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Dietary Patterns and Wheezing in the Midst of Nutritional Transition: A Study in Brazil

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To assess the influence of dietary patterns on the prevalence of wheezing in the child and adolescent population in Northeastern Brazil. This is a cross-sectional study of male and female students, 6–12 years old, from the public elementary schools of São Francisco do Conde, Bahia, Northeastern Brazil. The report of wheezing in the past 12 months was collected using a questionnaire from the International Study of Asthma and Allergies in Childhood Program phase III, adapted to Portuguese. Consumption patterns were derived from principal component analysis based on the frequency of consumption of 97 food items by the food frequency questionnaire. We also obtained the anthropometric status, level of physical activity, pubertal development, and socioeconomic information, for each participant. Multivariate logistic regression analyses were used to assess the associations of interest. Of the children surveyed, 10.6% reported having wheezing. We identified 2 dietary patterns named Western and Prudent. We found a positive statistically significant association of the Western pattern with wheeze (odds ratio = 1.77, 95% confidence interval: 1.10–2.84) after adjustment for total energy intake and controlling for potential confounders. The results showed that the Western dietary pattern was associated with wheezing. Our result is according with previous findings reported in several other studies.

Introduction

Asthma is a chronic respiratory disease characterized by hyper-responsiveness of the lower airways and variable airflow limitation, reversible spontaneously or with treatment and being observed more commonly among children.[1] In recent decades, there has been a significant increase in the prevalence of asthma in different populations.[2] Asthma is one of the world's most common chronic diseases with a conservative estimate of 300 million people being affected by it and significant variations in prevalence among different countries and regions.[3] The International Study of Asthma and Allergies in Childhood (ISAAC) found an average prevalence of asthma of 24.3% among urban Brazilian children.[4]

Asthma is a multifactorial disease; its causes are not fully understood, and there is no consensus on its etiology. A large body of research has emphasized the role of changing lifestyles on the occurrence of asthma and wheezing. Among them, one of the importances is eating habits.[5] The most important change related to eating habits is the increased availability of foods of high energy density at the expense of saturated fats, transfats, and simple carbohydrates, unlike foods of plant origin, which have a low caloric value and are good sources of micronutrients and fiber.[6]

It has been hypothesized that the effect of diet on asthma pathogenesis could be directly related to both antioxidant and immunomodulatory mechanisms.[7] Lines of evidence suggest that a westernized diet, as characterized by low intakes of antioxidants (eg, selenium, vitamin C, and vitamin E) and high intakes of fat [omega-(n)-6 polyunsaturated fatty acids (PUFAs)], contributes to a high inflammatory state, due to the activation of the innate immune response.[8] Several studies have shown that reduced consumption of fresh fruits, vegetables, and fish[9–11] and high consumption of foods rich in fats[12–15] are associated with an increased risk of

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developing asthma. Recent studies suggest that a high level of adherence to the Mediterranean diet early in life protects against the development of asthma and atopy in children.[16] On the other hand, some studies have not confirmed an association between consumption of these foods and protection of asthma.[17]

Most studies use food alone or associated with micronutrient ingestion to study the association between diet and asthma; nutrients and foods are not consumed in isolation, but in combination. As a result, the World Health Organization has suggested that assessments of food intake in population-based studies on nutrition should be based on eating patterns.[18] It is argued that focusing on the dietary pattern, as a whole, would be a stronger predictor of the risk of disease than analyzing foods or nutrients in isolation. For this purpose, the use of principal component analysis (PCA) has been used in several studies to determine dietary patterns. Although dietary patterns have been widely investigated as predictors of heart disease,[19,20] few studies have had the aim of assessing the influence of dietary patterns on respiratory diseases.[15,21–23] Given this gap in knowledge, especially of children and adolescents, the aim of this study was to assess the influence of dietary patterns on the prevalence of wheezing in a sample of children in Northeastern Brazil.

Materials and Methods

Study design/population/sample

A cross-sectional design was used to study 6- to 12-year-old children living in São Francisco do Conde, a municipality located in the metropolitan region of Salvador, Northeast Brazil. This municipality has 33,183 inhabitants and a high urbanization rate (80.2%). The municipality has the third-highest development economic development index in the Bahia State, and the City Council is the largest local employer. This municipality has marked social inequalities and challenges in other areas according to its social development index (30), levels of education (139), and health indicators (178).[24]

We used data from the Education Department of the Municipality of São Francisco do Conde for the year 2010 to estimate the sample. Of 3,734 registered students, 2,649 were from rural areas, and 1,085 were from urban areas. These students were distributed across 22 schools in the county school system. To minimize travel costs and the time for subject recruitment, the 9 schools with 150 or more students were included in the convenience sample. All students aged 6–12 years in each selected school were eligible for the study. Considering that the prevalence of respiratory allergies ranges from 15% to 40%, a sample size of 531 and 834 students from urban and rural areas, respectively, was determined, taking into account a 3% error and a 95% level of confidence. We added 10% to the total sample size to account for student declining to participate in the study, resulting in a total of 1,500 students to be enrolled in the study.

