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Dietary patterns and body adiposity in children in Brazil: a cross-sectional study

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ABSTRACT

Objectives: Many factors are associated with the increase in total and central body adiposity in children, especially eating habits. This has led to an increasing number of studies analysing food patterns, which consider the synergistic effect of food and nutrient intake on the nutritional status. The objective of this study was to identify the dietary patterns of children aged 4–7 years and associate these with different indicators of total and central body adiposity.

Study design: Cross-sectional study

Methods: The study consisted of 403 children from a retrospective cohort in Minas Geraes, Brazil. Four indicators of body adiposity were evaluated: body mass index (BMI), waist-to-height ratio (WHtR) and percentages of total and central body fat (assessed by dual-energy X-ray absorptiometry). The dietary habits of the children were evaluated by identifying the dietary patterns using principal component analysis. The adjustment predictor variables were related to the socio-economic characteristics, lifestyle and duration of exclusive breastfeeding. Food patterns were identified by factor analysis. Linear regression was used to estimate the regression coefficient and the confidence interval, considering statistical significance of $\alpha = 5\%$.

Results: Five dietary patterns were identified, which explained 42.3% of the data variance: 'Traditional', 'Unhealthy', 'Milk and chocolate', 'Snack' and 'Healthy'. The multiple linear regression model showed that a greater adherence to the 'Traditional' and 'Unhealthy' patterns was related to higher BMI, WHtR, and total and central body adiposity.

Conclusion: Children with a higher intake of food from the 'Traditional' and 'Unhealthy' patterns showed an increase in total and central body adiposity.

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Introduction

Childhood obesity is currently considered a serious public health problem and tends to persist during adolescence and adulthood.[1,2] It is associated with the risk of developing several comorbidities, including hypertension, type 2 diabetes and dyslipidaemia.[3]

In Brazil, research has shown a high prevalence of overweight in children aged 5–9 years, reaching 34.8% among boys and 32.0% among girls.[4] It is important to note that rates of central obesity have also increased in the early stages of life (i.e. childhood and adolescence).[5,6]

Different anthropometric indicators have been used to evaluate the presence of excess adiposity in children. The body mass index (BMI) has frequently been used in studies to evaluate overall obesity due to its low cost, easy application and good correlation with body fat.[2,7,8] However, there is still no consensus in the literature regarding the best indicator to assess central body fat in children, although several studies have found an association of waist circumference (WC) with waist-to-height ratio (WHtR) in the prediction of cardiometabolic risk factors.[9–11]

There are many factors associated with the increase of total and central body adiposity in children,[7,12–15] especially the development of inadequate eating habits related to family food habits, the media and the school environment.[16] In the last decade, there has been an increase in research analysing dietary patterns and considering the synergic effect of food and nutrient consumption on the nutritional status and health of individuals.[17–20]

The health risk of obesity and excess central fat, as well as its relationship with eating habits, has been established.[17,19] It is essential to carry out studies to evaluate this association in children and adolescents, adjusting for other variables that are also associated with adiposity, such as birth weight, breastfeeding and lifestyle.[7,13] It is also important to assess body adiposity using different indicators because there is currently no consensus on a standard measure for children.[11] Thus, this study aimed to identify the dietary patterns of children aged 4–7 years and to investigate its association with different indicators of total and central body adiposity.

Methods

Study design and sample

This is a cross-sectional, retrospective birth cohort study of children born at the only Maternity Hospital in Viçosa, Minas Geraes, Brazil. The children were followed up by the Lactation Support Program (PROLAC) in the first year of life and reassessed at age 4–7 years. PROLAC is a programme of the Federal University of Viçosa in partnership with the Human Milk Bank of the municipality. The main activities of the programme are to provide guidelines for mothers in the postpartum period, aiming to promote breastfeeding and provide nutritional care to nursing mothers and children in the first year of life.

Based on the information collected from the PROLAC care records and two inclusion criteria for the recruitment of children (identification data that allowed the location of the children and date of birth compatible with the ages between 4 and 7 years at the time of the study), 669 children were eligible for participation.

