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Assessing diets of 3 year old children: evaluation of a food frequency questionnaire

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Abstract

Objective—To evaluate the use of an administered 80-item food frequency questionnaire (FFQ) to assess nutrient intake and diet quality in 3 year old children.

Design—Frequency of consumption and portion size of the foods listed on the FFQ during the 3 months preceding the interview were reported by the child's main caregiver; after the interview a 2-day prospective food diary (FD) was completed on behalf of the child. Nutrient intakes from FFQ and FD were estimated using UK food composition data. Diet quality was assessed from the FFQ and FD, according to the child's scores for a principal component analysis-defined dietary pattern ('prudent' pattern), characterised by high consumption of fruit, vegetables, water and wholemeal cereals.

Subjects—892 children aged 3 years in the Southampton Women's Survey

Setting—Southampton, UK

Results—Intakes of all nutrients assessed by FFQ were higher than FD estimates, but there was reasonable agreement in terms of ranking of children (range for Spearman rank correlations for energy-adjusted nutrient intakes, r_s=0.41 to 0.59). Prudent diet scores estimated from the FFQ and FD were highly correlated (r=0.72). Some family and child characteristics appeared to influence the ability of the FFQ to rank children, most notably the number of child's meals eaten away from home.

Conclusion—The FFQ provides useful information to allow ranking of children at this age with respect to nutrient intake and quality of diet, but may overestimate absolute intakes. Dietary studies of young children need to consider family and child characteristics that may impact on reporting error associated with an FFQ.

Keywords

dietary assessment; young children; food frequency questionnaire

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Introduction

Accurate assessment of young children's diets is essential in order to examine relationships between early dietary experiences and later health outcomes. However, accurate assessment of the diets of young children is notoriously difficult. Firstly, young children do not have the cognitive ability to report their own dietary intake and therefore researchers generally rely on the information coming from the child's caregiver. This may prove problematic if responsibility for the study child is shared (for example if the child spends time in a nursery or with grandparents) and the caregiver providing the dietary information does not have knowledge of all foods consumed. Secondly, portion sizes are difficult to ascertain as the caregiver may report the amount of food that the child was given - not necessarily how much they actually consumed. Thirdly, young children's food habits change rapidly and making assessment of habitual diet difficult [1;2].

Food diaries (FD) have been regarded for many years as the 'gold standard' of dietary assessment[3]. Assessing dietary intake of young children using food records requires the caregiver to document detailed information on all food and drinks that the study child has consumed over a certain time period, usually a few days. Whilst food diaries are often considered the most accurate method, they are burdensome for the reporter which may bias study participation [4] and response rates may be low. Food frequency questionnaires (FFQ) have been widely used in large scale studies of adults and have been shown to be an effective tool for ranking individuals in terms of their nutrient intakes [5]. FFQs cover a longer time frame than short-term records (e.g. 24hour recalls or food diaries) and therefore may provide a better approximation of habitual diet [6]. However, they have been less commonly used to assess the diets of children. Previous studies evaluating the use of FFQs to assess the diets of children have raised concerns that FFQs overestimate intakes [2], although nutrient intakes assessed using an FFQ appear to show reasonable ranking when compared with 24hour recalls [7], food diaries [8] and some bio-markers[9]. Little is known about the determinants of reporting error when assessing the diets of young children. In their 2001 review of dietary assessment methods for preschool children, Serdula et al. pointed to the need for an evaluation of the maternal and child factors that may influence misreporting[2]. The challenges of dietary assessment for children of this age were also highlighted in a more recent review for the US National Children's Study[9], which concluded that there is a need for larger validation studies, conducted in more representative populations.

We have previously described the use of FFQs to assess the diets of infants at six and twelve months of age [10;11] in a large prospective study of mothers and children, the Southampton Women's Survey (SWS). In this paper we evaluate the use of a new FFQ developed to describe the diets of SWS children when they were aged three years. In a group of 892 SWS children we compare energy and nutrient intakes and a measure of dietary quality assessed by the FFQ with those determined using a prospective 2-day food diary. In addition, we consider some of the background factors that may affect the ability of the FFQ to rank children according to intakes of selected nutrients and diet quality, when compared to the food diary.

Methods

The Southampton Women's Survey (SWS)

The SWS is a large prospective cohort study of mothers and children that began in 1998. The study recruited 12,583 non-pregnant women aged 20-34 years. Detailed information about their diet and socio-demographic factors was collected upon enrolment and height and weight were measured [12] Children who were subsequently born to SWS women were

followed up at home by trained research nurses at the ages of 6 and 12 months, and at 2 and 3 years. There were 1981 singleton live births to women in the SWS up to the end of 2003. A total of 1640 (83%) of these children were followed-up at three years of age. A trained research nurse interviewed the child's main caregiver, usually the mother (99.5%), in the child's home, to collect information about the child's diet, eating behaviour, physical activity, sleep pattern and illnesses. The number of times per week over the past three months the child had consumed meals (excluding snacks) away from home was recorded. The child's nibbling behaviour was categorised as 'nibbles during the day, rarely eats meals'; 'nibbles during the day but also has meals'; 'nibbles on some days but also has meals'; 'doesn't nibble much, just has meals'. Caregivers were also asked if they had restricted the type or amount of food the child had consumed over this period. During the study visit the nurse measured the child's height (Leicester height measurer, Seca Ltd) and weight (calibrated digital scales, Seca Ltd). The study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the [removed for blinding purposes]. Written informed consent was obtained from all participants.

