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Research report

Salt taste sensitivity thresholds in adolescents. Are there any relationships with body composition and blood pressure levels?

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ABSTRACT

The aim of this study was to identify the salt taste sensitivity thresholds and relationships with body composition and blood pressure levels in a cross-sectional study of adolescents. Blood pressure and body composition were measured with a digital device and by anthropometry, respectively. The salt taste sensitivity threshold was measured with 9 solutions with different sodium chloride concentrations to assess the sensitivity to saltiness. The solutions (4, 8, 15, 30, 60, 120, 250, 500 and 1000 mmol/L sodium chloride) were served in increasing concentrations until the taste was correctly identified. The taste sensitivity threshold was then classified as normal or high. In total, 421 adolescents (55.6% female), with an average age of 15.8 ± 0.91 years, were evaluated. The median threshold was 30 mmol/L, and 36.1% had a high threshold. The high blood pressure prevalence was 12.6%, and 25.5% of the subjects were overweight. When the mean systolic and diastolic blood pressure levels were compared between the normal and increased threshold groups after adjusting for gender, age, sedentary lifestyle and body mass index, only diastolic blood pressure showed a statistically significant effect ($P < 0.0001$) between the groups. The effect of a high threshold on body composition after adjusting for gender, age and physical inactivity was not significant ($P = 0.177$). There was no relationship between a high threshold and systolic pressure or body composition in the evaluated adolescents; therefore, only diastolic blood pressure was affected.

Introduction

Great advances are being made in the fields of neuroscience and taste perception, and an understanding of how these findings might influence eating behaviors. It could help to identify and understand some of the many factors that influence food intake (Rolls, 2007).

A preference for tastes associated with highly palatable ingredients such as sugar and fats might be an important indicator of the choice of a highly energy-dense diet (Salbe, DelParigi, Pratley, Drewnowski, & Tataranni, 2004). Considering that flavor is the most important factor that influences food choice (Glanz, Basil, Maibach, Goldberg, & Snyder, 1998), the sensitivities and basic taste preferences have been studied in obese and normal weight individuals (Simchen, Koebnick, Hoyer, Issanchou, & Zunft, 2006).

The detection thresholds of primary tastes (sweet, salty, bitter and acid) are determined by the oral use of different solutions (generally placed on the tongue), in which individuals initially taste the lowest concentration of the gustatory component, followed by more concentrated solutions until a distinct taste from water is reported (Mattes, 1984). The salt taste threshold is the lowest concentration at which the subject identifies the salty taste (Nilsson, 1979b).

Most of these studies have emphasized the relationship between the perception of sweet tastes and its relationship with body mass (Drewnowski, Brunzell, Sande, Iverius, & Greenwood, 1985). Many studies have also suggested links between bitter taste perception and body composition, although these data are still very conflicting (Simchen et al., 2006). Among bitter tastes, 6-n-propylthiouracil-(prop) is the most studied compound with regard to obesity. Little is known about salt taste perception and its relationship with nutritional status (Donaldson, Bennett, Baic, & Melichar, 2009). However, several authors have published studies between the salt taste perception (taste threshold) and blood pressure (Arguelles et al., 2007; Azinge, Sofola, & Silva, 2011; Málaga et al., 2003; Rabin, Poli de Figueiredo, Wagner, & Antonello, 2009; Spritzer, 1985).

The consumption of high-sodium foods is considered an independent risk factor for increased cardiovascular disease development and correlates positively with an increased prevalence of systemic arterial hypertension (Taylor, Ashton, Moxham, Hooper, & Ebrahim, 2011). Thus, an evaluation of salt taste sensitivity in obese individuals is another tool that can contribute to an

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understanding of complex eating behaviors, because food consumption is the primary source of salt intake, and salty can be sensed on the tongue (Rabin et al., 2009).

Owing to the well-established childhood obesity epidemic, the population prevalence of high blood pressure in the young is increasing. Hypertension in childhood is commonly associated with other cardiovascular risk factors as well as obesity (Falkner, 2010). Therefore, investigations of modifiable risk factors such as excess weight and blood pressure levels and their relationships with salt taste sensitivities are important because these factors could be targeted by educational and preventive actions. Therefore, the aim of this study was to evaluate the salt taste sensitivity threshold (STST) and to verify the relationships between this threshold and body composition and blood pressure in adolescents.

Materials and methods

This was a cross-sectional study of 421 healthy adolescents of both sexes, aged 14–19 years, from a public school in southern Brazil. A non-validated self-report questionnaire with questions regarding demographic and socioeconomic data, tobacco smoking and alcohol consumption was applied.