Outcome variables

The prevalence of asthma and symptoms of rhinitis were measured using the previously validated ISAAC phase III questionnaire translated into Portuguese.[25] For this study, wheezing was defined based on the following 2 questions: (1) Has your child ever experienced asthma or wheezing in his/her lifetime? and (2) In the last 12 months, has your child experienced wheezing? The children whose parents provided positive answers to both questions or to the second question only were considered cases.

Food intake. A quantitative Food Frequency Questionnaire (FFQ) was used to assess the food intake frequency. The quantitative FFQ developed by Slater et al.[26] was used to assess the frequency of food. This instrument was validated by Voci et al.[27] However, we had to adapt it to take in account the local dishes; no fully validated tool exists for this at present. This questionnaire was administered to mothers or guardians of children by previously trained nutritionists. There were 97 foods or preparations listed. For the analysis, food items were grouped into 22 food clusters according to the nutritional content coded, for instance, sugars, typical Brazilian dishes (feijoada: a stew of black beans with beef and pork; feijão-tropeiro: a dish made with beans, cassava flour, sausage, garlic, onion, bacon and eggs; acarajé: a dish made from peeled black-eyed peas, formed into balls, and deep fried in palm oil), soft drinks, pastries, fast food, oils, milk, beef, chicken, fish, eggs, processed meat products, breads, cereals (rice, cassava flour, and pasta), cakes, roots, baked beans, legumes, fruits, leafy vegetables, sauces, and artificial sweeteners. The frequency of consumption of these items was divided into the following 4 categories: never consumes = 0; consumed 1–3 times a month = 1; once a week = 2; 2–4 times a week = 3; and ≥ 4 times in weeks = 4. Afterward, the scores of the frequency of consumption were calculated as weighed proportion consumption where the numerator is the sum of the categories of all food items into in food cluster multiplied by 4 and the denominator the number of food items into food cluster multiplied by 4. This score or weighed proportion consumption represents a summary measure of the food consumption.[28]

Confounding variables

Anthropometric status. Each participant's weight was obtained using a Master® portable digital scale and height using a Leicester Height Measure® portable stadiometer (Seca, Hamburg, Germany). The measurements were performed in duplicate using the techniques of Lohman et al.[29] To assess the anthropometric status, tables from the WHO (2007)[30] with percentile values of the body–mass index [BMI = weight (kg)/height (m)^2] according to age and gender were used as reference. For classification of the anthropometric status, we used the WHO 2006 proposal[31]: underweight (< 3rd percentile); normal weight (≥ 3rd percentile and < 85th percentile, category reference); overweight (≥ 85th percentile and < 97th percentile); and obese (≥ 97th percentile). For analysis, the overweight and obese categories were aggregated. Therefore, children with excess BMI were situated on or above the 85th percentile.

Level of physical activity. To evaluate the frequency of physical activity, we used the International Physical Activity Questionnaire, which assesses physical activity for leisure, transport, work, and domestic purposes in the past week.[32] This information allows to estimating the weekly time spent in physical activities. For this study, the final score was dichotomized using a cutoff of 300 min/week of moderate or vigorous physical activity.[33] Children with ≥ 300 min of activity per week were considered active (reference category),

and children with < 300 min per week were classified as inactive.

Pubertal development. The evaluation of the stages of sexual maturity was based on the characteristics of breast and pubic hair in girls and genital and pubic hair in boys. Based on this staging, the adolescents were grouped according to the categories described by Marshall and Tanner[34,35] into prepubescent (reference category) and pubescent. These stages were identified by self-description with the help of portraits provided by the interviewers.