Food frequency questionnaire (FFQ)

Diet was assessed using an 80-item FFQ that was administered by trained research nurses [13]. The list of food and beverage items was compiled from a review of dietary intake data collected from a nationally representative sample of children aged 3 years[14], SWS infants [15] and SWS women[16] and 3-year olds in the Avon Longitudinal Study of Pregnancy and Childhood [17]. The FFQ asked how often in the last three months the child had consumed each of the food and beverage items. The response options were never, less than once per month, 1–3 times per month, number of times per week (1-7) or more than once a day. If a food was consumed more than once a day, the number of times was recorded. Prompt cards were used during the interview to show examples of the foods included in each food group and to help standardise the responses to the FFQ. Portion sizes were recorded for all foods. Portions were quantified using normal household measures e.g. tablespoons or typical portions e.g. slices of bread; visual aids were also used to standardise portions that could be subjective e.g. slice of pizza. At the end of the FFQ, additional information was collected relating to milk consumption and sugar added to food and/or drinks each day. This included information on the type and quantity of milk consumed and the number of teaspoons of sugar added to the child's food and drinks. Frequencies of consumption and amounts of foods not listed in the FFQ were also recorded if they were consumed once a week or more. Dose and frequency of dietary supplements taken in the preceding 3 months were recorded.

Food diary (FD)

At the end of the visit, caregivers were invited to complete a 2-day prospective food diary (FD) on behalf of the child. In an open diary, they were asked to record all food and drinks consumed by the child from midnight the day following the interview until midnight two days later; food and drinks were described by weight, size (measured dimensions using a ruler), number, or in terms of a household measure e.g. tablespoon. Detail of cooking method, brand-names, ingredients of meals and leftovers was also requested. If the child had taken any dietary supplements over the two day period these were recorded. The completed FDs were returned by post using a prepaid envelope. Upon receipt they were checked by a member of the research team for completeness; in the case of missing or illegible information the caregivers were phoned to obtain clarification. Eight hundred and ninety two (54%) participants returned a complete FD.

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Dietary analysis

To calculate nutrient intakes from the FFQ and FD the portion weights of foods were multiplied by their nutrient content. The food composition database was based on McCance & Widdowson 5th Edition [18] and all related supplementary volumes[19-27] together with recipes, and information obtained from manufacturers. The composition of dietary supplements was provided by manufacturers. Nutrient intakes from supplements were calculated according to dose and frequency taken over the period covered by the FFQ and the 2-day period of the FD, and converted to average daily intakes. Total daily energy and nutrient intakes (food plus dietary supplements) are reported throughout this paper.

Prudent diet score

We have previously described the dietary patterns of the 3 year SWS old children, that were defined using Principal Component Analysis (PCA) of the FFQ data[13] Before the PCA, the 80 foods listed on the 3-year FFQ were grouped into 44 groups based on similarity of type of food and nutrient composition. Milks (full fat and reduced fat) and sugar (added to food and drinks) were put into three extra groups to give a total of 47 groups. Most additional foods recorded at the end of the FFQ were assigned to one of these groups, but for the remaining foods, four further groups were created (baby foods, fruit purees, cream, and yorkshire pudding and savoury pancakes), giving a total of 51 groups to be entered into the PCA. The first component in the PCA (that explains the greatest variance in the dietary data), described a dietary pattern that was characterised by high consumption of fruit, water and wholemeal cereals but low consumption of refined cereals, low-calorie soft drinks, crisps and confectionery[13]. This pattern was termed a ‘prudent’ diet pattern as it represented a diet consistent with healthy eating recommendations and was similar to the prudent pattern that we have previously described in the SWS women [16]. Individual prudent diet scores were calculated by multiplying the coefficients for the food groups by the child’s standardised frequencies of consumption recorded on the FFQ, and summed.

All food and beverages recorded in the food diaries were assigned to one of the same 51 food groups used for the PCA of the FFQ data. In a separate PCA of the FD data, the first dietary pattern identified was very similar to the prudent pattern defined in the PCA of the FFQ, and described compliance with healthy eating guidance (data not shown). In order to compare prudent pattern scores defined using the FFQ and FD with reference to a single scale, FD-defined prudent diet scores were calculated using the coefficients from the PCA of the FFQ, and the standardised frequencies of food consumption recorded in the FD. Prudent diet scores calculated using both FFQ and FD data were transformed using Fisher–Yates normal scores. This has the effect of mapping the scores onto a normal distribution with a mean of 0 and a standard deviation of 1.

