Nutrition 49 (2018) 57–65

Contents lists available at ScienceDirect

Nutrition

journal homepage: www.nutritionjrnl.com

Applied nutritional investigation

Associations between nutritional quality of meals and snacks assessed by the Food Standards Agency nutrient profiling system and overall diet quality and adiposity measures in British children and adolescents

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ARTICLE INFO

Article history:
Received 28 July 2017
Received in revised form
19 September 2017
Accepted 5 October 2017

Keywords:
Meal
Snack
Diet quality
Obesity
Nutrient profiling system

ABSTRACT

Objective: This cross-sectional study examined how the nutritional quality of meals and snacks was associated with overall diet quality and adiposity measures.
Methods: Based on 7-d weighed dietary record data, all eating occasions were divided into meals or snacks based on time (meals: 06:00–09:00 h, 12:00–14:00 h, and 17:00–20:00 h; snacks: others) or contribution to energy intake (meals: ≥15%; snacks: <15%) in British children aged 4–10 (n = 808) and adolescents aged 11–18 (n = 809). The nutritional quality of meals and snacks was assessed as the arithmetical energy intake–weighted means of the Food Standards Agency (FSA) nutrient profiling system score of each food and beverage consumed, based on the contents of energy, saturated fatty acid, total sugar, sodium, fruits/vegetables/nuts, dietary fiber, and protein.
Results: Regardless of the definition of meals and snacks, higher FSA score (lower nutritional quality) of meals was inversely associated with overall diet quality assessed by the Mediterranean diet score in both children and adolescents ($P < 0.0001$), whereas the inverse associations for the FSA score of snacks did not reach statistical significance. The FSA score of meals based on time was inversely associated with body mass index *z*-score only in children, whereas that of snacks based on time showed a positive association.
Conclusion: Lower nutritional quality of meals, but not snacks, assessed by the FSA score was associated with lower overall diet quality, whereas no consistent associations were observed with regard to adiposity measures.

Introduction

It has been suggested that diet in childhood and adolescence has a lifelong effect on the development of many chronic diseases such as obesity [1] and cardiovascular disease [2]. Additionally, evidence suggests that dietary characteristics established during childhood and adolescence persist into adulthood, at least to some extent [3,4]. Thus, investigation into the dietary characteristics that contribute to healthier dietary intakes in children and adolescents is a high public health priority. When eating, people mainly choose to combine foods in meals or snacks as per specific compositions [5,6]; thus, there should be some patterns or characteristics in meals and snacks. Understanding how nutritional quality of meals and snacks is associated with overall diet quality and health status (such as adiposity measures) would be helpful in the development of science-based recommendations for meals and snacks for children and adolescents [7]. Although Dietary Reference Intakes (DRIs) and other dietary recommendations are given on a per-day basis, nutritional advice considering meals and snacks separately might also be easier and more practical for people to understand and follow dietary guidelines [7,8].

Nevertheless, virtually no research has been conducted on children and adolescents, mainly because there is no consensus about what constitutes a snack, a meal, or an eating occasion, not only in adults [7,9–22] but also in children [23–30]. Although some researchers have relied on respondents' self-identification of

This work was supported in part by Grants-in-Aid for Young Scientists (B) from the Ministry of Education, Culture, Sports, Science and Technology of Japan (grant 15 K16213). The Ministry of Education, Culture, Sports, Science and Technology of Japan had no role in the design, analysis or writing of this article.
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https://doi.org/10.1016/j.nut.2017.10.011
0899-9007/

meals, snacks, or eating occasions [7,9–14,23–25], others have attempted to use more objective criteria (based on clock time, energy content/contribution, or both) [7,13–23,26–30]. An accurate distinction between meals and snacks is important because they are hypothesized to have different effects on energy and nutrient intake [27,31,32]. An understanding of the influence of different meal and snack definitions on the associations of the nutritional quality of meals and snacks with overall diet quality and adiposity may help establish consensus on the most appropriate research definition for meals and snacks [7]. Additionally, the association of meal and snack intake or pattern with adiposity measures (as well as dietary intake) may be confounded by possible underreporting of eating frequency (i.e., meal and/or snack intake) concomitant with the underreporting of energy intake (EI) by obese or overweight individuals [33,34].

Another important issue is a lack of established tools for assessing nutritional quality of meals and snacks [8]. In this context, the British Food Standards Agency (FSA) nutrient profiling system [35–37] may be an attractive choice. It has been shown that the FSA score of overall diet is prospectively associated with certain health outcomes such as metabolic syndrome [37] and weight change [38]. One advantage of the FSA score is that it is calculated based on the contents of individual components (i.e., energy, saturated fatty acid [SFA], total sugar, sodium, fruits/vegetables/nuts, dietary fiber, and protein) per 100 g of foods and beverages consumed and also is weighted for EI. Thus, it can provide a proportional measure of meal and snack quality in relation to EI.

Therefore, the aim of the present cross-sectional study in British children and adolescents was to explore how the nutritional quality of meals and snacks assessed by the FSA nutrient profiling system is associated with overall diet quality and adiposity measures by using different definitions of meals and snacks.

Materials and methods

Survey design

The present cross-sectional study was based on data from the National Diet and Nutrition Survey (NDNS): Young People Aged 4 to 18 Years. Data from the NDNS were obtained from the UK Data Archive, University of Essex. Full details of the rationale, design, and methods of the survey have been described elsewhere [39,40]. Briefly, the sample was randomly selected from 132 postal sectors within mainland Great Britain. Eligibility was defined as being ages 4 to 18 y. One eligible person per private household was selected at random. Data collection was conducted during a 12-mo period (January to December 1997).