Of the 669 children eligible for the study, 176 were not located (change of address) after at least three attempts to contact children through home visits, 75 were not authorised by parents to participate or did not complete all stages of the study, and eight had health problems that prevented participation. In addition, seven children were excluded for incomplete food intake data. Thus, 266 losses were recorded (39.8%), and the sample of the present study comprised of 403 children.

The study was approved by the Human Research Ethics Committee of the Federal University of Viçosa (Ref. No. 892476/2014) and complied with the norms that regulate research involving human beings of the National Health Council (resolution No. 466/2012). All the children included in the study had the informed consent term signed by parents or guardians.

Body adiposity indicators

Four indicators of body adiposity were evaluated: BMI and body fat percentage, which estimate total adiposity, and WHtR and central fat percentage, which estimate the risk associated with abdominal fat.

The anthropometric measurements taken were weight, height and WC. Weight was measured on an electronic digital scale, with 150 kg capacity and 10 g accuracy. Height was measured with a 2-m vertical wall stadiometer graduated in millimetres. The measurements were performed following recommended procedures.[21]

BMI by age (BMI/A) was calculated according to sex, using guidelines of the World Health Organization.[22,23] WC was measured using a 2-m, flexible and inelastic measuring tape graduated in millimetres at the level of the umbilical scar.[24] The measurements were taken in triplicate, using the two closest ones to calculate the average. WHtR was calculated by dividing the WC (cm) by the height (cm), considering values >0.5 as at risk.[25] Body composition was assessed by dual-energy X-ray absorptiometry (DXA), with the results of total central fat percentage. All evaluations were performed at the Federal University of Viçosa health division.

Assessment of dietary patterns

Food consumption was evaluated by three food records completed by parents/guardians of the children during nonconsecutive days, with one day in the weekend. All records were checked and reviewed by the researchers and parents/guardians to reduce errors when filling out the forms. The data were entered and processed using the software Dietpro® 5i. For the analysis of dietary pattern, the foods and preparations reported in the records were grouped based on their nutritional characteristics or botanical composition,[20,26] resulting in 19 food groups.

In the identification of dietary patterns, we used a posteriori statistic principal component analysis (PCA), which allows food groups to be combined based on the correlations between them. The dietary patterns were obtained by applying the factor analysis methodology, and the factors were excluded by using PCA. The sample size adequacy and the applicability of the analysis were evaluated before proceeding to PCA with the Kaiser-Mayer-Olkin coefficient (0.561) and the Bartlett's sphericity test ($P < 0.001$).

To improve the interpretation of the factors, orthogonal varimax rotation was applied, and the number of factors/components to be retained was determined based on the Cattell (scree plot) chart. Foods and food groups with factor loads $\geq |0.25|$ were considered strongly associated with the component, providing more information to identify a dietary pattern.[27] For the denomination of the patterns, we considered the characteristics of the foods and food groups that contributed the most to each component, as well as the terminology used in other studies.[18,20,28]

After the identification of the dietary patterns, we calculated the factor scores for each child in the study; thus, each child had a factorial score for each pattern identified. For the analyses, the factor scores were categorised in tertiles.

Adjustment variables

Information on birth weight and exclusive breastfeeding duration of the children were obtained from the PROLAC records. For collection of data when the children were aged between 4 and 7 years, a semistructured questionnaire was used to obtain sociodemographic information on age, area of residence (urban/rural), per capita income, maternal work outside the home (yes/no) and maternal education.

The information about life habits included daily screen time (e.g. television, computer, games) and regular physical activity (yes/no).

Data analysis

The distribution of variables was assessed using the Shapiro–Wilk normality test. Descriptive analysis of data was performed using measures of frequency distribution, central tendency and dispersion. The Spearman Correlation test was applied to evaluate the correlation between the indicators of body adiposity and dietary patterns.

In the bivariate analysis, the regression coefficient and confidence interval (CI) were estimated by linear regression, with adjustment variables of $P < 0.20$ considered for inclusion in the multiple model. The dependent variables were logarithmic transformed in the linear regression analysis for having non-normal distribution.