Statistical Analysis

The data reported in this paper are for 892 SWS children whose diets were assessed by FFQ and FD at 3 years. Body mass index (BMI) of mothers and children were calculated from height and weight measurements; maternal smoking status was defined when the child was aged 6 months. Statistical analysis was performed using Stata 11.1[28]. Spearman’s rank correlation coefficients were used to describe the association between the FFQ and FD estimates of nutrient intake. All nutrients were adjusted for energy intake using the Willett method[29], and correlation coefficients were recalculated. This method to ‘energy-adjust’ nutrients involves computing nutrient intakes as the residuals from a regression model where total caloric intake and absolute nutrient intake are the independent and dependent variable respectively. Thus the nutrient residuals provide a measure of intake which is uncorrelated with total energy intake. Percentage over- or under-assessment of the nutrient intakes by FFQ compared with FD were obtained. A Bland-Altman plot was produced to assess the

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level of agreement in prudent diet scores between the two methods. As the nutrients were not normally distributed log transformations were used prior to the Bland-Altman analysis. The Bland-Altman limits of agreement are expressed as symmetric percentages, which summarise the percentage differences between the FFQ and food diary [30]. A Pearson correlation was used to compare FFQ and FD prudent diet scores. Variations in ranking from FFQ assessments compared to FD by levels of maternal and children characteristics were examined by incorporating an interaction term into a separate linear regression model for each characteristic and nutrient.

Results

Characteristics of the children and their mothers who completed the both the FFQ and FD are detailed in Table 1. Mothers had a range of educational attainment; 36% left formal education at 16 years of age with General Certificate of Secondary Education (GCSE) level qualifications or below whilst 26% reported having a University degree. In total 13% of the children were overweight or obese, according to the International Obesity Task Force (IOTF) cut-off[31]. Around half of the children (48%) were described as regularly 'nibbling' food during the day, although most commonly this was in addition to eating meals. The majority of children (68%) had regularly eaten away from home over the 3-month period assessed by the FFQ. Nearly half of the mothers reported that they restricted the types of foods that their child consumed but only 24% reported restricting the amount of food consumed. 25% children had taken dietary supplements during the 3-month period preceding the interview, but the proportion taking supplements during the 2-day period of the FD was lower (16%). When compared to the SWS families who did not return a FD, some differences in background characteristics were observed. Mothers who did not return a FD tended to be educated to a lower level (48% educated to GCSE level or below, compared with 36%, $p<0.001$), and there was a small difference observed in maternal BMI (median BMI of mothers who did not return FD 24.7 (IQR 22.3, 28.5), compared with 24.2 (IQR 22.0, 27.0), $p<0.001$). There was also a small difference in BMI of children according to whether a completed FD was returned or not with 17% of children whose mothers did not return a FD being overweight or obese versus 12% of children of mothers who did (data not shown).

Comparison of FFQ with FD

Table 2 shows the FFQ and FD estimates of energy and nutrient intakes. In each case the FFQ estimates were higher than the FD. However, the difference between the two assessment methods varied. Differences in macronutrient intakes tended to be smaller than differences in micronutrient intakes ranging from 13% (saturated fat) to 31% (total sugar) compared with differences ranging from 23% (calcium) to 52% (vitamin C) for micronutrients. In terms of ranking children with respect to their energy and nutrient intakes, the Spearman's correlation coefficients comparing the FFQ and FD indicated moderate agreement, ranging from $r_s = 0.33$ (energy) to 0.54 (calcium and retinol). With the exception of retinol intakes, higher correlations were found for energy-adjusted intakes (range $r_a =$ 0.41 thiamin to 0.59 calcium).

When considering the children's dietary patterns we found that, in comparison with energy and nutrient intakes, prudent diet scores assessed by FFQ and FD were more highly correlated ($r = 0.72$) indicating comparable ranking of children in terms of their compliance with the prudent diet pattern. To examine agreement between prudent diet scores assessed by the two dietary methods, they were compared using a Bland-Altman plot (Figure 1). The prudent diet scores from the FFQ were defined in a PCA of the full cohort (n=1640), in which the mean score was zero because the scores were standardised[13]. For the children

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who provided FD data (n=892) in the present analysis, their prudent diet scores from the FFQ were slightly higher than the average for the full cohort, whereas the standardised scores for the FD had a mean of zero. This difference is evident on the Bland-Altman plot. Overall there was good agreement between methods; 95% of the differences lie within +1.6 and −1.4 standard deviations.

Comparison of ranking of children from FFQ and FD assessments of intake and diet quality, according to mother and child characteristics and eating behaviours

Additional analyses explored how ranking of children from the FFQ and FD assessments was influenced by mother's level of education, child's BMI, number of meals the child had eaten away from home, nibbling behaviour and restriction of types of foods in the child's diet. Table 3 shows correlation coefficients for intakes of selected nutrients and prudent diet scores assessed by the two methods, split according to the characteristics of interest. Nibbling behaviour was considered in 2 groups as the numbers of children who rarely had meals, or who only had meals, was relatively small.

