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ORIGINAL ARTICLE

Food Consumption is Associated with Hyperuricemia in Boys

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Abstract

Introduction Hyperuricemia is related to health issues among children and adolescents, once the uric acid concentration is associated with metabolic syndrome, hypertension, insulin resistance, obesity, and dyslipidemia. However, few studies are addressing uric acid levels and food uptake in this age group.

Aim To verify the association between food consumption and uric acid in children and adolescents.

Methods This is a cross-sectional study developed with 2335 children and adolescents of both genders aged 6–17 years old. Blood collection was performed after 12 h of fasting. Uric acid values were classified according to tertiles, in which the highest tertile was considered as hyperuricemia. Food consumption was evaluated by weekly consumption frequency questionnaire. Pearson correlation and logistic binary regressions were used for statistical analysis. Models were adjusted for age, systolic blood pressure, body mass index (BMI), and skin color/ethnicity.

Results It was found an association between red meat consumption and hyperuricemia only in boys in the crude model (OR = 1.56; 95% CI 1.12; 2.18). Also, there was an association between pasta (OR = 1.52; 95% CI 1.11; 2.10) with hyperuricemia in boys, when adjusted age, systolic blood pressure, BMI, and skin color/ethnicity.

Conclusion The knowledge of food patterns which are predisposing factors for the increase in serum uric acid levels is important for the implementation of strategies and public health policies for health promotion among children and adolescents.

Keywords Uric acid · Eating habits · Blood pressure · Body mass index · School children

1 Introduction

Uric acid is the final product of purine metabolism and is excreted in urine [1]. High levels of uric acid in blood [hyperuricemia] may be due to the low rate of excretion by the kidneys or increased production due to excess of purine precursors. Besides that uric acid levels are influenced by genetic and environmental factors, such as food intake, age, and body mass index (BMI) [2, 3]. Hyperuricemia is related to several health problems such as kidney and cardiovascular diseases [2–5], and high uric acid serum levels are associated with an approximate increase of 70% at risk for coronary disease [6].

Eating patterns are related to serum uric acid levels; thus, vitamin C, dairy products, and coffee are associated with low serum uric acid levels [7, 8]. Hyperuricemia is related to the consumption of foods rich in purines such as red meat, seafood, and drinks such as beers [9] and those sweetened with fructose [4]. Fructose uptake has increased over the last decade all over the world, which has been associated with an increase in serum uric acid levels [10]. In the last years, the consumption of sweetened food has been increased among children and adolescents and studies have shown an association with uric acid [11, 12]. The hyperuricemia is ascribed to health issues in this age group, once the uric acid concentration is associated with metabolic syndrome [13], hypertension, insulin resistance, obesity, and dyslipidemia [14, 15].

Eating habits may vary according to the age group and between different countries and regions, and inadequate nutrition in childhood and adolescence tends to continue

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into adulthood [16], the main reason for monitoring uric acid among this population. Also, Childhood hyperuricemia is an independent risk factor of hypertension in adulthood [17], highlighting the relevance of understanding it´s related factors at an early age. Although there are few surveys with the school-age population addressing uric acid levels and food uptake [12]. Besides that, the World Health Organization (WHO) alert for the need of more surveys analyzing food consumption together and not nutrients analyzed individually [18]. Therefore, the present study aimed to verify the association between food consumption and uric acid in children and adolescents.

2 Methods

Participated in the study 2335 schoolchildren, of both sexes, aged between 6 and 17 years (11.54 ± 2.78 years old), stratified by clusters, belonging to 25 public and private schools (rural and urban areas) of basic education in the municipality of Santa Cruz do Sul-RS (Brazil). This study is part of a bigger project called "Schoolchildren health—Phase III—Evaluation of biochemical, genetic, hematologic, immunologic, postural, somatomotor, oral health indicators, coronary diseases risk factors and lifestyle of schoolchildren: a study in Santa Cruz do Sul–RS", approved by the ethics and research committee from the Universidade de Santa Cruz do Sul (UNISC) (no CAAE: 31576714.6.0000.5343), concerning Resolution 466/12 of the National Health Council.