To verify the adequacy and fit of the linear regression model, the White general test was applied for heteroskedasticity in the error distribution. The analyses were performed in Stata version 13.0, at the significance level $\alpha = 5\%$.

Results

Table 1 shows the sample characteristics. Most children were male (55.1%), and the average age was 6.1 years. We found medians of 16.8% for the percentage of total body fat and 8.9% for the percentage of fat in the central region. The prevalence of overweight (overweight and obesity) was 25.6%, and alteration in WHtR was 24.1%.

Table 1 – Birth, breastfeeding, sociodemographic, lifestyle, and adiposity characteristics of children aged 4–7 years.

Variable	Median	Q1; Q3
Age (years)	6.1	5.1; 6.8
Weight at birth (g)	3195.0	2950.0; 3497.5
EBF duration (months)	4.0	2.0; 6.0
Per capita income (reals)	340.0	225.0; 533.3
Maternal education (years)	11.0	8.0; 11.0
Screen time (hours/day)	4.0	2; 5
BMI (z-score)	0.08	−0.60; 1.05
WHtR	0.47	0.44; 0.50
Body fat (%)	16.8	11.9; 22.4
Central fat (%)	8.9	5.7; 15.1
	n	%
Sex		
Boys	222	55.1
Girls	181	44.9
Maternal work[a]		
Yes	283	70.6
No	118	29.4
Physical activity		
Yes	64	15.9
No	339	84.1
Nutritional status (BMI/A)		
Low weight	11	2.7
Healthy	289	71.7
Overweight	95	23.6
Obesity	8	2.0
WHtR[b]		
<0.5	303	75.9
≥0.5	96	24.1

BMI = body mass index; BMI/A = BMI by age; EBF = exclusive breastfeeding; WHtR = waist-to-height ratio; Q1; Q3 = interquartile range.
[a] $n = 401$.
[b] $n = 399$.

PCA produced five dietary patterns, which explained 42.3% of the data variance (Table 2). The first dietary pattern, named as 'Traditional', included foods/preparations typical of Brazilian foods, such as white rice, beans, vegetables, tubers, baked polenta and flour, meats, fish and eggs. The 'Unhealthy' dietary pattern was represented mainly by foods and food groups with high sugar and fat content, such as artificial juices and soda, fried foods, snacks and sausages, sweets and cream-filled biscuits. The 'Milk and chocolate' dietary pattern was named as such because it was mainly composed of milk and milk products and chocolate, foods which were frequency consumed by the children in the study. The dietary pattern named 'Snack' was represented mainly by typical bakery foods such as breads, cakes and biscuits, butter and margarine, coffee and teas. Finally, the dietary pattern 'Healthy' was represented mainly by natural juices, fruits, vegetables and broths/soups.

Figs. 1 and 2 show the correlation plots between the indicators of body adiposity and the 'Traditional' and 'Unhealthy' dietary patterns, respectively. The 'Traditional' dietary pattern correlated positively and significantly with BMI/A (Fig. 1). On the other hand, the 'Unhealthy' dietary

Table 2 – Dietary patterns and factorial loads of food groups consumed by children aged 4–7 years.[a,b]