There were no differences observed according to the BMI status of the child. However, some differences were found for other characteristics; significant interactions are shown in the table in bold. Higher correlations, indicating more comparable ranking of children with respect to energy intakes, were found for children born to mothers with lower levels of educational attainment ($p=0.01$). Single differences were also observed according to nibbling behaviour (vitamin D) and restriction of foods (calcium). However, the most consistent differences appeared to be in relation to number of meals the child ate away from home during the 3-month period assessed by the FFQ. Poorer consistency of ranking of children was found among those who regularly ate away from home in terms of calcium intake and prudent diet score ($p<0.001$ and $p=0.01$ respectively); a comparable pattern was also seen for energy, fat and vitamin D intakes although these interactions were not statistically significant. As the poorer ranking of children according to energy intake observed among more highly educated mothers was unexpected, further analyses explored the association between educational attainment and number of meals eaten by the child away from home. These showed that level of maternal education and frequency of meals eaten away from home were linked, such that higher educational attainment was associated with greater frequency of meals consumed away from home. For example, 29% of children whose mothers had a high level of educational attainment consumed more than 4 meals per week away from home as compared to only 18% of children whose mothers were more poorly educated ($p<0.001$).

Discussion

In a large population sample of children aged 3 years we have evaluated the use of a new FFQ to assess diet by comparison with a prospective 2-day food diary (FD). We found that the FFQ appears to provide useful information to enable ranking of children in terms of their nutrient intake and quality of their diets, but in comparison with the FD, estimates of absolute intake were higher. In examining the impact of maternal and child characteristics on reporting error, we found that these characteristics may be of importance when assessing the diets of young children using an FFQ, most notably the number of meals eaten by the child away from home.

Absolute intakes assessed by the FFQ

Intakes assessed by the FFQ were consistently higher than those assessed by FD. The largest differences were observed for micronutrient intake; differences ranged from 23-52% compared to 13-31% for macronutrients. Whilst some of the differences in micronutrient

intake may be due to having more accurate composition data for individual foods recorded in the FD, the mean difference in energy intake (17%) is of concern and suggests either over-reporting of the child's intake in response to the administered FFQ and/or incomplete recording in the FD. Higher intakes assessed by FFQ is consistent with our earlier findings using an FFQ to assess the diets of the SWS children when they were aged 12 months (mean difference 19%[10]), and with other published validation studies of FFQs designed to assess the diets of pre-school children[2;9]. For example, Stein and colleagues[32] found that an FFQ used to assess the diets of 224 children aged 3.5-5 years (administered at two time points) overestimated absolute intakes of energy and all nutrients except sodium when compared to mean intakes from four 24-hour recalls (intake estimates were 1.4 – 1.9 times higher). Similarly Parrish *et al*[7] observed consistent overestimation of nutrient intakes assessed by an FFQ in 68 pre-school children when compared to those assessed by three 24-hour recalls (70% overestimation of energy intake). These differences in absolute intakes may be explained by difficulties encountered by caregivers in describing portion size and/or frequency of foods consumed by the child – a concern that has been highlighted in a review of dietary assessment methods in preschool children[2]. In the present study it is unlikely that the differences between the FFQ and FD can be explained by underreporting of intake during the FD, as the estimate of energy intake (kJ/kg bodyweight) was in the expected range, and slightly higher than published energy requirements for children of this age (334 and 320kJ/kg for boys and girls aged 3-3.9 years respectively[33]).

Ranking of children by the FFQ

In contrast to differences in estimates of absolute intake, the ranking of children in terms of nutrient intake appeared to be reasonably comparable using the FFQ and FD. When we compared the present data with the correlations for the FFQ we used to assess the diet of SWS infants at 12 months of age [10] we found the range of coefficients at 3 years was slightly narrower (range for energy-adjusted nutrient intakes 0.41-0.59 at 3 years (Table 2), compared with 0.31-0.71 for the same nutrients assessed at 12 months)[10]. Our data are consistent with other published validation studies of FFQs used to assess the diets of young children. Andersen[34] and colleagues carried out a study to validate an FFQ against a 7-day weighed food diary in 187 2-year-old children in Norway and observed correlation coefficients ranging from 0.26-0.5. In comparison, Stein *et al*[32] validated an FFQ against multiple 24-hour recalls in 4-5 year old children in America and similarly found the FFQ to rank the children reasonably well with correlations ranging from 0.16-0.60.

In comparison with the FFQ ranking of children in terms of their energy and nutrient intakes, prudent pattern scores were highly correlated with scores defined from the FD (correlation coefficient 0.72), indicating very comparable assessment of quality of the children's diets by the two dietary methods. Whilst, to our knowledge, dietary pattern scores of preschool children assessed by different dietary methods have not been evaluated before, this finding is in line with other published data from our group. At 6 months, the correlation for SWS infants' scores for the first PCA component ('infant guidelines' pattern) assessed by FFQ and 24-hour recall was 0.81 [15], whilst among a group of pregnant women the correlation for prudent diet scores assessed by FFQ and a 4-day food diary was 0.67[35]. Our findings are also consistent with other adult studies [36;37] in which FFQs have been shown to identify similar patterns of diet as other dietary methods, and that dietary pattern scores determined using different dietary methods are highly correlated. Whilst there are concerns about the measurement error associated with estimates of nutrient intakes assessed using FFQs[9], they may be particularly well-suited to the description of broader dietary patterns.

