European Journal of Clinical Nutrition (2005) 59, 809–816
 0954-3007/05 $30.00
www.nature.com/ejcn

ORIGINAL COMMUNICATION

Development and testing of a computerised 24-h recall questionnaire measuring fruit and snack consumption among 9–11 year olds

L Moore[1]*, K Tapper[1], A Dennehy[2] and A Cooper[3]

[1]*Cardiff Institute of Society, Health and Ethics, Cardiff University, Cardiff, UK;* [2]*Department of Social Medicine, University of Bristol, Bristol, UK; and* [3]*Department of Exercise and Health Sciences, University of Bristol, Bristol, UK*

Objective: To evaluate the validity, reliability and sensitivity of a computerised single day 24-h recall questionnaire designed for the comparison of children's fruit and snack consumption at the group (school) level.
Design: Relative validity and reliability were assessed in relation to (i) intake at school and (ii) intake throughout the whole day, using diary-assisted 24-h recall interviews and a 7-day test–retest procedure. Sensitivity was assessed in relation to intake by comparing results from schools with differing food policies, and by sex.
Subjects and setting: Eight schools took part in the validity and reliability assessments, with 78 children completing the 24-h recall interviews and 195 children completing the test–retest procedure. A total of 43 schools (1890 children) took part in the sensitivity analysis. All children were aged 9–11 y. All schools were in South Wales and South-west England.
Results: For fruit intake at school, the questionnaire showed fair levels of validity at the individual level (kappa = 0.29). At the group level, there were little or no differences in fruit intake at school between the two measures and two occasions. The questionnaire was sufficiently sensitive to identify statistically significant differences between girls and boys, and between schools with different food policies. For snack intake at school, validity at the individual level was slightly lower (kappa = 0.22–0.25), but the data remained of value in analyses at the group level. For fruit and snack intake throughout the whole day there was little agreement at the individual level (kappa = 0.00–0.06), and at the group level there tended to be substantial differences between the two measures and two occasions.
Conclusions: The computerised questionnaire is a quick and cost-effective means of assessing children's consumption of fruit at school. While further development is required to improve validity and reliability, it has the potential to be particularly useful in randomised controlled trials of school-based dietary interventions.
Sponsorship: The research was funded by the Food Standards Agency Food Acceptability and Choice research programme and the Health Promotion Division of the National Assembly for Wales. Laurence Moore is supported by a Public Health Career Scientist Award funded by the Welsh Assembly Government.
European Journal of Clinical Nutrition (2005) **59,** 809–816. doi:10.1038/sj.ejcn.1602146
Published online 11 May 2005

Keywords: measurement; child; diet; food habits; fruit; health behaviour

Introduction

Epidemiological studies show an inverse relationship between dietary intake of fruit and vegetables and incidence of cardiovascular disease, stroke and cancer (Gaziano *et al*, 1995; Gillman *et al*, 1995; Key *et al*, 1996; Steinmetz & Potter, 1996). For these reasons experts recommend an intake of at least five portions of fruit and vegetables a day for both adults and children over 2 y of age (eg US Department of Health and Human Services, 1996; Williams, 1997; Department of Health, 2000a). However, despite these recommendations, children in the UK currently eat an average of just two portions a day, with many children eating far fewer (Department of Health, 2000b). In an attempt to improve children's diets, the school is increasingly being targeted as a setting for intervention, in terms of both food provision (eg

***Correspondence: L Moore, Director, Cardiff Institute of Society, Health & Ethics, Cardiff University, 53, Park Place, Cardiff CF10 3AT, UK.**
E-mail: MooreL1@cf.ac.uk
***Guarantor*: L Moore.**
***Contributors*: LM, AC and AD developed and piloted the computerised questionnaire; LM and KT undertook data analysis and drafted the paper. All authors contributed to finalisation of the manuscript.**
Received 2 February 2004; revised 15 February 2005; accepted 1 March 2005; published online 11 May 2005

Department for Education and Employment, 2000; Department of Health, 2000a) and the introduction of programmes designed to encourage healthy eating (eg Department of Health, 2000a; Glasgow City Council, 2002). Given the time and resources being directed at such measures, an accurate assessment of their effectiveness is essential.

Randomised controlled trials (RCTs) are generally considered to be the most reliable means of assessing intervention effectiveness (eg see Campbell *et al*, 2000). However, for school-based interventions, randomisation has to take place at the school level. As a consequence, relatively large numbers of participants are needed in order to detect any intervention effect. For such a trial to be feasible it is therefore important that the outcome measures employed are relatively quick, cost-effective and easy to implement.

