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Added sugar intake that exceeds current recommendations is associated with nutrient dilution in older Australians

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ABSTRACT

Objectives: A nutrient dilution effect of diets high in added sugar has been reported in some older populations, but the evidence is inconsistent. The aim of this study was to investigate the association between added sugar intakes (according to recommended guidelines) and nutrient intake, food consumption, and body mass index (BMI).
Methods: A cross-sectional analysis of data collected between 2007 and 2009 from participants of the Blue Mountains Eye study 4 was performed ($n = 879$). Dietary intake was assessed using a semiquantitative food frequency questionnaire. Added sugar content of foods was determined by applying a systematic step-wise method. BMI was calculated from measured weight and height. Food and nutrient intakes and BMI were assessed according to categories of percentage energy from added sugar (EAS% < 5%, EAS% = 5%–10%, and EAS% >10%) using analysis of covariance for multivariate analysis.
Results: Micronutrient intake including retinol equivalents, vitamins B_6, B_{12}, C, E, and D, and minerals including calcium, iron, and magnesium showed a significant inverse association with EAS% intakes ($P_{trend} < 0.05$). In people with the lowest intake of added sugars (<5% energy) intake of alcohol, fruits, and vegetables were higher and intake of sugar sweetened beverages was lower compared to other participants (all $P_{trend} < 0.001$). BMI was similar between the three EAS% categories.
Conclusions: Energy intake from added sugar greater than the recommended level of 10% is associated with lower micronutrient intakes, indicating micronutrient dilution. Conversely, added sugar intakes <5% of energy intake are associated with higher micronutrient intakes. This information may inform dietary messages targeted at optimizing diet quality in older adults.

Introduction

Nutrient dilution is a phrase that describes displacement of nutrients due to poor quality of diet [1]. High intake of energy-dense, nutrient-poor foods can result in low intake of micronutrients that are essential for optimal body functioning across life stages. Compared to energy requirements, the requirements for many nutrients increase with advancing age because of chronic illnesses and intake of various medications [2], thus

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placing older adults at risk of malnutrition. Food choices that result in nutrient dilution are particularly problematic in older adults who may have an accompanying decreased appetite and reduced food intake [3].

There is some evidence that a diet high in added sugar (AS) contributes to nutrient dilution in vulnerable populations, including children and older adults [4–7]. In children and adolescents, a high AS intake has been associated with low intake of some micronutrients, including calcium and zinc [8–10]. In older age groups, however, findings are inconsistent. Micronutrient dilution has been shown to be associated with high levels of AS intake in older African women [11], but this was not evident in older British adults [2]. Additionally, high AS consumers have been noted to have low fruit and vegetable intakes, coupled with more energy-dense, nutrient-poor foods [6,9,12], but this trend has not been investigated in older populations.

Typically, AS includes sugars and syrups that have been added to foods during processing and preparation [13]. It is recommended that AS intake be limited to a maximum of 10% of daily energy intake and, for additional health benefits, this intake should be reduced to 5% [14,15], despite limited evidence for the latter recommendation [16]. No studies have assessed the impact on nutrient dilution in older adults according to these cut-off points, in particular, the 5% recommendation. Hence, we aimed to investigate whether there is an association between the recommended levels of AS consumption, food, and nutrient intakes in a sample of older Australians. Differences in body mass index (BMI) according to categories of recommended AS intake were investigated as a secondary objective.

Material and methods

Subjects

Data from participants of the Blue Mountains Eye Study (BMES) were used. Details of BMES have been described elsewhere [17]. BMES is a population-based cohort study of older Australians, aged 49 y and over at baseline, who lived in the Blue Mountains area in New South Wales, Australia. The BMES was conducted over four waves. The first wave of the BMES (BMES1) was conducted between 1992 and 1994, and data collection has occurred every 5 years (BMES 2–4). In BMES4 (2007–2009), 1149 participants (55.4% of survivors) attended eye examinations. For the purpose of the current analysis, cross-sectional data from participants of the BMES4 who had plausible data (n = 879) were used, reflecting the most recent dietary intake data from this ageing cohort.

BMES has ethics approval from the Sydney West Area Health Services and the University of Sydney Human Research Ethics Committees. Written informed consent was obtained from all participants.

Data collection

BMES4 participants' characteristics were collected using comprehensive questionnaires. Questions included demographic, quality of life, eye health, general health, and medication use. For the calculation of BMI as weight (kg) divided by height squared (m^2), measured weight from the BMES4 and measured height from the BMES3 were used. BMI <18.5 kg/m^2 and BMI ≥ 30 kg/m^2 were considered as underweight and obese, respectively [18].