Influences on reporting diet using the FFQ

We considered a number of maternal and child factors that could affect the accuracy of describing diet in response to our administered FFQ when the children were aged 3 years[9]. We observed some small differences according to the child's eating behaviour for individual nutrients (nibbling frequency, restriction of types of foods), but there were no differences according to the weight status of the child. The most consistent pattern of association appeared to be in relation to number of meals eaten away from home during the 3-month period covered by the FFQ. Unsurprisingly, higher correlations were observed among children who ate at home (calcium intakes, prudent diet scores); this pattern was also evident for the other nutrients considered, although the interactions were not statistically significant. Our findings differ from the study by Parrish *et al* [7], in which estimated nutrient intakes assessed by FFQ and three 24-hour recalls were compared in 68 preschool-age children. In this study the authors assessed the differences in agreement between the assessment methods in children whose mothers were the sole provider of meals over the reference time period compared with those who were not. The authors did not find differences, and suggested that mothers who were not the sole provider of their children's meals were able to report as accurately as those who were. It is not clear whether these differing findings are explained by the different sizes of the groups studied or the setting in which the research was undertaken, and further work is needed. However, it would seem likely that proxy reporting of dietary intake might be expected to be poorer for children who routinely consume meals away from home[38] - an effect that may be more marked among children at older ages. Our findings suggest that establishing the balance of food consumed in the home/outside the home could be useful data to collect in future dietary studies of young children

An unexpected finding in this study was that there were higher correlations between the FFQ and FD estimates of energy intake in the children whose mothers had lower levels of educational attainment. The link between educational attainment and misreporting of children's diets is not clear. It has been hypothesised that educational attainment might affect a person's cognitive skill and therefore ability to recall and estimate portion size[39]. However, the few studies that have considered reporting error in relation to educational attainment of parents have returned inconsistent results. Andersen and colleagues found no significant differences by educational level when comparing absolute intakes of their FFQ with a seven-day food diary. However, Vereecken *et al*[39] found that mothers with low educational attainment significantly underestimated their child's percent energy from fat in their FFQ compared with use of an online dietary assessment tool. This lack of consistency could be explained by variations in maternal work patterns and associated childcare arrangements that differ according to level of educational attainment. Our findings would be consistent with this suggestion, as when compared with other children, the children whose mothers were highly educated consumed their meals away from home more frequently, – which in turn was associated with lower correlations between FFQ and FD estimates of energy intake.

Strengths and weaknesses

Strengths of the study are that the FFQ was administered by trained research nurses, and the size of the population studied. Our study was considerably larger than traditional validation studies in similar populations, and addresses the recommendation from the US National Children's Study review that validation studies of dietary assessment methods in preschool age children need to include larger more representative populations [9]. A limitation is that we did not have FDs returned by all SWS children who were followed up at 3 years, although the 892 children studied are from a wide range of backgrounds, and represented many characteristics that are comparable with the wider UK population [12]. We would therefore hope that our findings should be applicable across the whole cohort. A further

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limitation may arise from our use of a 2-day food diary as the reference method, that varied in terms of the combinations of weekdays and weekend days included. Whilst estimates of energy intake by the FD were consistent with expected values, and widespread underreporting in the FD seems unlikely, its short duration may be an important limitation in terms of its ability to capture the habitual diet of the children. This may be better described by the FFQ and it is possible therefore that in using a short FD we have underestimated the true level of agreement between these two dietary assessment methods.

Conclusion

In a large population of young children we have evaluated the use of a new FFQ. Whilst there may be particular challenges in using FFQs to assess absolute nutrient intake at this age, we have shown that an FFQ can be used to provide sufficient information to rank the children effectively according to nutrient intake. FFQs may be particularly well suited to the assessment of dietary patterns – and in our study, in the description of children's quality of diet and their compliance with healthy eating guidance.

Reference List

(1). Stein AD, Shea S, Basch CE, Contento IR, Zybert P. Variability and tracking of nutrient intakes of preschool children based on multiple administrations of the 24-hour dietary recall. Am J Epidemiol. Dec 15; 1991 134(12):1427–37. [PubMed: 1776617]

(2). Serdula MK, Alexander MP, Scanlon KS, Bowman BA. What are preschool children eating? A review of dietary assessment. Annu Rev Nutr. 2001; 21:475–98. [PubMed: 11375446]

(3). Gibney, M.; Margetts, B.; Kearney, J.; Arab, L. Public Health Nutrition. Blackwell Publishing; Oxford: 2004.