Other variables

Variables used in the study as confounders were gender (male, female reference category), age (< 10 years, ≥ 10 years reference category), education of caregiver (≤ 4th grade, 5th grade ≥ reference category), household location (urban, rural reference category), per capita income [as minimum salary (MS); ≤ 1 MS, > 1 MS reference category], number of people living in the household (> 3, ≤ 3 reference category), and presence of smokers in the house (no reference category, Yes)

Ethics issues

Ethics approval was provided by the Ethics Committee of the School of Nutrition, the Federal University of Bahia, Brazil, registration number 27-09/CEPNUT. Written informed consent detailing all procedures to be carried out with the subjects was signed by a parent or the legal guardian of each child.

Statistical analysis

For processing and construction of the database, we used Epi Info version 6.04 (Centers for Disease Control and Prevention, Atlanta, GA). The data were entered in duplicate after reviewing the questionnaires and correcting for errors in data collection. The characteristics of the population were identified by descriptive analysis using categorized data of prevalence. Consumption patterns were derived from PCA.[36] Before proceeding to the exploratory factor analysis, the Kaiser-Mayer-Olkin coefficient was estimated, and Bartlett's sphericity test was used to indicate the adequacy of the data analysis. To reduce correlation between the factors, the Varimax method by maximizing the sum of the variance of the loading components was used. The number of extracted factors was guided by the interpretability of the data, as recommended by Hearty and Gibney.[37] The internal consistency of the dimensions of QFF was assessed and considered acceptable at levels of Cronbach's alpha > 0.65. The scores of each consumption pattern were dichotomized as Percentile > P75 versus Percentile ≤ P75.

The magnitude of the associations between wheezing and different dietary patterns was expressed as the odds ratio (OR) with 95% confidence intervals (95% CI). The statistical analysis used 2-tailed tests and a significance level of 5%. The logistic multivariate analysis to study the association between food intake and wheezing was adjusted for age, gender, education of caregivers, per capita income, number of people living in the household, presence of smokers in the house, BMI, stages of sexual maturity, and physical activity. The effects of the dietary patterns were also adjusted for each other since, although principal components are uncorrelated, rotations (even orthogonal rotations) can introduce correlations between the dietary patterns. The choice of variables for modeling was based on knowledge gathered from preexisting literature.[38] The likelihood ratio test was used to test for interactions between BMI and dietary patterns.

The statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, v. 13.0).

Results

Of the total number of students initially selected (1,500 students), 193 (12.8%) declined or discontinued participation in the study (due to refusal, family moving to another city, or children transferring to another school), resulting in 1,307 students of both genders, aged 6–12 years. A total of 1,187 students who presented complete information for the variables used here were included in the present analysis. It should be emphasized that there were no statistically significant differences of socioeconomic and demographic characteristics between the excluded and studied children (Supplementary Table S1; Supplementary Data are available online at www.liebertpub.com/ped).

There was slightly higher percentage of male students (53.3%), and students aged between 6 and 10 years (50.6%). The other characteristics are shown in Table 1. It was also found that 10.6% (95% CI: 8.9–12.31) of the study participants had symptoms of asthma (wheezing in the last 12 months).

From this analysis, 2 components (patterns) were extracted that accounted for 45.7% of the total variance. The eating patterns that were extracted were named as Western and Prudent. The food group loadings for each component are presented in Table 2. The first component was positively correlated with the intake of sugars, typical Brazilian dishes, pastries, fast food, oils, milk, cereals, cakes, and sauces. The second component was positively correlated with roots, legumes, fruits, and leafy vegetables. The indices relating to internal consistency ($a > 0.60$) ensured an acceptable level of accuracy of measurement for the 2 patterns, ensuring internal consistency for the dimensions of the questionnaire. Certain foods and food groups were not considered in the analysis due to the low communality presented ($h_2 < 0.30$): soft drinks, beef, chicken, fish, eggs, processed meat products, bread, baked beans, and artificial sweeteners.

The data analyzed by multivariate unconditional logistic regression indicated a positive and statistically significant association of the Western pattern with wheezing. After adjustment for total energy intake, adherence to the Western dietary pattern (percentile ≥ 75%) remained significantly associated with frequent wheezing (OR = 1.77, 95% CI: 1.10–2.84). There was also negative association between the Prudent pattern (percentile < 75%) and wheezing, although not statistically significant (OR = 0.82, 95% CI: 0.52–1.28) (Table 3). There was no interaction between BMI and dietary patterns (Prudent pattern $P = 0.287$; Western pattern $P = 0.848$).