Schoolchildren of both gender, aged between 6 and 17 years, with no restrictions on blood collection, were included, who returned the questionnaire on food consumption completely and correctly filled out and with the consent form signed by the parents and the signed consent form by the participant ($n = 2502$). Of these, 167 were excluded, as they did not perform blood collection and discrepancies in the datasheet after verification in the exploratory analysis.

All assessments were carried out at the University of Santa Cruz do Sul-UNISC by trained professionals for each function. Blood collection for uric acid measurement was performed after 12 h of fasting in the brachial vein, at the UNISC Exercise Biochemistry Laboratory by trained professionals (nursing technicians and pharmacists at the university), respecting biosafety standards. Serum acid uric concentration was determined by enzymatic photometric methodology using proper reagents (Kovalent) and the automated system Miura 200 (I.S.E., Rome, Italy). Uric acid values were classified according to tertiles, in which the highest tertile was considered as hyperuricemia.

The evaluation of weekly food consumption was performed through the Barros and Nahas adapted questionnaire [19] and considered the ingestion of the following: red meat, fish, pasta, fried snacks, sweets and biscuits, and rice with beans. The frequency of consumption was classified into two categories: (1) infrequent consumption (up to once a week); (2) frequent consumption (two or more times a week).

Sex, skin color/ethnicity, and living area were obtained through a self-reported questionnaire, in which the participants should tick one of the following options: sex (female and male), skin color/ethnicity (white, black, brown/mulatto, indigenous and yellow), and living area [rural or urban]. To assess weight and height an anthropometric scale with a coupled stadiometer (Filizola®) was used, then body mass index was calculated using the formula: weight/height^2. Systolic and diastolic blood pressure were measured using the auscultatory method using a sphygmomanometer, a stethoscope on the left arm and, and a cuff appropriate to the individual's brachial circumference. The participants should remain at rest for 5 min and then two measurements were made, considering the lowest values of blood pressure.

2.1 Statistical Analysis

Descriptive analyses were reported in frequency and percentage. Independent t-test and Chi-square tests were used to examine differences between boys and girls. Pearson correlation was used to determine the association between uric acid with age, blood pressure, and BMI. Logistic binary regressions were applied to test the association between food consumption and hyperuricemia, considering the following models: crude (model 1), and adjusted for systolic blood pressure, age, BMI, and skin color/ethnicity (model 2). All analyses were carried out using the IBM SPSS 23 (SPSS, Inc., Armonk, New York, USA). The level of statistical significance was established as $p < 0.05$.

3 Results

Among the students evaluated, 31.7% of boys and 19.9% of girls presented hyperuricemia. In both genders was observed frequent consumption of red meat (77.5% and 76.4% for boys and girls, respectively). The same was observed for rice with beans consumption (91.3% and 89.6% for boys and girls, respectively). On the other hand, only 14.1% of boys and 10.3% of girls consumed frequently fish (Table 1).

Correlations between uric acid with age, systolic, and diastolic blood pressure and BMI are presented in Table 2. The only variables that did not show correlation with uric acid were age and systolic blood pressure in girls.

Table 3 shows the association between food consumption and hyperuricemia in boys and girls. In the crude model, it was found that red meat and pasta consumption increases the odds ratio of hyperuricemia in boys. However, when adjusted for systolic blood pressure, age, BMI, and skin

