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Measuring diet in primary school children aged 8-11 years: Validation of the Child and Diet Evaluation Tool (CADET) with an emphasis on fruit and vegetable intake

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Running title: Validation of the CADET diary in children aged 8-11 years

Abstract

Background: The Child And Diet Evaluation Tool (CADET) is a 24-hour food diary that measures the nutrition intake of children aged 3-7 years, with a focus on fruit and vegetable consumption. Until now CADET has not been used to measure nutrient intake of children aged 8 to 11 years. To ensure that newly assigned portion sizes for this older age group were valid, participants were asked to complete the CADET diary (the School and Home Food diary) concurrently with a one day weighed record diary.

Method: A total of 67 children with a mean age of 9.3 years (SD: +/- 1.4, 51% girls) participated in the study. Total fruit and vegetable intake in grams and other nutrients were extracted to compare the mean intakes from the CADET diary and Weighed Food Dairy using t-tests and Pearson's r correlations. Bland-Altman analysis was also conducted to assess the agreement between the two methods.

Results: Correlations comparing the CADET diary to the weighed record were high for fruit, vegetables and combined fruit and vegetables (r=0.7). The results from the Bland Altman plots revealed a mean difference of 54 grams (95% CI: -88, 152) for combined fruit and vegetables intake. CADET is the only tool recommended by the National Obesity Observatory that has been validated in a UK population and provides nutrient level data on children's diets.

Conclusion: The results from this study conclude that CADET can provide high quality nutrient data suitable for evaluating intervention studies now for children aged 3 to 11 years with a focus on fruit and vegetable intake.

Keywords: Validation, food diaries, children, fruit and vegetables, United Kingdom

Introduction

Dietary assessment attempts to accurately estimate habitual intake for a group of individuals of interest. However, measuring food intake is difficult due to the wide variation that can occur daily, weekly, or even seasonally[1]. The importance of accurately measuring food intake in children is a concern, as dietary habits formed in early life can have a serious impact on long term health status[2]. Measuring food and nutrient intake in children is more challenging than in adults. Until children are eight years or older, they are not aware of the food they are consuming or do not have the cognitive abilities to identify their own food intake[3]. This means parents play a vital role in reporting their child's food intake. Epidemiological research involving primary school aged children tends to rely on parents or field workers to report children's food intake. Evidence suggests that parents can reliably report their child's food intake using either dietary recalls or 24-hour food diaries in the home environment[4]. This reliability is strengthened when both parents are involved in the reporting process[3]. Food eaten outside the home is less reliable, and often a major source for possible bias. When children are absent from their parent's care for four or more hours of the day, such as when children are at school, their parents ability to accurately recall their child's dietary intake dramatically decreases[4]. Therefore using field workers to complete the children's recall at school reduces this risk of bias. Another area of measurement error is portion sizes in both adult and child studies. There are mixed views as to whether children can estimate the quantities of food they have consumed. Some studies state children aged 8-15 years can estimate within ten percent the food they actually consumed when measures such as household items are used to help aid quantification[5]. It is accepted that there is no perfect way of measuring habitual intake in children[6]. For large population studies it is essential that the dietary assessment method is easy to complete.

When validating a dietary assessment method it is important to look at the agreement in daily energy intake between the two methods; it is also necessary to explore differences in nutrient intake. Generally speaking variability in nutrient intake is lower for those nutrients regularly found ubiquitously in the diet e.g. protein, carbohydrates; and higher for nutrients concentrated in a smaller range of foods such as carotene, retinol, folic acid, and unsaturated fatty acids[3].

For children, the validity of a 24-hour recall compared to a more complex food diary has been shown to accurately reflect energy intake of the sample population, however, they are generally not precise enough to accurately measure individual intake[7]. Overestimation or underestimation of energy intake is likely to be caused by errors associated with the portion sizes assigned to different foods. Misreporting in dietary questionnaires is a major problem in adult studies let alone in paediatric populations that rely on information from parents and children. It is vital that all studies build in validation methods to critically examine evidence of measurement error in the reporting.

Nevertheless, the CADET diary is the only tool recommended by the National Obesity Observatory that provides nutrient level data on children's diets[8]. There are few tools validated in a UK population that provide nutrient level data that can be used in children from age 3 to 11 years. Whilst the CADET diary has been previously validated in children aged 3 to 7 years, it has not been validated in children aged 8 to 11 years[9]. This study aims to evaluate whether a modified version of CADET has the potential to measure the diet of children aged 8 to11 years by validating it against a weighed record as a reference method [10, 11].