Food/groups	Dietary patterns				
	Traditional	Unhealthy	Milk and chocolate	Snack	Healthy
Milk and dairy products	−0.038	−0.234	**0.738**	0.164	−0.018
Chocolate and sugar	−0.026	0.028	**0.856**	0.028	−0.050
Coffee and teas	0.036	−0.234	**−0.502**	**0.252**	−0.181
Butter and margarine	0.194	0.182	0.034	**0.573**	−0.027
Breads, cakes and biscuits	0.044	0.032	−0.012	**0.703**	0.091
Cream-filled biscuits	−0.111	**0.273**	0.105	**−0.381**	−0.026
Beans	**0.684**	−0.159	−0.102	−0.139	0.110
White rice	**0.749**	0.004	−0.144	−0.043	−0.161
Leafy green vegetables	**0.499**	−0.051	0.073	0.178	0.256
Vegetables	0.371	0.031	0.002	0.055	**0.433**
Tubers, polenta and flour	**0.381**	−0.080	0.017	0.204	−0.019
Fruits	0.125	−0.114	0.115	**−0.273**	**0.532**
Natural juice	−0,.132	0.034	−0.051	0.231	**0.620**
Artificial juice and soda	−0.127	**0.755**	0.020	0.001	−0.083
Meat, fish and eggs	**0.408**	0.329	0.093	0.122	−0.142
Fried foods, snacks and sausages	−0.088	**0.631**	−0.106	−0.028	0.067
Sweets	0.010	**0.477**	0.031	−0.144	0.443
Broths and soups	−0.090	**−0.334**	−0.021	0.049	**0.306**
Pasta	0.052	0.151	−0.072	**−0.458**	0.027
% of variance explained	9.8	9.0	8.5	8.0	7.0
Total variance explained	42.3%				

[a] Extraction method: Principal component analysis. Varimax rotation with Kaiser normalisation.
[b] The values in bold indicate factor loads ≥ | 0.25 |.

pattern showed a positive and significant correlation with the four indicators of body adiposity (Fig. 2).

Table 3 shows the results of the bivariate linear regression analyses between the indicators of adiposity and the dietary patterns identified. We found that a greater adherence to the 'Traditional' dietary pattern was positively associated with BMI/A, and the higher consumption of foods of the 'Unhealthy' pattern was positively associated with the four outcomes (BMI, WHtR, body fat and central fat). However, the 'Healthy' dietary pattern was also positively associated with body fat. The dietary patterns 'Milk and chocolate' and 'Snack' showed no association with any of the adiposity indicators evaluated.

The multiple linear regression model showed, after adjustment for the control variables, that a greater adherence

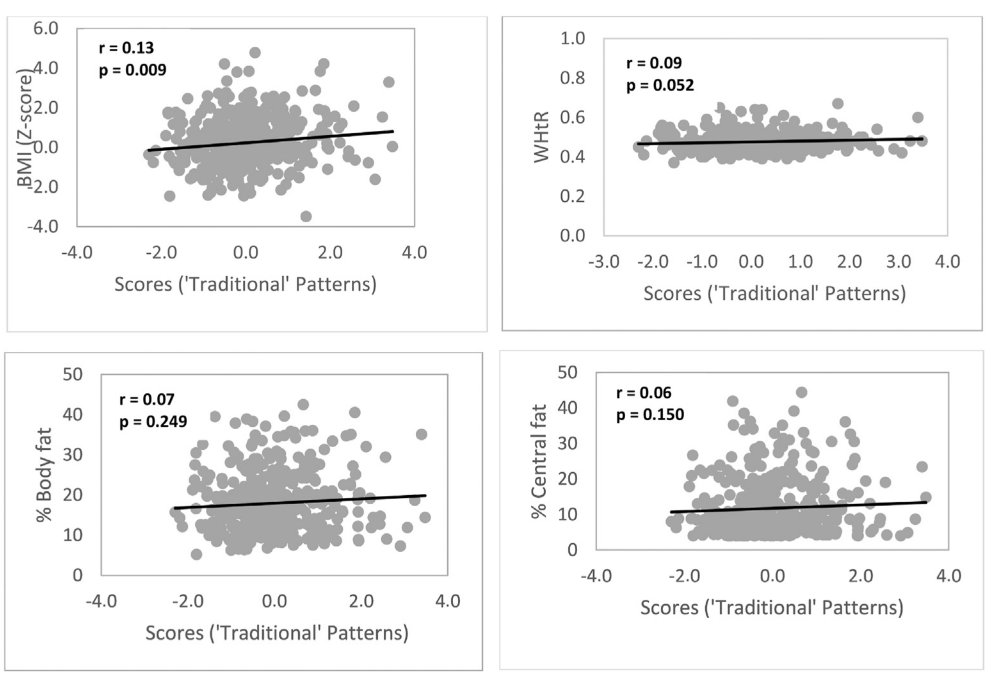

Fig. 1 – Correlation between the indicators of body adiposity and the 'Traditional' dietary patterns of children aged 4–7 years. BMI/A, BMI by age; WHtR, waist-to-height ratio.