(4). Rockett HR, Colditz GA. Assessing diets of children and adolescents. Am J Clin Nutr. Apr; 1997 65(4 Suppl):1116S–22S. [PubMed: 9094907]

(5). Cade J, Thompson R, Burley V, Warm D. Development, validation and utilisation of food-frequency questionnaires - a review. Public Health Nutr. Aug; 2002 5(4):567–87. [PubMed: 12186666]

(6). Margetts BM, Cade JE, Osmond C. Comparison of a food frequency questionnaire with a diet record. Int J Epidemiol. Dec; 1989 18(4):868–73. [PubMed: 2621023]

(7). Parrish LA, Marshall JA, Krebs NF, Rewers M, Norris JM. Validation of a food frequency questionnaire in preschool children. Epidemiology. Mar; 2003 14(2):213–7. [PubMed: 12606888]

(8). Ortiz-Andrellucchi A, Henriquez-Sanchez P, Sanchez-Villegas A, Pena-Quintana L, Mendez M, Serra-Majem L. Dietary assessment methods for micronutrient intake in infants, children and adolescents: a systematic review. Br J Nutr. Dec; 2009 102(Suppl 1):S87–117. [PubMed: 20100370]

(9). National Cancer Institute. Dietary Assessment Literature Review. 2011. http://riskfactorcancergov/tools/children/review/agegroups/preschool/validationhtmlcited 2011 Nov

(10). Marriott LD, Inskip HM, Borland SE, Godfrey KM, Law CM, Robinson SM. What do babies eat? Evaluation of a food frequency questionnaire to assess the diets of infants aged 12 months. Public Health Nutr. Jul; 2009 12(7):967–72. [PubMed: 18702837]

(11). Marriott LD, Robinson SM, Poole J, Borland SE, Godfrey KM, Law CM, et al. What do babies eat? Evaluation of a food frequency questionnaire to assess the diets of infants aged 6 months. Public Health Nutr. Jul; 2008 11(7):751–6. [PubMed: 18005490]

(12). Inskip HM, Godfrey KM, Robinson SM, Law CM, Barker DJ, Cooper C. Cohort profile: The Southampton Women's Survey. Int J Epidemiol. Feb; 2006 35(1):42–8. [PubMed: 16195252]

(13). Fisk CM, Crozier SR, Inskip HM, Godfrey KM, Cooper C, Robinson SM. Influences on the quality of young children's diets: the importance of maternal food choices. Br J Nutr. Jan; 2011 105(2):287–96. [PubMed: 20807465]

(14). Gregory, J.; Collins, D.; Davies, PSW., et al. National Diet and Nutrition Survey children aged 1 1/2 to 4 1/2 years. Vol. 1: Report of the Diet and Nutrition Survey. HMSO; London: 2009.

(15). Robinson S, Marriott L, Poole J, Crozier S, Borland S, Lawrence W, et al. Dietary patterns in infancy: the importance of maternal and family influences on feeding practice. Br J Nutr. Nov; 2007 98(5):1029–37. [PubMed: 17532867]

(16). Robinson SM, Crozier SR, Borland SE, Hammond J, Barker DJ, Inskip HM. Impact of educational attainment on the quality of young women's diets. Eur J Clin Nutr. Aug; 2004 58(8): 1174–80. [PubMed: 15054431]

(17). North K, Emmett P, The Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) Study Team. Multivariate analysis of diet among three-year-old children and associations with socio-demographic characteristics. Eur J Clin Nutr. Jan; 2000 54(1):73–80. [PubMed: 10696149]

(18). Holland, B.; Welch, AA.; Unwin, ID.; Buss, D.; Paul, AA.; Southgate, D. The Composition of Foods. 5th ed.. The Royal Society of Cambridge; Cambridge: 1991.

(19). Chan, W.; Brown, J.; Church, SM.; Buss, D. Supplement to McCance and Widdowson's The Composition of Foods. Royal Society of Chemistry adn Ministry of Agriculture, Fisheries and Food; UK: 1996. Meat Products and Dishes.

(20). Chan, W.; Brown, J.; Buss, D. Supplement to McCance and Widdowson's The Composition of Foods. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food; UK: 1994. Miscellaneous Foods.

(21). Chan, W.; Brown, J.; Lee, SM.; Buss, D. Supplement to McCance and Widdowson's The Composition of Foods. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food; UK: 1995. Meat Poultry and Game.

(22). Holland, B.; Brown, J.; Buss, D. Third supplement to McCance and Widdowson's The Composition of Foods. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food; UK: 1993. Fish and fish products.

(23). Holland, B.; Unwin, ID.; Buss, D. Third Supplement to McCance and Widdowson's The Composition of Foods. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food; UK: 1988. Cereals and Cereal Products.

(24). Holland, B.; Unwin, ID.; Buss, D. Fourth Supplement to McCance and Widdowsons The Composition of Foods. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food; UK: 1989. Milk and Milk Products.

(25). Holland, B.; Unwin, ID.; Buss, D. Fifth Supplement to McCance and Widdowson's The Composition of Foods. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food; UK: 1991. Vegetables, Herbs and Spices.

(26). Holland, B.; Unwin, ID.; Buss, D. First Supplement to McCance and Widdowson's The Composition of Foods. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food; UK: 1992. Fruit and Nuts.

(27). Holland, B.; Welch, AA.; Buss, D. Second Supplement to McCance and Widdowson's The Composition of Foods. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food; UK: 1992. Vegetable Dishes.

(28). Stata Statistical Software: Release 10. College Station, TX: 2007. [computer program]. Version 11

(29). Willett, W. Nutritional Epidemiology. 2nd ed.. Oxford University Press; Oxford: 1998.