Table 1 Characteristics of the sample according to sex

	Boys (n = 1,033) Mean (SD)	Girls (n = 1,302)	p
Uric acid (mg/dL)	4.35 (1.44)	4.02 (1.82)	< 0.001
Body mass index (kg/m^2)	20.04 (4.22)	20.41 (4.28)	0.03
Systolic blood pressure (mmHg)	107.24 (14.73)	105.77 (14.19)	0.01
Diastolic blood pressure (mmHg)	65.03 (11.08)	65.07 (10.83)	0.92
	Boys (n = 1,033) n (%)	Girls (n = 1,302)	p
Age group			
Children (6–9 years)	289 (28.0)	342 (26.3)	0.190
Adolescent (10–17 years)	744 (72.0)	960 (73.7)	
Uric acid			
Normal	705 (68.3)	1039 (80.1)	< 0.001
Hyperuricemia	327 (31.7)	258 (19.9)	
Ethnicity			
White	825 (75.7)	1051 (74.7)	
Black	105 (9.6)	115 (8.2)	0.430
Brown/mulatto	142 (13.0)	215 (15.3)	
Indigenous	6 (0.6)	10 (0.7)	
Yellow	12 (1.1)	16 (1.1)	
Housing zone			
Urban	806 (78.0)	1067 (82.0)	0.009
Rural	227 (22.0)	234 (18.0)	
Body mass index			
Normal weight	606 (58.7)	792 (61.1)	0.252
Overweight/obese	426 (41.3)	505 (38.9)	
Red meat ingestion			
Infrequent	232 (22.5)	306 (23.3)	0.527
Frequent	800 (77.5)	991 (76.4)	
Fish ingestion			
Infrequent	886 (85.9)	1164 (89.7)	0.004
Frequent	146 (14.1)	133 (10.3)	
Pasta ingestion			
Infrequent	747 (72.4)	950 (73.2)	0.642
Frequent	285 (27.6)	347 (26.8)	
Fried snacks ingestion			
Infrequent	515 (49.9)	648 (50.0)	0.978
Frequent	517 (50.1)	649 (50.0)	
Sweets and biscuits ingestion			
Infrequent	459 (44.5)	576 (44.4)	0.974
Frequent	573 (55.5)	721 (55.6)	
Rice with beans ingestion			
Infrequent	87 (8.4)	139 (10.7)	0.064
Frequent	945 (91.6)	1158 (89.3)	

Independent t test and Chi-square test were used to examine differences between boys and girls

SD standard deviation

Table 2 Pearson correlation between uric acid with age, blood pressure, and body mass index

	Uric acid			
	Boys		Girls	
	r	p	r	p
Age	0.44	< 0.001	0.015	0.583
Systolic blood pressure	0.33	< 0.001	0.04	0.105
Diastolic blood pressure	0.26	< 0.001	0.05	0.04
Body mass index	0.30	< 0.001	0.17	< 0.001

color/ethnicity there was an association only between pasta with hyperuricemia in boys (model 2).

4 Discussion

The current study aimed to analyze the association between food consumption and hyperuricemia in children and adolescents. The main findings of the present study indicated that frequent consumption of pasta is associated with hyperuricemia only in boys. These associations were observed after adjustments for potential confounders, such as age, systolic blood pressure, BMI, and skin color/ethnicity. Red meat consumption was also associated with hyperuricemia only in the crude model. We highlight the relevance of these findings, since it is one of the first studies to indicate an association between food consumption with hyperuricemia in boys, emphasizing the need for a healthy diet early in life.

In our sample, boys (31.7%) had a higher prevalence of hyperuricemia than girls (19.9%). This finding is similar to a study conducted with adolescents in Thailand, in which the prevalence of hyperuricemia among boys was also higher than in girls [20]. On the other hand, a study conducted with Korean children and adolescents reported a smaller prevalence of hyperuricemia in females (10.5%), compared to males (8.4%) [15]. At this point, it worth mentioning the use of cut-off points to estimate the prevalence of hyperuricemia, for example, if we consider the cut-off suggested for children and adolescents [21], the prevalence was 18.3% in boys and 8.4% in girls. Once there is no clear definition of hyperuricemia in childhood we find it more suitable to work with tertiles. Also, in adults the threshold level of serum uric acid to contribute to the cardiovascular risk is not established, is suggested that the upper threshold to be considered is < 6.0 mg/dL [22].