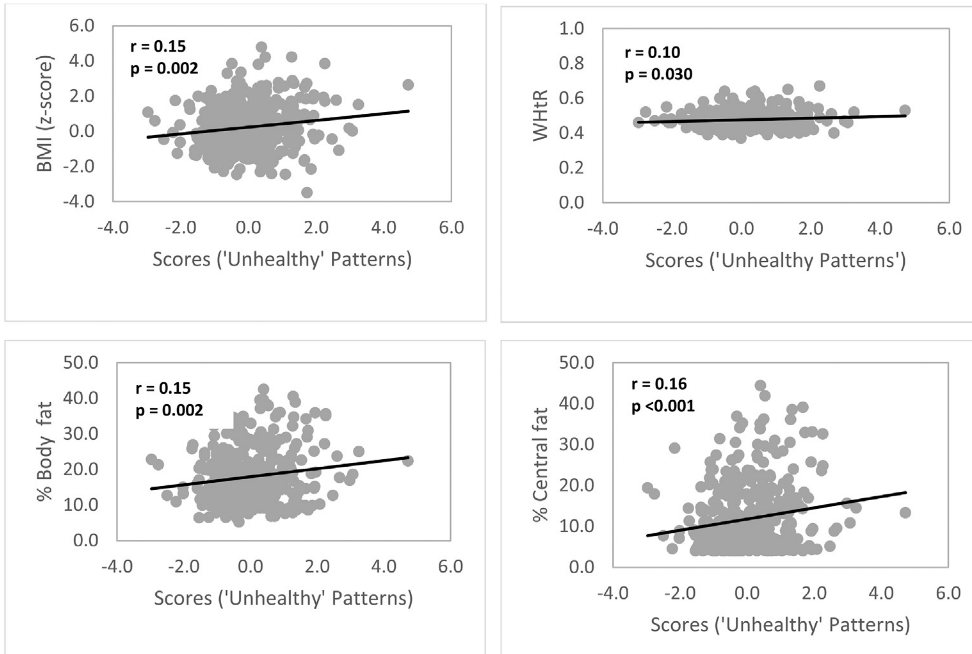

Fig. 2 – Correlation between the indicators of body adiposity and the 'Unhealthy' dietary patterns of children aged 4–7 years. BMI, body mass index; WHtR, waist-to-height ratio.

to the 'Traditional' dietary pattern was related to higher values of BMI, WHtR and body fat. In the 'Unhealthy' dietary pattern, the higher consumption of foods and food groups of this pattern was associated with increased BMI, WHtR, body fat and central fat (Table 4). After adjusting for sex, age and income, the association between the 'Healthy' dietary pattern and body fat was not maintained ($P = 0.072$).

Discussion

This study, with children aged 4–7 years from a retrospective cohort, identified five eating patterns ('Traditional', 'Unhealthy', 'Milk and chocolate', 'Snack' and 'Healthy'), which explain 42.3% of the variance of the original data. We found that a greater adherence to the 'Traditional' and 'Unhealthy' dietary patterns was positively associated with the indicators of total and central body adiposity evaluated.

In fact, PCA is a robust technique and has become a very useful tool for understanding the impact of diet on health and disease development.[29] In this context, the 'Traditional' and 'Unhealthy' dietary patterns identified in this study corroborate with previous studies carried out with children in Brazil. Other studies also found a dietary pattern that composed of foods that are part of the eating habit of the Brazilian population, namely rice, beans, tubers, flours and meats. Another dietary pattern represented by sweets, fried foods and sugary drinks was also found in this population, commonly called 'Unhealthy', 'Goodies' or 'Snacks'.[18,20,30] A pattern represented mainly by milk and chocolate was also described in two other national studies, indicating a trend of consumption of this sugary drink by children.[20,30]

