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Dietary energy density was associated with diet quality in Brazilian adults and older adults

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ABSTRACT

Cross-sectional and longitudinal studies present association of low dietary energy density with higher intake of vitamins, minerals and dietary fiber, lower intake of fat, and better balance of macronutrients. The objective of this study was to verify the relationship between dietary energy density and diet quality measured by an index of diet quality. This study used data from 496 adults and 445 older adults of cross-sectional population-based survey from São Paulo conducted in 2008–2009, Brazil. Dietary intake data was assessed by two 24-h dietary recalls. Dietary energy density values were calculated based on foods only method. Dietary energy density and revised Brazilian Health Eating Index and its components, were estimated by usual intake using *Multiple Source Method*. The relationship between dietary energy density and the total revised Brazilian Health Eating Index and its components were assessed by Gaussian family log-link model for each age group. The analyses showed an inverse association between dietary energy density and total revised Brazilian Health Eating Index in adults (T2:$\beta = 0.96$, $p < 0.001$; T2:$\beta = 0.86$, $p < 0.001$) and older adults (T2:$\beta = 0.96$, $p < 0.001$; T2:$\beta = 0.90$, $p < 0.001$), and an inverse association between dietary energy density and nine of twelve revised Brazilian Health Eating Index components in adult and/or older adults groups. Dietary energy density was associated with diet quality in Brazilian adults and older adults regardless of sex, per capita household income, body mass index, physical activity level, current smoking habits status, alcohol beverage drinking status and usual energy intake (kilocalories) from beverages.

1. Introduction

Dietary energy density (DED) is the amount of energy in food per unit weight (Rolls, 2010), often expressed as kilocalories per 100 g. A positive association between DED, energy intake, weight gain and excess body weight has been observed in adults and children (Aburto, Cantoral, Hernández-Barrera, Carriquiry, & Rivera, 2015; Ledikwe et al., 2006a, 2007; Mendoza, Drewnowski, & Christakis, 2007; Wang et al., 2008) by showing a positive association between DED and: excess body weight (Ledikwe et al., 2006a), metabolic syndrome (Mendoza et al., 2007), diabetes (Wang et al., 2008), body mass index (BMI) (Howarth, Murphy, Wilkens, Hankin, & Kolonel, 2006; Ledikwe et al., 2006a; Murakami, Sasaki, Takahashi, Uenishi, & Japan Dietetic Students' Study for Nutrition and Biomarkers Group, 2007) and waist circumference (Murakami et al., 2007). Accordingly, several health organizations recommend the intake of a low energy-dense diet, as an important strategy for weight management, preventing obesity and associated morbidities as part of a healthier diet (Food and Agriculture Organization, & World Health Organization [FAO/WHO], 2003; Muñoz-Pareja, Guallar-Castillón, Mesas, López-García, & Rodríguez-Artalejo, 2013; National Heart, Lung, and

Abbreviations: BMI, Body Mass Index; BHEI-R, Revised Brazilian Health Eating Index; CI, Confidencial Interval; CNPq, National Council for Scientific and Technological Development; DASH, Diettary Approaches to Stop Hypertension; DED, Dietary Energy Density; EI, Energy Intake; FAO/WHO, Food and Agriculture Organization/World Health Organization; FAPESP, São Paulo Research Foundation; GLM, Generalized Linear Models; HEI, Health Index Eating; HS-SP, Health Survey of São Paulo; NDSR, Nutrition Data System for Research; SE, standard error; SMS – SP, Health Department of the City of São Paulo; SoFAAS, Solid Fat, Alcohol and Added Sugar; USDA, United States Department of Agriculture; 24HR, 24-h dietary recall.

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Blood Institute, 1998; US Departament of Health and Human Services & US Departament of Agriculture, 2010).

To achieve a healthy diet, it is a universal consensus to include fruits and vegetables and avoid foods high in fat and sugar. It is the same approach to achieve a low energy-dense diet. Cross-sectional and longitudinal studies reported the association of low DED with multiple individual indicators of a more favorable eating patterns, e.g. eating patterns more in line with food-based dietary guidelines, including a higher intake of fruit and vegetables, higher intake of vitamins and minerals and dietary fiber, lower intake of fat, and a generally better balance of macronutrients (Ledikwe et al., 2006b; O'Connor, Walton, & Flynn, 2013; Schröder, Covas, Elosua, Mora, & Marrugat, 2008a; Schröder, Vila, Marrugat, & Covas, 2008b; O'Connor, Walton, & Flynn, 2015).

The nutritional quality of the diet can be evaluated by dietary indexes, which allow obtaining a summary measure and shows how one's diet is consistent or inconsistent with guidelines or recommendations for healthy diets (Ministério da Saúde, 2008; Previdelli et al., 2011). There are several scores to evaluate diet quality, such as the Health Index Eating (HEI) (based on Dietary Guidelines for Americans), Mediterranean Diet Score (based on Dietary guidelines for adults in Greece), Diettary Approaches to Stop Hypertension (DASH) score, and in Brazil, the Brazilian Health Eating Index (BHEI-R) (based on Dietary Guidelines for Brazilians and adapted from HEI-2005) (Fung et al., 2008; Guenther et al., 2013; Panagiotakos, Pitsavos, & Stefanadis, 2006; Previdelli et al., 2011). These indexes have some limitations, especially about applying the same index in different countries with different cultural context and nutritional recommendations, because each index is based on different guidelines of a target population and the same index should not be used for another population without a previous adaptation for their nutritional approaches. (Arvaniti & Panagiotakos, 2008; Previdelli et al., 2011; Waijers, Feskens, & Ocké, 2007). However, using DED as an indicator of diet quality less prone to socio cultural influences could overcome the difficulties in assessing and comparing diets in multiple contexts and different points on time (O'Connor et al., 2013). Based in this context, the hypothesis of this study is that a low energy-dense diet has inverse relationship with diet quality, measured by an index of diet quality.