In the present study boys which consumed more red meat had a higher odds ratio of hyperuricemia, although this association disappeared after controlling for systolic blood pressure, age, BMI, and skin color/ethnicity. Indeed, it has been reported that these variables exert an essential role in hyperuricemia in children and adolescents [14]. Moreover, even after adjustments for potential confounders, there was an association between pasta with hyperuricemia. The association between food consumption and hyperuricemia in children and adolescents have been poorly described. The available data are mainly concerning fructose consumption, which is associated with hyperuricemia in children and adolescents [12]. Also, Nguyen [11] indicates that sugar-sweetened beverage consumption, which represents a significant source of dietary fructose, is associated with higher serum uric acid levels in adolescents. However, in the current study, the sweet and biscuits consumption was not related to uric acid. The discrepancies between those findings might be related to the different methods used to determine food consumption.

These variables have been more addressed in adult populations. High meat consumption several times is associated with unhealthy eating habits being linked with a high intake of eggs, refined grains, beer, and candies [23]. Schmidt et al. [2] searched for differences in serum uric acid levels of meat eaters, fish eaters, vegetarians, and vegans in 1693 adults over 20 years old from Oxford (United Kingdom). Higher levels of uric acid were found in vegans and meat-eaters and lower levels in fish eaters and vegetarians. The differences between groups were more significant among men, corroborating our results since we found statistical differences only in boys, although this association was dependent on potential confounders. In this aspect, another study performed with 1,583 Chinese adults aiming to evaluate the association between hyperuricemia and food risk factors highlighted the high prevalence of hyperuricemia in this population, especially among men. No statistically significant association was found in women crossing hyperuricemia and food risk factors [24], corroborating with the present study. A possible explanation for this might be the effect of estrogen in uric acid excretion [25]. Also, it has been suggested that this gender-related difference would be associated with the genetic influence on uric acid metabolism, and indeed gene function is different for boys and girls [26]. In adults, some recent studies have been shown that hyperuricemia was more pronounced in women compared to men. The authors argue that this finding could be related to the fact that women were older and presented a greater burden of cardiovascular risk factors, also the uric acid concentration seems to increase after menopause [27, 28]. Indeed, there are many physiological and genetic issues ascribed to sex that may intervene in uric acid concentration, which deserves more attention, especially in the pediatric population.

The results concerning the adult population, highlight the importance of the establishment of healthy eating early in life, as one of the consequences of inadequate food consumption is associated with hyperuricemia, which in turn related to different health issues [15]. Indeed, studies performed with children and adolescents in several countries