Discussion

This study allowed us to characterize 2 patterns of food consumption among children and adolescents in the city of São Francisco do Conde, the Western and the Prudent. The Western pattern is unfavorable to the healthy growth of children and adolescents, especially for integrating food sources with fats in general, saturated and transfats, similar

Table 1. Characteristics of Caregivers and Children and Adolescents Aged 6–12 Years Enrolled in Public Schools in São Francisco do Conde, Bahia, Brazil, 2010

	Population number		*Wheezing within last 12 months*		
Variables	N	%	n	%	P *value*
Gender					
Male	633	53.3	69	10.9	0.657
Female	554	46.7	56	10.1	
Age (years)					
6 to <10	601	50.6	71	11.8	0.145
≥10 to <13	586	49.4	54	9.2	
Caregiver education					
≥4 years	820	69.1	84	10.2	0.630
<4 years	367	30.9	41	11.2	
Per capita income[a,b]					
>1 MS	945	79.7	95	10.1	0.270
≤1 MS	240	20.3	30	12.5	
Household location					
Rural	779	65.6	73	9.4	0.072
Urban	408	34.4	52	12.7	
No. people at the household					
≤3	281	23.7	24	8.5	0.214
>3	906	76.3	101	10.8	
Level of physical activity[b]					
Active	285	24.0	16	8.0	0.120
Inactive	902	76.0	109	11.3	
Smokers at the household[b]					
No	929	79.9	92	9.9	0.131
Yes	223	20.1	31	13.3	
Anthropometric status					
Eutrophic	879	74.1	85	9.7	0.243
Malnourished	116	9.8	14	12.1	
Overweight/obese[c]	192	16.2	26	13.5	
Pubertal development					
Prepubertal	712	60.0	72	10.1	0.565
Pubertal	475	40.0	53	11.2	
Energy intake Mean (SD) (kcal)[d]	2,449.97 (808.03)				

[a]Measured in Brazilian minimum salary (BMS; value in 2010; BRL510.00, equivalent to US$ 290.7).
[b]Different totals because of nonavailable data.
[c]The percentages of students were overweight versus obese (9.7% and 6.8%). The BMI mean (SD) in kg/m^2 was 16.53 (3.06).
[d]Energy intake mean (SD) in kcal for wheezers 2,552.10 (869.30) versus no wheezers 2,423.53 (790.14); *P*-value 0.077.
SD, standard deviation.

to those reported by other studies for the same age group.[39,40] The adoption of the Western pattern reflects changes in the lifestyle experienced by Brazilian families in recent years, including eating out and expanded use of fast and processed foods.[41]

The present study investigated the association between dietary patterns and the prevalence of wheezing. After adjustment for energy intake and potential confounders, a statistically significant positive association between the Western diet and wheezing was observed. Thus, the higher intakes of students adopting the Western dietary pattern increased the chance of presenting wheezing by 1.77 times (OR = 1.77, 95% CI: 1.10–2.84) compared with a lower consumption of such foods. This association was independent of the BMI, suggesting that the association was not linked to obesity. In contrast, there was an inverse, but not significant, association between the Prudent dietary pattern and the risk of developing wheezing.

The study of eating patterns using factor analysis for the extraction of main components, rather than specific foods or nutrients, is a new approach in nutritional epidemiology and

Table 2. Distribution of Factor Loadings of Food Consumption Patterns, São Francisco do Conde, Bahia, Brazil, 2010

Food or food group	*Western standard*	*Prudent standard*	h_2
Sugars	0.697		0.498
Typical Brazilian dishes	0.601		0.378
Pastries	0.586		0.351
Fast food	0.767		0.590
Oils	0.619		0.457
Milk	0.656		0.470
Cereals	0.424		0.326
Cakes	0.531		0.290
Roots		0.641	0.460
Legumes		0.825	0.684
Fruits		0.503	0.449
Leafy vegetables		0.747	0.568
Sauces	0.640		0.423
% Variance explained	28.62	17.08	
% Variance cumulative	45.70		

Table 3. Odds Ratio and Respective 95% Confidence Intervals of the Association Between Eating Patterns and Wheezing, São Francisco do Conde, Bahia, Brazil, 2010

		Wheezing last 12 months			
Dietary patterns	n	*Crude OR*	*95% CI*	*Adjusted OR*	*95% CI*
Prudent dietary pattern					
Percentile <75%	889	0.80	0.53–1.19	0.82	0.52–1.28
Percentile ≥75% (reference category)	298	1		1	
Western dietary pattern					
Percentile <75% (reference category)	890	1		1	
Percentile ≥75%	297	**1.74**	**1.18–2.55**	**1.77**	**1.10–2.84**

Multivariate model adjusted for age (≥10 years reference category), gender (female reference category), education of caregivers (fifth grade ≥reference category), per capita income (≥1 MS reference category), number of people living in the household (≤3 reference category), presence of smokers in the house (No reference category), body–mass index (BMI), stages of sexual maturity (prepubertal reference category), physical activity (≥300 min of activity per week reference category), and energy intake.