Dietary data were collected using a 145-item semiquantitative food frequency questionnaire (FFQ). Validity and reproducibility of the BMES FFQ has been previously reported in this population [19]. Dietary data were analyzed for nutrient content using the NUTTAB2010 food composition database [20]. Since AS content of foods cannot be determined analytically for inclusion in the food composition database, a systematic stepwise method [21] was used to estimate the AS values of food items in the FFQ. This stepwise method includes identification of natural foods and 100% sugar products; use of recipes, analytical data and food labels; comparison of sweetened and unsweetened products; and borrowed data from foreign databases [21].

To exclude under- and overreporters, participants with implausible energy and nutrient intakes were excluded according to the BMES data cleaning protocol. For example, extreme energy intake was considered as <1800 kJ or >2500 kJ, and extreme AS intake was considered as mean $\pm$ 4 SD. After data cleaning, 971 participants had plausible dietary data, and of these 879 participants had complete data for BMI and confounding variables.

Food grouping in the BMES was based on the 1995 Australian National Nutrition Survey food grouping hierarchy [22] and details of this process have been discussed elsewhere [23]. Food groups included in this analysis were fruit (fresh, dried, and canned), vegetables including legumes, sugar sweetened beverages (sweetened juices, cordial, and soft drink), cereal products (breakfast cereals, bread, rice, and pasta), cereal-based products and dishes (biscuits, cakes, buns and scones, pastries, and mixed dishes), dairy product and dishes (milk, cheese, yoghurt, custard, ice-cream, cream, and dairy-based desserts), sugar products and dishes (discretionary sugar, honey, jam, and syrup), and confectionary (lollies and chocolate).

Statistical analyses

Statistical analyses were conducted using SPSS (version 21, SPSS: IBM, Armonk, NY, USA). Percentage of energy from AS (EAS%) was classified into three categories: category 1 (C1): $<5\%$; category 2 (C2): 5% to 10%, category 3 (C3): $>10\%$. Data were log transformed where they were not normally distributed. The association between EAS% intake and participants' characteristics were investigated using a chi-square test. Differences in food and nutrient intake and BMI between the three EAS% categories were assessed using analysis of variance (ANOVA) for unadjusted and analysis of covariance (ANCOVA) for adjusted data. For energy adjustment, food and micronutrient data were expressed as a function of energy (per 1000 kJ/d). In addition, these data were adjusted for age, sex, and BMI. Macronutrient data were reported based on percentages of total energy intake and adjusted for age, sex and BMI. The adjusted model for BMI included energy intake, age and sex as covariates. Regression was used to determine the association between EAS% intake and food, nutrients, and BMI. Statistical significance was set at $P < 0.05$.

Results

Participants' mean (standard error of the mean) intake of AS in C1, C2, and C3 were 16.81 (0.58), 40.13 (0.68), and 74.76 (1.59) g/d, respectively. Baseline characteristics of the BMES4 participants are summarized in Table 1. Participants in the highest EAS% category (C3) found to be older than participants in the other EAS % categories. There were fewer men and married participants in the lowest EAS% category (C1) compared to other categories. A higher proportion of participants with the lowest EAS% intake had diabetes and/or were classified as obese, compared to other EAS% categories. Despite a higher prevalence of underweight in the lowest EAS% category compared to the middle and highest categories, this association was not significant ($P = 0.35$). A lower proportion of participants rated their health as poor in the lowest EAS% category compared to other categories, although the association was not statistically significant.

Nutrient intake across categories of EAS% intake is shown in Table 2. Energy and carbohydrate (E%) intake increased significantly across categories of EAS% ($P_{trend} < 0.001$), whereas, protein (E%), alcohol (E%), LCn-3 PUFA, and fiber intake decreased significantly ($P_{trend} < 0.001$). For micronutrient intakes, retinol equivalents and vitamins B_6, C, and E decreased significantly across EAS% categories ($P_{trend} < 0.05$). Intakes of vitamin B_{12} and magnesium were quadratic across EAS% categories ($P_{trend} < 0.05$). After adjusting for relevant covariates, findings were in the same direction for the majority of nutrients. In the multivariate adjusted model, energy and iodine intakes were quadratic across EAS% categories.

Significant differences were observed in intakes of a range of macro and micronutrients among the three categories of EAS% intake. In the adjusted model, intakes of protein (E%), fiber, retinol equivalents, vitamin B_{12}, riboflavin, C, E, zinc, and magnesium were significantly lower in the participants of the highest intake category (C3) compared to the other two categories ($P < 0.05$). Participants in the lowest EAS% category (C1) had the lowest energy intake but also the highest alcohol (E%) intake compared to other categories.