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human participants were approved by the National Health Service Local Research Ethics Committee covering each of the postal sectors. Verbal informed consent was obtained from all participants and their parents/guardians. Verbal consent was witnessed and formally recorded.

Anthropometric measurements

All anthropometric measurements were performed in duplicate by trained fieldworkers, and the mean value of two measurements was used in the analysis. Height (to the nearest 0.1 cm) and weight (to the nearest 0.1 kg) were measured while the child was barefoot and wearing light clothes only. Body mass index (BMI) (kg/m^2) was calculated as weight (kg) divided by height (m) squared and converted to age- and sex-specific *z*-score according to British growth-reference data [41]. For children aged ≥11 y, waist circumference was measured at the midpoint between the iliac crest and the lower rib (to the nearest 0.1 cm). Waist-to-height ratio (WHtR) was calculated as waist circumference divided by height.

Dietary assessment

Dietary data were collected from a 7-d weighed dietary record. A detailed description of the procedure has been published elsewhere [39,40]. Briefly, the participant, the parent, or both, depending on the age of the child, were asked to keep a weighed record of all food and drinks consumed by the child, both in and out of the home, over 7 d consecutively. They were supplied with a set of digital food scales and recording diaries and given both written and verbal instructions by trained interviewers on how to weigh and record items in the diary. When weighing was not possible (e.g., eating out), the participant was asked to record as much information as possible. Generally, children aged ≥10 y were able to complete the diary themselves, whereas for children aged <10 y the parent/guardian was expected to complete the diary. Trained interviewers visited the household at least twice during the recording period and checked the completeness of food recording. Trained dietitians checked the collected diaries for coding, recorded weights, and descriptions of items consumed. Estimates of daily intake for foods, energy, and selected nutrients were calculated based on the FSA nutrient databank [42], which is in turn based on McCance and Widdowson's composition of foods series [43] and manufactures' data where applicable. For all dietary variables, mean daily values over 7 d were used in the analysis. Values of food and nutrient intake were energy-adjusted using the density method (i.e., percent of energy for energy-providing nutrients and amount per 10 MJ of energy for foods and other nutrients).

Assessment of overall diet quality

As a measure of diet quality, the Mediterranean diet score (MDS) was calculated. The MDS represents a Mediterranean-type diet and is based on the consumption of eight different components (vegetables, legumes, fruits, cereals, fish, the ratio of unsaturated to saturated fats, meat, and dairy products) [44,45]. To modify the score for children and adolescents, the alcohol consumption component was removed from the score [27,46]. The MDS was selected not only because it is one of the most established measures of diet quality but also because it focuses largely on the intake of food groups (i.e., food choice) rather than the intake of nutrients. Several previous studies among British young populations have applied the MDS to measure overall diet quality [27,46]. For each component, participants with an intake (g/10 MJ) above or equal to the age group- and sex-specific median were assigned a score of 1 (a score of 0 to those below), except for meat and dairy products, for which the score was assigned in the reverse manner. Scores for all eight components were summed and resulted in a total range from 0 to 8, whereby a higher score reflected better adherence to a Mediterranean-type diet.

Calculation of FSA nutrient profiling system diet score

A detailed description of the procedure for calculating the FSA nutrient profiling system diet score has been published elsewhere [35–37]. Briefly, the FSA score was computed for each food and beverage on the basis of the nutrient content per 100 g. Positive points (0 to +10) were allocated for the content of energy (kJ), SFA (g), total sugar (g), and sodium (mg), whereas negative points (0 to –5) were allocated for the content of fruits/vegetables/nuts (g), dietary fiber (g), and protein (g). Scores for foods and beverages were thus based on a discrete continuous scale theoretically ranging from –15 (most healthy) to +40 (least healthy).

Aggregated scores at the individual level (FSA diet scores) were computed with the use of arithmetical EI-weighted means: for each food or beverage consumed, the FSA score of the food or beverage was multiplied by the EI provided by that food or beverage, and then these terms were summed for all foods and beverages consumed and divided by the sum of the EI provided by all foods and beverages for each individual. Thus, FSA scores of total diet, meals, and snacks were calculated as follows:

$$\text{FSA score of total diet} = \sum[(\text{FSA score of food}) \times (\text{EI from food})]/(\text{total EI})$$

$$\text{FSA score of meals} = \sum[(\text{FSA score of food consumed as meals}) \times (\text{EI from food consumed as meals})]/(\text{EI from meals})$$

$$\text{FSA score of snacks} = \sum[(\text{FSA score of food consumed as snacks}) \times (\text{EI from food consumed as snacks})]/(\text{EI from snacks})$$

Alcoholic beverages were excluded from the computation because they were not included in the FSA scoring system. Increasing FSA diet score therefore reflected decreasing quality in the foods consumed.

Definition of meals and snacks

In the present study, eating occasions were defined as any occasion when any food or drink was consumed [9,10,15,22,26–28]. If two eating occasions occurred in ≤15 min, the two events were counted as a single eating occasion; when >15 min separated two eating occasions, they were considered distinct eating occasions [15–17,22,27]. All eating occasions were further divided into either meals or snacks with the use of two different published definitions: on the basis of clock