of serum lipoprotein concentrations and blood pressure[25]. Because adiposity and cardiovascular risk factors track from childhood into adulthood, early identification of children with high central adiposity is important.

These results have implications for the diagnosis of obesity-related health concerns among children, as well as the assessment of total and regional adiposity in growth studies. For example, WC is a common component of clinical definitions of metabolic syndrome in children[23]. Within the context of metabolic syndrome, WC is primarily viewed as a marker of "abdominal" obesity, as generalized obesity has not typically

been considered as an important component of the syndrome. Some information exists on the stability and tracking of abdominal fat distribution and it indicates rather moderate tracking, especially for indices describing subcutaneous adipose tissue.

We found that MVPA is a correlate of adiposity. Systematic reviews have concluded that higher levels of objectively measured physical activity are associated with lower levels of body fatness in children and adolescents[20]. More recent evidence from studies using objective measures of physical activity is supportive of the conclusion that higher levels of physical activity are associated with lower adiposity[26]. Steele et al.[26] reported negative associations between bioelectrical impedance determined body composition variables with time spent in accelerometer-determined MVPA (defined as >2000 counts/min). In contrast to our study, however, their definition of MVPA (defined as >2000 counts/min) differed from our own both in magnitude and epoch time length (≥574 counts/15 sec). The magnitude of the associations was strongest as what we observed (β= -0.044 versus β= -0.0021 for WC and MVPA). A recent systematic review concluded that physical activity was associated more consistently with adiposity in boys than girls[20], and the present study was consistent with this finding. It is not clear why adiposity development might be more sensitive to variation in physical activity in boys than in girls, but it is possible that influences on the energy-intake side of the energy-balance equation may be more important in girls than boys. In particular, low physical activity is considered in children as significant correlates of excess body fat[17].

The relationship between dietary patterns and childhood overweight and obesity is still unclear in the literature[27]. Children with overweight problems have been reported to be more likely to skip breakfast[27]. The sample in the present study reported consuming breakfast with 57% being categorized as frequent (6–7 days/week), 25.6% occasional (3–5 days/week) and 17.4% rare (0–2 days/week) breakfast consumers. These values are consistent with previous reviews reporting that 10–30% of young people in Europe and the United States regularly skip breakfast. Consistent with past work[21], we showed an inverse association between breakfast frequency and adiposity indicators (BF and WC). Furthermore, our analyses showed these associations to be independent of ethnicity and age with school as a random effect. Zakrzewski et al.[27] analyzed data from children from 12 countries in ISCOLE and showed that frequent breakfast consumption (6–7 days/week) was associated with lower BMI and BF% compared with both occasional (3–5 days/week) and rare (0–2 days/week) consumption independent of age, sex and parental education. However, relationships were not consistently observed across the 12 study sites; some countries showed no association (Australia, Finland and Kenya), and others showed that occasional, but not rare, consumption was associated with higher BMI z-scores compared with frequent consumption (Canada, Portugal and South Africa). The role of dietary patterns with respect to the risk of overweight and obesity in children and the interaction with other variables (e.g., physical activity) needs to be determined in future studies.

Previous studies have found significant associations between short sleep duration and obesity in children[28]. A meta-analysis among children showed an odds ratio for overweight and obesity of 0.91 (95% CI: 0.84–1.00) per each additional hour of sleep duration[28]. However, all of the studies in this review were from high and upper-middle income countries. Katzmarzyk et al.[29] presented mean BMI z-scores across quintiles of sleep duration. The authors found the significant linear trends across quintiles of nocturnal sleep duration ($p<0.01$; negative) in both boys and girls from ISCOLE[29]. In our data, the results demonstrated a significant negative association between self-reported sleep quantity and quality and obesity. Brazilian researchers[30] have reported significant associations between short sleep duration and obesity among adolescents. The authors showed that each hour of sleep was associated with an odds ratio of obesity of 0.70 (95% CI: 0.49–0.99)[30].

Especially in children, prevention is universally seen as the best approach to reverse the increasing global prevalence of overweight/obesity[3]. Despite the apparent fascination of prevention, to date, there is limited evidence on the most effective means of preventing childhood obesity. This may be partly related to the relatively small sample sizes for the expected effect size and/or insufficient duration of the longitudinal study in many prevention trials. Prevention is multi-level and measures should be instituted at the individual, family, community, and institutional healthcare levels[3].

This study has several strengths and limitations. The limitations include the cross-sectional design, and not being representative of the population. The work presented was restricted

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to children 9 to 11 years of age and, therefore, limits the generalizability to other age groups and we did not assess of pubertal development. Nevertheless, this study provides robust objective measures of several healthy active living variables and related correlates among a large group of Brazilian school children and represents the first study of this kind in Brazil. The limitations of accelerometry should also be considered. However, objective measurement of PA reduces the error and bias commonly associated with self-reported measures. This is one of only a few studies to identify correlates of BF and WC among children in a middle income country, and the first to examine this issue in a sample of Brazilian children.

Conclusion

The current study has shown evidence of significant correlates of BF and WC in children. However, few correlates were common for both BF and WC, and for both boys and girls.

In boys, breakfast consumption, bad sleep quality, and MVPA were associated with BF. Among girls, the only variables associated with BF were breakfast consumption and bad sleep quantity. Bad sleep quality and MVPA were associated with WC in boys. Among girls, WC was associated with breakfast consumption and bad sleep quantity.

Some of significant correlates are modifiable (i.e., physical activity), and require more intense behavioral interventions. The results of this study support the idea that a single strategy to reduce BF and WC is unlikely to be effective; however, a strategy aimed at similar behaviours (i.e., correlates identified), is possible. Future work should adapt these findings to provide meaningful public health strategies and messages and test these correlates in a intervention to reduce BF and WC in children. This may help to improve lifestyle behaviors such as physical activity, reduce excessive time spent in SB and screen time, and ultimately reduce the risk of preventable chronic diseases such as obesity.

Collaborators

All authors have sufficiently contributed to the development of this study.

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