The first relevant finding of the present study was the positive association of the 'Unhealthy' pattern with the four adiposity indicators evaluated, that is, children with higher food intake belonging to this group had higher total body fat and central fat. This dietary pattern consisted of sugary drinks, fried foods, sausages, sweets and other goodies commonly consumed by children. A previous study in Brazil analysed the food consumption data of children evaluated by the National Demographic and Health Survey conducted in 2006. The authors found that 50% of the children evaluated did not consume leafy green vegetables, and 25.9% did not consume vegetables in the seven days before the interview. In addition, the prevalence of consumption of fried foods was about 60% and that of soft drinks and artificial juices was 82% in at least one day in the week before the interview.[31] This dietary pattern has been related to a higher risk of obesity and associated comorbidities in other populations.[6,32] In a study carried out in Colombia with children and adolescents aged 5–12 years, the authors used PCA to identify a 'Snacking' dietary pattern, consisting primarily of sugary drinks and treats. The children in the highest quartile adhering to this pattern had higher BMI/A than those in the lowest quartile.[32] Together, these results show the need to delay the introduction of foods with low nutrient density and high calorific density because unhealthy eating habits that are formed in childhood and maintained throughout life can lead to the development of diseases.

The 'Traditional' dietary pattern was also positively associated with BMI/A, WHtR and percentage of total body fat. Although this diet contains legumes and leafy green vegetables, considered healthy foods and sources of fibre, it also contains tubers, flours and baked polenta, which are rich in carbohydrates and high in energy. Moreover, this pattern also

Table 3 – Simple linear regression coefficients and respective confidence intervals for the association of body adiposity indicators (dependent variables) and dietary patterns (independent variables) in children aged 4–7 years.

Dietary pattern	BMI/A (z-score)			WHtR		
	β	95% CI	P value	β	95% CI	P value
Traditional	0.163	0.041–0.286	0.009	0.004	−0.000–0.008	0.053
Unhealthy	0.191	0.069–0.313	0.002	0.005	0.000–0.009	0.030
Milk and chocolate	0.054	−0.068–0.178	0.385	0.001	−0.002–0.006	0.482
Snack	−0.008	−0.131–0.115	0.898	0.001	−0.002–0.006	0.446
Healthy	0.041	−0.082–0.164	0.513	0.000	−0.004–0.005	0.898
	Body fat (%)			Central fat (%)		
	β	95% CI	P value	β	95% CI	P value
	0.542	−0.197–1.283	0.150	0.466	−0.328–1.262	0.249
	1.135	0.389–1.872	0.003	1.371	0.583–2.159	0.001
	−0.054	−0.795–0.686	0.886	−0.124	−0.919–0.670	0.758
	0.104	−0.636–0.846	0.781	0.427	−0.367–1.222	0.291
	0.810	0.693–1.551	0.032	0.386	−0.412–1.185	0.343

BMI/A = BMI by age; WHtR = waist-to-height ratio; CI = confidence interval.

included meats, fish and eggs, which are often prepared with the excessive addition of oils and fats, increasing the calorific quantity of these foods. A similar result was observed by Ambrosini et al.[17] in a prospective study of adolescents in England. The authors identified a high-calorie, high-fat and low-fibre dietary pattern, and by associating the dietary pattern with body adiposity, evaluated by BMI and DXA, they found that the body fat indicators increased with the increase in the consumption scores of this dietary pattern.

The 'Healthy' dietary pattern, consisting mainly of fruits, natural juices, vegetables and soups, was not associated with the indicators of body adiposity in the present study. In a study carried out with children aged 2–9 years in eight European countries, the authors found that the 'Mediterranean' dietary pattern, mainly represented by the consumption of fruits, vegetables, oilseeds and fish, was inversely associated with excess weight, BMI (odds ratio [OR] = 0.85; 95% CI, 0.77 to 0.94) and body fat percentage (OR = 0.22; 95% CI, −0.43 to −0.01), regardless of age, gender, income, study site and level of physical activity.[33]