Method

Participant

Eight primary schools in the Leeds and the West Yorkshire area were asked to participate in the study from years 3 to 6 with an age range of 8 to 11 years.

Design

Data collection was carried out between November 2010 and June 2012. The children received a consent letter to take home to their parents a week before the day of data collection. All parents who gave consent attended an information session at the end of the school day.

Dietary Assessment Method: Child and Diet Evaluation Tool (CADET)

For this study, diet was assessed using a modified version of the validated Child And Diet Evaluation Tool (CADET) questionnaire[9]. The CADET uses age and gender specific food portion sizes to calculate food and nutrient intake for children aged 3 to 11 years old [12]. The

portion sizes used are based on the National Diet and Nutrition Survey of young people aged 4 to 18 years (NDNS)[17]. The NDNS was conducted to explore food consumption and nutrient intake in the general population, living in privately owned houses across Britain. The NDNS data is based on an interview, a seven day weighed food diary as well as blood and urine samples. The CADET diary was updated for children aged 8 to 11 years. The CADET diary is comprised of a list of 115 separate food and drink types, divided into 15 categories. The categories of foods are cereals (6 items); sandwich/bread/cake/biscuit (5 items); spreads/sauces/soup (7 items); snacks (8 items); cheese/egg (6 items); chicken/turkey (3 items); meat other (9 items); fish (5 items); vegetarian (3 items); pizza/pasta/rice (9 items); desserts/puddings (6 items); sweets (2 items); vegetables and beans (22 items); potato (2 items); fruit (13 items); and drinks (9 items). The CADET diary for this study was split into a School Food Diary and a Home Food Diary. Both diaries included the same food items, with different meal time options. The School Food Diary had the meal time options of morning break, lunch time, afternoon break, whereas the Home Food Diary had the following options: after school/before tea, evening meal/tea, after tea/during night, and breakfast/before school. To complete the School and Home Food diary participants ticked each item consumed, under the appropriate meal time heading within the 24-hour period (an example page is provided in figure 1).

INSERT Figure 1

The School Food Diary was completed by a trained fieldworker at school for all school time meals, whilst the children were given the Home Food Diary to take home for their home food, which included their evening snacks and meals, as well as breakfast the next day. A DVD which explains how to complete the CADET diary was sent home for parents/carers and children to watch (http://www.youtube.com/watch?v=AIbzqaJiHq0). A pilot study of the instructional DVD revealed that parents who watch the DVD were more likely to complete the CADET diary accurately than parents who did not watch the DVD[13]. The following day the fieldworker went back to the school to collect the Home Food Diary, and check that it had been completed accurately. If a child forgot to return their Home Food Diary the fieldworker did a retrospective recall for the after school dietary intake, including snacks, evening meals, and breakfast that morning.

Comparison Method: Weighed record

The method used for comparison with the School and Home Food Diaries was a weighed record. This diary is again a prospective food diary, administered on the same day as the School and Home Food Diaries. Similar to the School and Home Food Diaries it involves two sections, one to be completed by field workers at school, the other to be taken home to be completed by the parents.

Researchers asked the parents to weigh all food their child ate using standard kitchen scales provided by the study team. Children who brought a packed lunch to school had their food weighed in the morning, and their left-overs collected at the end of lunchtime, weighed and recorded again. For children who received a school meal, the administrator recorded on a tick list what the children consumed from the food provided, then weighed a standard portion size provided by the school kitchen.

Parents were asked to weigh and record all food consumed after school as well as the left-overs from each meal. They were also required to weigh and record the breakfast that the child consumed the next day. Scales were provided if the parents required them. The diaries and scales were then returned to the fieldworker the following day, and checked for completeness.

Data Coding

The weighed record data was entered using a MS Access spreadsheet based on the in-house dietary analysis software: Diet And Nutrition Tool for Evaluation (DANTE). Nutritional information was based on the McCance and Widdowson's the composition of foods by the Royal Society of Chemistry[14] and using standard predefined algorithms to convert weights of composite foods into total daily nutrient values for each child.

Ethical Approval

Ethical approval was obtained through the Leeds Institute of Health Sciences and Leeds Institute of Genetics, Health and Therapeutic Joint Ethics Committee (Reference number: 09/012).

Statistical Analysis

All statistical analysis was performed using Stata IC version 12[15]. The results from the two methods were compared using Bland-Altman plots, Pearson's correlation coefficients, and paired t-test or Wilcoxon signed rank test for non-parametric data to identify any significant differences between the two methods[9]. Correlation coefficients (r) determine any significant correlations between the CADET tick list and weighed record. Correlation coefficients measure the strength of the relationship between the two dietary methods[16]. Paired t-tests were used to assess significant differences between the two methods of assessment.