OR, odds ratio; CI, confidence interval.

Boldface numbers are statistically significant.

is used to assess the effects of diet in general. Nevertheless, only a few studies using dietary patterns and the prevalence of wheezing/asthma, especially among children and adolescents, have been reported. Takaoka and Norback,[15] using the same type of analysis, investigated the influence of dietary patterns on the prevalence of allergies and respiratory diseases. In that study, the authors reported that the dietary pattern that included fast food, soda, and artificial juice was associated with respiratory infections and wheezing in Japanese adolescents. A positive association of the Western dietary pattern and symptoms of asthma was reported in the Netherlands,[42] Saudi Arabian,[43] New Zealand,[13] Sweden,[14] and Chinese[44,45] children. Although the role for food-based saturated fat in the risk of wheezing and asthma remains inconclusive, the effects of other specific nutrients (eg, antioxidant vitamins A, C, and E and selenium) have been reported associated with a higher prevalence of wheezing and asthma.[46]

Possibly, the consumption of diets with proinflammatory effects may contribute to the increased prevalence of wheezing and asthma in westernized societies. In the typical westernized diet, omega-(n)-6 PUFAs dominate, resulting in the release of proinflammatory arachidonic acid-derived metabolites.[47] Furthermore, westernized diets, more deficient in antioxidants, have been associated with increased susceptibility to allergen hypersensitivity. Suboptimal dietary intake of antioxidant vitamins, in particular vitamins A, C, and E and carotenoids, as well as other antioxidants such as selenium and flavonoids, may have an adverse effect on the modulation of oxidative lung stimuli; on the contrary, higher intakes may have a beneficial effect upon the modulation of oxidative lung stimuli, decreasing airway hyperactivity, wheezing symptoms, and asthma.[48]

Some possible limitations of the study need to be considered. It is noteworthy that the main limitation of this study is the fact that it is cross sectional. This affects the interpretation of the results to the extent that this type does not indicate the temporal sequence between exposure to the studied risk factors and the subsequent development of the disease, and while unlikely the fact that people with asthma may alter their diet toward a more healthy pattern cannot be disregarded. In this study, the report of wheezing in the past 12 months was used as an outcome, as commonly used in other population-based studies. While the lack of physician asthma diagnosis and medication usage could be interpreted as limitations of the study, on another hand, the report of symptoms (wheezing) is less dependent on access and quality of health services. Furthermore, in Brazil, a validation study showed that wheezing in the past 12 months had high sensitivity, specificity, and positive and negative predictive value, reinforcing the concept that this is the key question for the diagnosis of asthma.[49] Caudri et al.[50] found wheezing to be predictive for the development of asthma. The use of dietary patterns has the following advantages compared with the methods focusing on nutrients and food alone to evaluate the association between diet and diseases, particularly for chronic diseases.[18] This approach reduces the chance of finding spurious associations between exposure (dietary) and outcome (chronic diseases), and it incorporates both the complex interactions between nutrients (synergistic or antagonistic) and their correlations, which can modify bioavailability. However, the arbitrary use of extracting the number of factors retained and the method of rotation of the correlation matrix of factor analysis may be a limitation of the study. Nevertheless, decisions concerning the number of retained factors were made considering the objectives of the research and the interpretability of the data, as recommended by Hearty and Gibney.[37]

Conclusion

The results showed that the Western dietary pattern was associated with wheezing. Our result is according with previous findings reported in several other studies.

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Authors Contribution

Rita de Cássia Ribeiro Silva participated in the study design, data collection, interpretation of results, and writing of the manuscript. Ana Marlúcia Oliveira Assis participated in the interpretation of results and writing of the manuscript.

Luce Alves da Silva participated in the field work and reviewed the manuscript. Rosemeire Leovigildo Fiaccone designed the work and reviewed the manuscript. Mauricio L. Barreto, Silvana DInnocenzo, Alvaro A. Cruz, and Laura C. Rodrigues participated in the interpretation of results and revision of the manuscript. Neuza Maria Alcantara-Neves participated in the study design and revision of the manuscript.

Author Disclosure Statement

The authors declare no conflicts of interest.

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