(30). Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet. Feb 8; 1986 1(8476):307–10. [PubMed: 2868172]

(31). Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ. May 6; 2000 320(7244):1240–3. [PubMed: 10797032]

(32). Stein AD, Shea S, Basch CE, Contento IR, Zybert P. Consistency of the Willett semiquantitative food frequency questionnaire and 24-hour dietary recalls in estimating nutrient intakes of preschool children. Am J Epidemiol. Mar 15; 1992 135(6):667–77. [PubMed: 1580243]

(33). Torun B. Energy requirements of children and adolescents. Public Health Nutr. Oct; 2005 8(7A): 968–93. [PubMed: 16277815]

(34). Andersen LF, Lande B, Trygg K, Hay G. Validation of a semi-quantitative food-frequency questionnaire used among 2-year-old Norwegian children. Public Health Nutr. Sep; 2004 7(6): 757–64. [PubMed: 15369614]

(35). Crozier SR, Inskip HM, Godfrey KM, Robinson SM. Dietary patterns in pregnant women: a comparison of food-frequency questionnaires and 4 d prospective diaries. Br J Nutr. Apr; 2008 99(4):869–75. [PubMed: 18005481]

(36). Khani BR, Ye W, Terry P, Wolk A. Reproducibility and Validity of Major Dietary Patterns among Swedish Women Assessed with a Food-Frequency Questionnaire. The Journal of Nutrition. Jun 1; 2004 134(6):1541–5. [PubMed: 15173426]

(37). Hu FB, Rimm E, Smith-Warner SA, Feskanich D, Stampfer MJ, Ascherio A, et al. Reproducibility and validity of dietary patterns assessed with a food-frequency questionnaire. Am J Clin Nutr. Feb; 1999 69(2):243–9. [PubMed: 9989687]

(38). Baranowski T, Sprague D, Baranowski JH, Harrison JA. Accuracy of maternal dietary recall for preschool children. J Am Diet Assoc. Jun; 1991 91(6):669–74. [PubMed: 2040780]

(39). Vereecken C, Covents M, Maes L. Comparison of a food frequency questionnaire with an online dietary assessment tool for assessing preschool children's dietary intake. J Hum Nutr Diet. Oct; 2010 23(5):502–10. [PubMed: 20163509]

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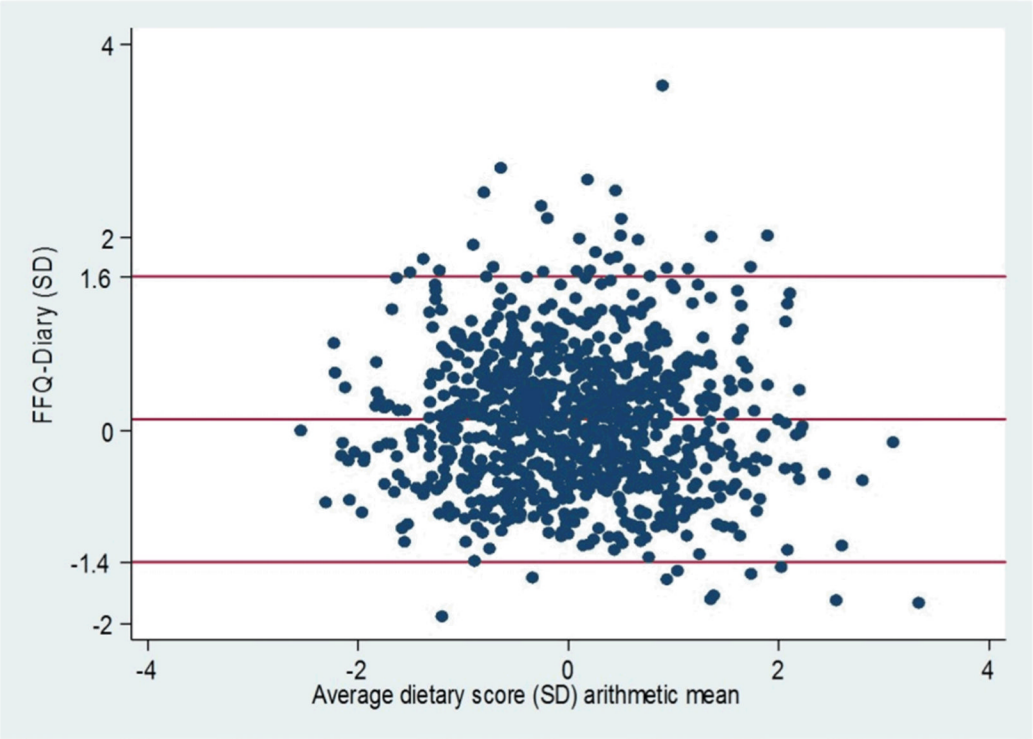

Figure 1. Bland-Altman plot for agreement between children's prudent diet scores assessed by FFQ and food diary