To examine the agreement between the School and Home Diary and the Weighed Food Dairy Bland-Altman plots were reviewed. For this the mean values of nutrients from the two diaries are plotted against the differences between the diaries. The differences between the methods were also checked for normality of distribution before attempting the Bland-Altman plots.

A sub-analysis exploring the mean differences between fruit and vegetables was conducted to explore whether a particular fruit or vegetable was affecting the overall accuracy of the CADET diary. Paired t-tests were used to determine whether there was a significant difference between individual fruit and vegetables.

Results

The total sample consisted of 67 children who completed the questionnaires, with a mean age of 9.3 years old (SD: +/- 1.4) and of whom 51% were girls.

Accuracy of the CADET Diaries compared to the Weighed record

Table 1 shows the mean and standard deviation of the daily intake of fruit (g), vegetables (g) fruit and vegetables combined (g) and key nutrient intakes as recorded by the CADET Diaries and the weighed record. As the main outcomes for this data were found to be normally distributed, paired t-tests were conducted, which showed no statistically significant differences for fruit, total energy, protein, carbohydrates, fibre, and sodium. However, there were statistically significant differences between the CADET Diaries and the Weighed Food Diaries record for combined fruit and vegetable intake, vegetable intake, fat, calcium, vitamin C and total sugar. The CADET Diaries recorded higher fruit and vegetable intake and macronutrient intake values than the weighed record. The CADET diary correlated well with the weighed record for fruit, vegetables and combined fruit and vegetable intake. However,

for the micronutrient intake there was a poor correlation between the CADET diary and the weighed record.

INSERT TABLE 1

Agreement between the two methods

Figure 2 and 3 show the Bland-Altman plots for the agreement between the CADET Diary and the weighed record for fruit intake, vegetable intake, total fruit and vegetable intake combined, total fat intake, energy intake (in kcal) and vitamin C by calculating the standard deviation of the difference between the two methods[16]. This area increases in size when the mean difference between the methods increases. The large cluster on the scatter plots at zero for fruit and vegetable intake represent the number of children who had no fruit or no vegetable intake. From the sample of 67 children five did not consume any vegetables and 14 did not consume any fruit on the day that data was collected in both diaries.

INSERT FIGURES 2& 3

The results of the Bland-Altman analyses for figures are summarised in Table 2. The difference between the CADET diary and weighed record is relatively small for fruit (22g) and vegetable (32g) intake measured separately. However, when combined the mean difference between the two methods increased to 54g, approximately half a portion, with wide 95% limits of agreement at -226 to 333. For energy intake was a mean difference of 191 kcal in the two methods, with again wide 95% limits of agreement for energy intake from -1497 to 1881 kcal. The mean difference for fat intake was small only 18 g (95% limits of agreement -63 g to 99 g) and similar a small difference was found for the ratio of vitamin C intake of 1.5 % (95% limits of agreement -0.2 to 9 %).

INSERT TABLE 2

Sub-analysis of fruit and vegetables – reviewing age/gender portion sizes

There were significant differences in the mean intake of fruit and vegetables between recordings taken with CADET and those with the weighed record; to explore the possible causes for these results a sub-analysis assessing the mean differences for individual fruit and vegetable was conducted. From conducting this analysis it was evident that compared to the

weighed record more fruit and vegetables were ticked on the CADET diaries. The participants only recorded 90 times consuming fruit and vegetables in the weighed record, whereas they ticked 215 fruit and vegetables in the CADET diaries. This is a substantial difference. One of the primary reasons for this difference was parents listing combinations of fruit or vegetables in one weighed portion and ticking each item on the CADET diary, rather than selecting fruit salad, or mixed vegetables. From the 90 foods recorded in the weighed record these items were broken down into the list of fruit and vegetables (see Table 3). Paired t-tests were conducted to explore which particular fruit and vegetables were contributing to the significant differences between the two dietary measurements.

The results revealed small non-significant differences for apples, bananas, strawberries oranges and satsumas, peaches, plums, nectarines and apricots. Whilst for grapes the paired t-tests revealed there was no significant differences in portion sizes, whereas for melon and watermelon did have a significant difference in the mean difference of 104 g (95%CI: 33, 175), suggesting that the portion sizes for melon and watermelon might be reducing the accuracy of the CADET diary to measure fruit intake. For vegetables there were no significant differences between mean intakes for carrots and cucumber. However, there were significant differences between assessment methods for peas and sweetcorn (mean difference 23 g, 95%CI 10, 36) and broccoli, brussels sprouts and cabbage (mean difference 25 g, 95%CI: 18, 33). Again the differences in these vegetable items might be reducing the accuracy of the CADET diary to measure vegetable intake.