Table 3 Association between food consumption and hyperuricemia in boys and girls

Eating habits	Hyperuricemia					
	All		Boys		Girls	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Model 1						
Red meat						
Frequent	1.42 (1.12 1.80)	0.003	1.56 (1.12 2.18)	0.008	1.28 (0.91 1.79)	0.147
Infrequent	1		1		1	
Fish						
Frequent	1.18 (0.89 1.56)	0.244	1.14 (0.79 1.65)	0.473	1.08 (0.69 1.68)	0.723
Infrequent	1		1		1	
Pasta						
Frequent	1.21 (0.98 1.49)	0.064	1.44 (1.08 1.91)	0.013	0.99 (0.73 1.36)	0.997
Infrequent	1		1		1	
Fried snacks						
Frequent	0.93 (0.77 1.13)	0.511	1.05 (0.78 1.32)	0.874	0.85 (0.65 1.12)	0.260
Infrequent	1		1		1	
Sweet and biscuits						
Frequent	0.90 (0.74 1.09)	0.289	0.93 (0.72 1.22)	0.632	0.85 (0.65 1.13)	0.299
Infrequent	1		1		1	
Rice with beans						
Frequent	0.85 (0.62 1.16)	0.315	0.87 (0.54 1.38)	0.558	0.77 (0.51 1.17)	0.230
Infrequent	1		1		1	
Model 2						
Red meat						
Frequent	1.22 (0.96 1.56)	0.099	1.28 (0.89 1.85)	0.178	1.21 (0.86 1.71)	0.259
Infrequent	1		1		1	
Fish						
Frequent	1.27 (0.95 1.70)	0.104	1.46 (0.96 2.21)	0.072	1.05 (0.67 1.65)	0.817
Infrequent	1		1		1	
Pasta						
Frequent	1.18 (0.96 1.47)	0.112	1.52 (1.11 2.10)	0.009	1.02 (0.74 1.40)	0.876
Infrequent	1		1		1	
Fried snacks						
Frequent	0.96 (0.79 1.17)	0.729	1.14 (0.85 1.52)	0.376	0.89 (0.67 1.17)	0.417
Infrequent	1		1		1	
Sweet and biscuits						
Frequent	0.95 (0.78 1.15)	0.632	1.04 (0.77 1.39)	0.790	0.95 (0.72 1.26)	0.745
Infrequent	1		1		1	
Rice with beans						
Frequent	0.90 (0.66 1.24)	0.554	0.84 (0.50 1.41)	0.524	0.80 (0.52 1.22)	0.310
Infrequent	1		1		1	

Logistic binary regression; Model 1: crude; Model 2: adjusted for systolic blood pressure, age, BMI, and skin color/ethnicity

CI confidence interval, *OR* odds ratio

showed a great diversity of eating habits around the world. Alves, Muniz e Vieira [26] described food consumption characteristics of 3083 children from all regions of Brazil. The authors observed high consumption of fried food, soft drinks, and artificial juice. However, González-Jiménez et al. [27] evaluated Spanish adolescents aiming to analyze the intake of macro and micronutrients, found different results according to age: adequate intake of protein, fats, carbohydrates, calico, and zinc, demonstrating ideal nutritional health, nutritionally equilibrated and with healthy eating habits.

In the present study, we have only found an association between pasta and hyperuricemia, after controlling for potential confounders. One explanation for this finding could be that the relationship between hyperuricemia and food intake is limited because people eat a combination of several kinds of foods and not only specific items [8]. Meat and fish have high purine content which is directly related to uric acid production in the human body, being responsible for its increase in serum; on the other hand, dairy-based foods may reduce uric acid levels, increasing its excretion [2]. Therefore, a balanced diet should be adopted to prevent high levels of uric acid.

The strength of this study is that it includes a large sample of children and adolescents, which allowed us to consider the role of important potential confounding factors, such as blood pressure, age, BMI, and skin color/ethnicity. Also, is one of the first studies to investigate the association between food consumption and hyperuricemia in children and adolescents, once most of the available data are regarding the adult population. Some limitations should also be mentioned. The cross-sectional design, which doesn't allow inferring a causal relationship between the independent variables and the outcome. Also, all subjects have completed a dietary questionnaire to assess their food consumption and this assessment may not truly reflect all dietary consumption, as well as we did not consider the amount of total calorie intake.

5 Conclusion

Frequent consumption of pasta is associated with hyperuricemia only in boys**,** after adjustments for age, systolic blood pressure, age, BMI, and skin color/ethnicity. The knowledge of food patterns which are predisposing factors for the increase in serum uric acid levels is important for the implementation of strategies and public health policies for health promotion among children and adolescents.

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Author contributions LNR and CPR conceptualized and designed the study. LNR, LB, CB, and CPR acquired the data, carried out the analyses, interpreted the data, and drafted the article. CB, SIRF, JDPR, ARG, and JBS critically reviewed the article. All authors read and approved the final manuscript.

Data availability The dataset analyzed during the current study is available from the corresponding author on a reasonable request.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of University Santa Cruz do Sul (July 10, 2014).

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