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Table 1

Characteristics of 892 mother-child pairs studied

Mother	
Age (years) when child was 3 years old (median (IQR))	33.6 (30.9-36.5)
Educational attainment (n(%))[†]	
None	12 (1.3)
GCSE grade D or lower	81 (9.1)
GCSE grade C or above	228 (25.6)
A-Level or equivalent	257 (28.8)
HND or equivalent	77 (8.6)
Degree	235 (26.4)
Smoker[*] (n(%))	125 (14.1)
BMI at initial interview (median (IQR))	24.2 (22.0-27.0)
Child	
Weight status (n(%))[‡]	
Normal weight	758 (87.0)
Overweight	102 (11.7)
Obese	11 (1.3)
Sex	(n(%))
Male	477 (53.5)
Eating Behaviour (n(%))	
Nibbles during the day, rarely eats meals	32 (3.6)
Nibbles during the day, also has meals	393 (44.2)
Nibbles on some days, also has meals	317 (35.6)
Does not nibble much, just has meals	148 (16.6)
Number of meals (per week) eaten away from home in the past 3 months (n(%))	
0	286 (32.1)
1-3	381 (42.7)
4+	225 (25.2)
Has types of food consumed restricted (n(%))	422 (47.3)
Has amounts of food consumed restricted (n(%))	218 (24.4)
Took dietary supplements during the 3 month period of FFQ (n (%))	223 (25)
Took dietary supplements during the 2-day FD (n (%))	144 (16.1)

IQR, interquartile range

[*] Data collected when child was 6 months old

[†] GCSE, general certificate of secondary education; HND, higher national diploma

[‡] IOTF cut offs

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Table 2

Energy and nutrient intakes at 3 years assessed by FFQ and food diary

	FFQ		Food Diar					
	Median	**IQR**	**Median**	**IQR**	r_s *	r_a *	**Mean difference FFQ minus food diary (%)**	**Limits of agreement (%)**
Energy (kJ)	6318	5511, 7412	5410	4632, 6205	0.33	N/A	17	−34, 69
Energy (kJ) per kg body weight	424	366, 501	363	311, 417	0.38	N/A	17	−69, 34
Protein (g)	53	45, 63	46	37, 54	0.42	0.51	20	−17, 57
Total fat (g)	56	48, 68	52	42, 62	0.42	0.47	15	−19, 50
Saturated fat (g)	25	20, 30	23	18, 29	0.52	0.56	13	−34, 60
Carbohydrate (g)	204	173, 241	167	143, 193	0.37	0.51	25	−1, 51
Total sugar (g)	115	93, 142	91	73, 109	0.43	0.52	31	−16, 77
Ca (mg)	972	768, 1194	817	626, 1060	0.54	0.59	23	−39, 85
Fe (mg)	8.1	6.7, 10.1	6.5	5.1, 8.0	0.47	0.57	28	−22, 77
Zn (mg)	6.3	5.3, 7.7	5.2	4.2, 6.3	0.46	0.55	26	−19, 70
Retinol (μg)	426	307, 640	358	239, 492	0.54	0.53	30	−76, 136
Vitamin D (μg)	2.1	1.5, 3	1.5	1.0, 2.4	0.40	0.46	42	−88, 172
Thiamin (mg)	1.4	1.1, 1.6	1.0	0.8, 1.2	0.38	0.41	38	−17, 93
Folate (μg)	203	166, 247	115	124, 192	0.38	0.44	31	−20, 82
Vitamin C (mg)	100	71, 139	63	38, 101	0.43	0.46	52	−78, 182
Carotene (μg)	1533	1023, 2203	1217	655, 2204	0.38	0.42	28	−137, 192
Fibre (g)	10	8, 13	7.8	6.0, 10.3	0.50	0.58	31	−34, 95

Spearman rank correlation coefficients (r_S), energy-adjusted correlation coefficients (r_a), and Bland-Altman statistics.

*All p<0.001

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Table 3

Correlations between FFQ and diary estimates of intakes of energy and selected nutrients and prudent diet scores, according to maternal and child characteristics[*†‡]

Characteristics	Energy r_a	Total Fat r_a	Calcium r_a	Vitamin D r_a	Prudent Diet Score r
Mother's educational attainment					
- ≤ GCSE (n 322)	**0.38**	0.44	0.62	0.42	0.70
- >GCSE (n 570)	**0.30**	0.49	0.56	0.48	0.67
Child BMI					
- Normal weight (n 758)	0.33	0.47	0.59	0.47	0.71
- Overweight/obese (n 113)	0.38	0.49	0.68	0.51	0.77
Nibbling behaviour in two groups					
- Nibbler (n 425)	0.33	0.50	0.61	**0.50**	0.72
- Non- nibbler (n 465)	0.32	0.45	0.57	**0.43**	0.72
Number of meals (per week) eaten away from home in the past 3 months:					
- 0 (n 286)	0.38	0.50	**0.70**	0.47	**0.75**
- 1-3 (n 381)	0.31	0.45	**0.55**	0.46	**0.72**
- 4+ (n 225)	0.31	0.46	**0.51**	0.46	**0.64**
Has types of foods consumed restricted					
- No (n 470)	0.30	0.50	**0.64**	0.43	0.73
- Yes (n 422)	0.37	0.44	**0.54**	0.50	0.70

[*] text in bold indicates significant differences in the associations between FFQ and FD according to level of the maternal and child characteristic, assessed by test for interaction in linear regression

[†] nutrients were energy adjusted

[‡] Spearman rank correlations are shown for nutrients; Pearson correlation coefficients are shown for prudent diet score