Interestingly, to the best of our knowledge, this is the first study to evaluate the association of dietary pattern with different indicators of body adiposity in pre-school and school-aged children. Other studies have used only the BMI[18,19,32] and/or the WC.[18] In addition, no study has been found that used DXA, which is considered a very accurate method for estimating total and central body fat.[34]

The prevalence of overweight was high among the children in the study when assessed by BMI/A (25.6%), as well as the excess of abdominal adiposity, by using the WHtR (26.8%). It has already been demonstrated[35,36] that the WHtR has good prediction power to identify excess weight because we found prevalence of alteration close to that of BMI. WHtR is a single cutoff point applicable to both the sexes and all age groups, regardless of ethnicity, which makes it useful when screening excess abdominal adiposity in children.[25] Excess body fat represents risk to the child's health, especially excess central abdominal fat.[3,10,24] Studies have shown that the combination of BMI and WC improved the prediction of cardiometabolic risk factors in children.[8,37] Thus, for early and more reliable diagnosis of changes in adiposity in children, one should, whenever possible, use more than one indicator. The lack of internationally recommended cutoff points for the children prevented us from determining the prevalence of total and central body fat increase (assessed by DXA).

A possible limitation of this study is the subjectivity during the identification of food patterns in several stages of the analysis, such as the criteria used to group foods, the number of factors to be retained, and the way the identified patterns are named. However, to minimise the effects of this limitation, the criteria adopted during all stages of the analysis were described in detail.

The present study has noteworthy strengths. For example, the estimation of the habitual food consumption of the children. It is also worth noting the adjustment of the multiple models by variables potentially associated with the outcome, thus obtaining an independent association between dietary patterns and body adiposity. In addition, as previously mentioned, studies evaluating this relationship in children are rare.

Table 4 – Final models of multiple linear regression analysis between the indicators of body adiposity (dependent variables) and the 'Traditional' and 'Unhealthy' dietary patterns (independent variables) in children aged 4–7 years.

Adiposity variable[a]	Traditional pattern			Unhealthy pattern		
	β	95% CI	P value	β	95% CI	P value
BMI (z-score)	0.163	0.396–0.287	0.010	0.175	0.050–0.300	0.006
WHtR	0.005	0.001–0.002	0.029	0.006	0.002–0.011	0.004
Body fat (%)	0.849	0.142–1.547	0.019	0.911	0.196–1.625	0.013
Central fat (%)	0.616	−0.165–1.398	0.122	1.143	0.358–1.927	0.004

BMI = body mass index; WHtR = waist-to-height ratio; CI = confidence interval.
[a] Adjusted by sex, age and per capita income.

In conclusion, the present study found a positive association between the 'Unhealthy' and 'Traditional' dietary patterns and the indicators of total adiposity (BMI and total body fat) and central adiposity (WHtR and central fat) in children aged 4–7 years, whereas the 'Healthy' dietary pattern showed no significant association. Our results indicate the need for policies to improve the quality of eating habits in childhood, as well as the implementation of the use of adiposity indicators such as BMI and WHtR to assess the nutritional status of children in routine health services.

Author statements

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Ethical approval

The study was approved by the Human Research Ethics Committee of the Federal University of Viçosa (Ref. No. 892476/2014) and complied with the norms that regulate research involving human beings of the National Health Council (resolution no.: 466/2012). All the children included in the study had the informed consent term signed by parents or guardians.

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Competing interests

The authors declare that they have no conflicts of interest.

Contributor statement

A.C.S. was involved in designing the study, field work, data collection, analysis and writing of the manuscript. V.A.S. completed field work, data collection, analysis and writing of the manuscript. F.P.C.A. was involved in data collection, analysis and writing of the manuscript. R.A.Q. contributed to the statistical analyses and critical review. H.H.H.H.M., P.P.F., and P.S.E. participated in critical review. F.S.C.C. was the project leader in the Federal University of Viçosa and contributed to general coordination, design and data interpretation, analysis and writing of the manuscript. All authors critically reviewed the manuscript and approved the version submitted for publication.

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