To assess body composition, anthropometric measurements were performed in duplicate, according to the World Health Organization protocols, and the mean values were used (WHO Expert Committee on Physical Status: the Use and Interpretation of Anthropometry, 1995, Geneva Switzerland), & World Health Organization, 1995). Adolescents' body compositions were characterized according to the body mass index (BMI), waist circumference (WC) and percentage of body fat (%BF). Adolescents were considered overweight if their BMI percentile was greater than or equal to 85 (Table 1). The WC was measured at the smallest abdominal circumference with an inelastic tape. The %BF was estimated with a bioelectrical impedance analyzer (Biodynamics® model 310; Biodynamics Corp., Shoreline, WA, USA), using equations previously programmed into the instrument by the manufacturer.

Blood pressure was measured while the subjects were at rest, using a calibrated digital device (Omrom 705CP-II; Omrom Healthcare Europe B.V., Hoofddorp, The Netherlands). Two consecutive readings, taken at 60-second intervals, were recorded, and the second reading was used for classification. Classifications corresponded to values for the 90th, 95th and 99th percentiles of blood pressure in adolescents according to age, sex and height percentiles (Table 1). Blood pressure values below the 90th percentile were considered normal, values between the 95th and 99th percentiles were considered borderline and values equal to or above the 99th percentile were considered increased ("Update on the, 1996, Task Force Report on High Blood Pressure in Children and Adolescents: a working group report from the National High Blood Pressure Education Program. National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents," 1996).

Table 1
Criteria for classification of the study variables.

Variable	Criterion	Classification
Body composition	BMI/age ≤ percentile 85	Eutrophia
	BMI/age > percentile 85	Overweight
Blood pressure	Percentile < 90	Normal
	Percentile > 95 and < 99	Borderline
	Percentile > 99	Increased
STST	Solutions 1, 2, 3 and 4	Normal
	Solutions > 4	High

Blood pressure (17, 18).
BMI, body mass index (16); STST, salt taste sensitivity threshold (14, 11).

The STST was defined as the ability of an individual to detect a salty taste. The method used to determine the STST was previously described by Nilsson (Nilsson, 1979b). Sodium chloride (NaCl) solutions were prepared with distilled water, and room temperature solutions were applied with a dropper to the tip of the tongue. The salt used to prepare the solutions was purchased from a supermarket.

The adolescent received the solutions (1, 4 mmol/L; 2, 8 mmol/L; 3, 15 mmol/L; 4, 30 mmol/L, 5, 60 mmol/L; 6, 120 mmol/L; 7, 250 mmol/L; 8, 500 mmol/L and 9, 1000 mmol NaCl/L) in progressive concentration intervals until the taste was correctly identified (occurrence of error or hit). For each concentration, 3 drops of the test solution were placed on the tongue (average drop, 0.33 mL), and the subjects waited for 10 seconds without breathing or closing their mouths. Next, if the volunteers indicated the correct concentration corresponding to the taste sensed, the solution was applied again. If the same concentration were identified a second time, the less concentrated solutions would be tested until an identification error occurred. The next higher concentration was considered the STST. Between the tests, the subjects rinsed their mouths with water. The subjects who identified the salty taste in solutions 1, 2, 3 and 4 (≤30 mmol/L) were considered to have a normal STST, and those who identified the salty taste in solutions 4–9 (>30 mmol/L) were considered to have an increased STST (Table 1), according to Nilsson (1979a, 1979b) and Spritzer (1985).

This research was approved by the Research Ethics Committee of the Franciscan University Center (Centro Universitário Franciscano), and all participants provided consent forms that had been signed and authorized by their guardians.

Quantitative data were summarized as the means and standard deviations, and categorical variables were assessed as frequencies and percentages. For the NaCl solution concentrations, the median and interquartile range (P25–P75) was used. Groups were compared with Student's *t*-test (continuous data) or the chi-square test (categorical data). Associations were assessed according to a linear regression model to control for the effects of potential confounding factors. The adopted significance level was 5%. Data were analyzed with SPSS (Statistical Package for the Social Sciences) software, version 18.0 (SSPS, Inc., Chicago, IL, USA). The classifications of the variables are described in the table below.

Results

Four hundred and twenty one adolescents with a mean age of 15.84 ± 0.91 years were evaluated; 55.6% of the subjects were female, 10.0% were obese, 62% had a normal blood pressure, 60.6% were physically inactive, 57.6% had consumed alcohol and a minority (5.5%) was smokers (Table 2).

Table 2
General characteristics of the evaluated adolescents ($n = 421$).

Variable	Value
Gender, *n* (%)	
Male	187 (44.4)
Female	234 (55.6)
Age (years)	
Mean ± standard deviation	15.84 ± 0.91
Physically inactive, *n* (%)	255 (60.6)
Smoker, *n* (%)	23 (5.5)
Have already consumed alcoholic beverages, *n* (%)	242 (57.5)
Body composition (BMI), *n* (%)	
Eutrophics	313 (74.5)
Overweight	107 (25.5)
Blood Pressure, *n* (%)	
Normal	261 (62.0)
Borderline	107 (25.4)
Increased	53 (12.6)

BMI, body mass index.