2. Methods

2.1. Population and study design

This study used data from a cross-sectional population-based survey called "Health Survey of São Paulo (HS-SP, http://www.fsp.usp.br/isa-sp/)" conducted in 2008–2009. The study used a complex sampling design with a two-stage cluster based on National Household Sample Survey (2005) (Instituto Brasileiro de Geografia e Estatística, 2005): census tracts and households, considering the ratio of 0.5 for the estimated parameters, a design effect of 1.5, a confidence interval of 95%, a sampling error of 7%, a non-response rate of 20%, and a 5% chance of empty houses. This sample was representative of São Paulo metropolis and the elegibility of sample study includes: to be resident of São Paulo metropolis, had 13 years old or more (adolescents, adults and older adults) and to be sorted considering the sampling design. More details on sampling are available elsewhere (Fisberg & Marchioni, 2012).

From the total of adults and older adults (n = 1102) assessed in the HS-SP study, 42 individuals did not present self-reported weight or height information; 5 individuals did not inform their alcoholic beverage drinking, and 114 individuals under-reported or over-reported their diet energy intake. The under-reporting or over-reporting of dietary energy was identified using the methodology proposed by McCrory, Hajduk, and Roberts (2002), considering ±2 standard error deviation of the estimated energy requirement as the cutoff point (McCrory et al., 2002). These authors based their proposal on the equations developed by Vinken et al. (1999) that uses age, weight, height and sex to predict total energy requirements. The energy under-report and over-report cutoff points were 884.24 kcal and 4892.44 kcal for adults and 591.49 kcal and 4100.81 kcal for older adults. Therefore, 161 individuals (89 adults and 72 older adults) were excluded, and the final sample was 941 individuals: 496 adults (20–59 years old) and 445 older adults (60 years old or more) (Ministério da Saúde, 2011). The difference between food habits and physiologic changes that ageing process involves (Murray, Kroll, & Avena, 2015) were the priori rationale for stratifying by age and the posteriori rationale for maintain the stratify according the age was the significant difference of mean for DED values and their scores between adults and older adults.

Sociodemographic and lifestyle data (sex, age, per capita household income, current smoking habits, alcoholic beverage drinking) were obtained using a structured questionnaire interviewer-administered in the households. Self-reported weight and height measurements was obtaining on a second contact by telephone. The BMI was calculated as weight in kilograms divided by the square height in meter (kg/m^2).

Physical activity was assessed using the International Physical Activity Questionnaire, long version, validated in Brazil; and diet information was assessed by two interviewed based 24-h dietary recalls (24HR) (Craig et al., 2003; Matsudo et al., 2001).

2.2. Assessment of dietary intake

The participation rate of two 24-h recalls was 56%, and the first 24HR was interviewer-administered at households using Multiple Pass Method (Raper, Perloff, Ingwersen, Steinfeldt, & Anand, 2004) and the second 24HR was interviewer-administered by telephone using Automated Multiple Pass Method (Dwyer, Picciano, Raiten, Continuing Survery of Food Intakes by Individuals, & National Health and Nutrition Examination Survery 2003). The telephone calls were made to the participant home or their mobile phone. These methods are structured in five steps: 1) quick list, that participants list all the foods and beverages consumed uninterruptedly; 2) forgotten list, that participants are asked about commonly forgotten foods consumed, such as candies, coffees and sodas; 3) time and location of food and beverage intake; 4) detailing cycle, that the way of preparation and amounts consumed are described; and 5) final review, that verifies whether a certain food consumed during the day was not previously recorded (Dwyer et al., 2003; Raper et al., 2004). The 24HR were collected over one year covering all weekdays, weekends and seasons (Thompson & Byers, 1994) and the mean of elapsed time between food recalls was 4.37 months (SE = 0.27 months) for adults and 4.02 months (SE = 0.26 months) for older adults.

The reported household measures were converted into grams and milliliters according to Brazilian publications (Fisberg & Villar, 2002; Pinheiro, Lacerda, Benzecry, Gomes, & Costa, 2000). This dietary data was entered in Nutrition Data System for Research (NDSR software) and were converted into nutrients (Nutrition Data System for Research [NDSR], 2005). The NDSR database is based on the United States Department of Agriculture (USDA) food composition table, but the criteria to choose food and recipes of NDSR database for this study was the similarity in the composition of foods (80–120% of energy and macronutrients contents) with Brazilian databases (Fisberg & Villar, 2002; Pinheiro et al., 2000). The choice of software NDSR was carried out for two reasons: Brazilian programs are incomplete in their nutrients database,