It was noted that melon and watermelon, peas and sweetcorn, broccoli, brussels sprouts and cabbage were all consumed both at home and at school. To explore how these items were affecting the mean differences they were removed from the analysis and paired t-tests were conducted again on combined fruit and vegetable intake. These results revealed that after removing the above mentioned items the mean difference between combined fruit and vegetable intake was 4 g (95%CI: -5, 14) demonstrating that a small number of foods were contributing to the poor agreement between methods.

INSERT TABLE 3

Discussion

Validity of the CADET 24hr diet diary

The CADET is one of the few existing dietary assessment tools available that can provide a reliable and valid nutrient analysis on children's diets. The CADET is an un-weighed 24hr diet diary that shows acceptable agreement with a weighed method [(1)]. The use of age related portion size data provided by the NDNS[(17)] enabled the CADET diary to be adjusted so it was suitable for older children in this study. NDNS portions sizes are based on a representative sample from the UK. However, the comprehensive nature of the foods included in the CADET meant using portion sizes based on relatively small samples for some foods. This is due to assigning age and gender portion sizes for all foods and drinks. The simple tick box style of CADET is considered an appropriate tool for populations with large variations in literacy rates that require simple and easy to complete methods to assess dietary intake. The aim of CADET is to capture the mean intake of a population; as the instrument is not sensitive enough to identify individual differences in diet[(18)]. A previous review of validation studies in children comparing different dietary assessment methods with double labelled water concluded that 24hr recalls tended to slightly overestimate intakes while weighed methods underestimated intakes[(25)]. This study concurs with these results as energy intake for the weighed method were generally lower than the results obtained with the CADET 24hr food diary.

Fruit and vegetables intake combined

The primary aim of the CADET tool has been to measure fruit and vegetable intake in children, and this analysis has demonstrated that for children aged 3 to 11 years CADET is a reasonably effective method of capturing this type of dietary data. As for energy intake, fruit and vegetable intake with the weighed method was higher than for the CADET 24hr diary.

The mean daily intake in the CADET diary was nearly double at 253 g compared with 119 g for the weighed record The intakes from the CADET diary were similar to intakes in the NDNS (2008/9 – 2010/11) of 2.8 portions for boys and 3 portions for girls[(17)] indicating that the weighed diary may potentially be underestimating fruit and vegetable intake by a significant amount. The Bland-Altman plot showed that the mean difference for combined fruit and vegetable intake was equivalent to about half a portion although the levels of agreement were wide indicating that the CADET diary overestimated consumption of fruit and vegetables compared with the weighed method. The mean difference in fruit and vegetable intake was slightly larger for the age group 8 to 11 years than in the previous validation study [(9)], however the current study had smaller 95% limits of agreement are

broadly similar to the previous validation results of this tool. This indicates that the CADET diary consistently overestimates intakes compared to the weighed record, a common problem with tick list food style questionnaires[9]. The correlation coefficients were strong for fruit and vegetable intake, all equalling 0.7 but a high correlation coefficient does not reveal the relationship between each method for each participant. The bland altman plot is a better method to determine the agreement between methods and provides the difference for each method (from the mean) for each participant. It is then possible to determine whether one method consistently overestimates intake compared to the second method although there are no rules regarding when the limits of agreement are deemed to be large[24]. Compared to the previous validation of CADET[9], overall the results from this study have slightly higher correlations for combined fruit and vegetable intake, and vegetables and fruit intake measured separately. As the tool is often used in trials that have a primary outcome of fruit and vegetable intake, these results indicate that it is a valid method for measuring fruit and vegetable intake, one of the fundamental aims of the questionnaire. This suggests that the CADET tool is suitable to measure children's fruit and vegetable intake.

Sub-analysis exploring portions sizes for fruit and vegetables

Additional analysis was carried out to explore the impact of individual fruit and vegetables on agreement between the two methods. This revealed that the portion sizes for peas, sweetcorn, watermelon, and other types of melon showed significant differences between the two dietary assessment methods. None of the children actually consumed watermelon, which might be affecting the portion size of other melon intake such as honeydew melon. Whilst there was a significant difference in peas, sweetcorn and broccoli intake, children's portions sizes do vary for these types of vegetables, more so than consuming a piece of fruit such as an apple. These differences in true consumption patterns reduce the chances of accurately measuring intake of these items using standard portions. Nevertheless unlike melon which was found to have a mean difference in intake of 104 grams between the dietary methods, the difference in vegetable intake (peas, sweetcorn and broccoli) was only 23 to 25 grams, which is a considerably smaller. The higher variation in portion sizes for fruit or vegetables that are not eaten whole (like an apple) make it particularly difficult to estimate vegetables that are consumed as part of a meal.

Nutrients

The comparison between the CADET diary and the weighed record for nutrient intakes shows a similar trend. The CADET diary had higher mean intakes for every nutrient (energy, protein, carbohydrate, fat, fibre, calcium, total sugar and sodium) compared to the weighed intake, apart from vitamin C intake, with correlation results of 0.2 to 0.6, equivalent to other 24hr recall questionnaires[1, 9]. There were however three nutrients that did have statistically significant results for the correlations with the weighed intake; these were energy, protein and fibre. The Bland-Altman plots showed that the mean difference for energy, vitamin C and total fat were small with reasonably narrow 95% limits of agreement, demonstrating that the CADET diary can provide valid nutrient data on macronutrients in particular.

Strengths and limitations

One limitation of the study is that only one day was assessed which is unlikely to reflect true long term intake and does not intake into account individual daily variation. This is particularly true for micronutrients, however correlations were still adequate between the two methods. Also, all the data for both the food record and CADET was collected on the same day, therefore the two methods could not be entirely independent. It is likely that we would have seen stronger agreement between the two methods if more than one day was included. The sample size is relatively small in this study although similar to existing validation studies[22, 23]. Since the sample size for this study was relatively small, it is possible that only large differences in the two methods would be statistically significant[19]. Seventy children are needed to detect a difference in energy of at least 200 Kcal with 90% power assuming a standard deviation of 500 Kcal. This sample size is therefore sufficient to detect reasonable differences between the two methods. The burden of weighing the foods for the parents is usually the main reason for not participating in a study of this type. A major limitation of this type of validation study is that neither method is known to be perfect. A review of different dietary assessments in children compared with doubled labelled water reported that all methods tended to under or overestimate energy intake[24].

Nevertheless, the CADET diary does provide an adequate method with few alternatives available. It avoids issues of misreporting with child self-reported food intake, and is less of a burden on the participants than the most commonly used alternative, a weighed or semi-weighed 3 or 4 day food diary[20]. It is completed by trained field workers during the school day, and parents, not children for the evening meal and breakfast increasing validity. When the diary was returned to school the following day, the data completed by the parents was

checked by the field workers, working one to one with each child. Furthermore, the CADET has been used in large intervention trials where measuring food intake is a difficult task in terms of time, funding and resources[21]. The sub-analysis which explores individual items on the CADET also revealed that parents ticked more items on the CADET diary than they entered in the weighed record. This could be partly due to combining mixed vegetables dishes or fruit salad being recorded as one item in the weighed record, but as separate items in the CADET diary. With the additional development of the DVD to help explain how to complete the CADET to parents, CADET is one of the few diary assessment tools that can be quickly implemented by non-professionals[8]. Future studies using CADET should amend the DVD to explain to how to fill the CADET diary in when consuming fruit or vegetable salads, to reduce the risk of this error occurring. Successful validation of CADET against a double labelled water method would further strengthen the evidence for using CADET to estimate dietary intake in children.

Conclusion

The results from this validation study conclude that the CADET diary is a valuable nutritional epidemiological tool for measuring children's diets from age 3 to 11 years. It is easy to implement in large studies, and simple to complete. Whilst it does tend to overestimate children's intake compared to weighed methods, this is a limitation of all tick list based questionnaires. CADET is the only tool validated in a UK population that provides nutrient level data on children's diets that has been recommended by the National Obesity Observatory.

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Department of Health disclaimer

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Ethics Approval

Ethical approval was obtained through the Leeds Institute of Health Sciences and Leeds Institute of Genetics, Health and Therapeutic joint ethics committee (Reference number: 09/012).

Contributors

MSC managed the project, the statistical analysis the data and wrote the initial draft of the manuscript. JEC secured funding and was guarantor of the project. Both JEC and CELE supervised the project, the interpretation of the data and the preparation of the manuscript. CN was the research assistant for the project. NH was the database manager for the project. All authors contributed to the final version of the paper.

Competing interests

None to declare.

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Figure Legend

Figure 1. Example of how to fill in the CADET diary.

Figure 2. Differences between CADET Diary and Weighed record mean fruit intake, vegetable intake and fruit and vegetables combined (g).

Figure 3. Differences between CADET Diary and Weighed record mean energy intake (kcal) fat intake (g) and the ratio of vitamin C intake (%).