Rigorous evaluations of school-based interventions aimed at altering children's diets are currently limited by an absence of such measures. Assessment of dietary intake in RCTs with adult populations is often achieved using Food Frequency Questionnaires (FFQs) which assess normal intake of specific foods over particular time periods (eg see Thompson & Byers, 1994). However, these questionnaires can be unsuitable for use with children who tend to lack the cognitive skills needed to estimate 'normal' intake (Domel *et al*, 1994; Baranowski *et al*, 1997; Livingstone & Robson, 2000; McPherson *et al*, 2000). Asking parents to complete FFQs on behalf of school-aged children is also likely to result in imprecise measures of intake, partly because parents are not privy to their child's eating habits at school, and partly because parents do not necessarily observe the substantial amounts of snacking that children of this age engage in, both inside and outside the home (Davidson *et al*, 1986; Byers *et al*, 1993). FFQs also tend to lead to over or inconsistent reporting of fruit and vegetable intake (Krebs-Smith *et al*, 1995; Baranowski *et al*, 1997), which may be problematic if it is these foods that represent the main focus of an intervention.

Alternative measures include food diaries, in which the respondent keeps a record of all foods and beverages consumed over a period of days, and 24-h dietary recalls in which the respondent is asked to recall and report all foods and beverages consumed during the previous day or 24 h (eg see Thompson & Byers, 1994). These methods can be a good means of assessing dietary intake in children (McPherson *et al*, 2000). However, they are problematic for school-based RCTs, not only because they are relatively time consuming and expensive but also because they involve high levels of respondent burden that may result in recruitment difficulties and attrition and thus introduce bias into the sample. Such measures are also unnecessarily onerous when one is interested in a limited number of foods, such as fruit and vegetables.

The Day in the Life Questionnaire (DILQ) was devised in an attempt to address these issues (Edmunds & Ziebland, 2002). It was designed to assess fruit and vegetable consumption by 7–9 y olds and consists of a single day 24-h recall questionnaire that is completed by children as a supervised classroom exercise. The questionnaire asks children to describe everything they had to eat or drink at various points of the previous day (eg at breakfast, on their way to school, during morning break). These items are ordered chronologically and are embedded within other items that relate to the child's activities (such as how they travelled to school). These latter items are designed both to act as memory prompts and to reduce social desirability bias by drawing attention away from the researchers' interest in food consumption. Questions about portion size are not included. This avoids the difficulties associated with children's assessment of portion size (Lytle *et al*, 1993; Livingstone & Robson, 2000) and also helps keep the questionnaire relatively brief and easy for the child to complete with minimal assistance. Fruit and vegetable intake is instead assessed using frequency of servings, which has been shown to account for more variation in intake than portion size (Thompson & Byers, 1994).

The questionnaire relies on data from a single day rather than multiple days and can therefore only be used to assess intake at the group level rather than the individual level (Thompson & Byers, 1994). However, it shows acceptable levels of validity and reliability and is sensitive enough to detect increases in fruit consumption at morning break as a result of children being provided with free fruit (Edmunds & Ziebland, 2002). The authors also report that the questionnaire is popular with children and acceptable to teachers. For these reasons, this type of approach may be useful for the evaluation of school-based dietary interventions that target specific foods.

The present paper reports on the development and testing of a computerised 24-h recall measure designed to assess both fruit and snack consumption among 9–11-y-old children. Computers are increasingly being used in dietary assessment (eg Johnson & Hackett, 1997; Baranowski *et al*, 2002; Bakker *et al*, 2003). They enhance data quality, eliminate the need for data entry and help to maintain children's attention (Hackett *et al* (1989); see also Cullen *et al*, 1998). There is also evidence to suggest that they can reduce social desirability or interviewer bias (Hackett *et al*, 1989; Bakker *et al*, 2003). Like the DILQ, the computerised questionnaire described in this study consists of a single day 24-h recall procedure that includes questions regarding the child's activities during the previous day. All items are ordered chronologically. Unlike the DILQ, the questionnaire uses prompted recall for specific items. This reduces the likelihood that target items are omitted (Thompson & Byers, 1994; Baxter *et al*, 2000) and also enables the use of closed questions that can be answered rapidly and require only limited computer skills. The questionnaire was designed as part of an evaluation of the impact of school fruit tuck shops on children's diet and for this reason measures consumption of both fruit and of other sweet and savoury snacks such as crisps and chocolate. Given that the evaluation employed a randomised controlled trial methodology, the questionnaire

was designed to provide accurate measures of consumption at the group (school) level rather than the individual level.

The present paper reports the validity, reliability and sensitivity of the computerised questionnaire. Validity was assessed by comparisons with diary-assisted 24-h recall interviews. Reliability was determined using a test–retest procedure, and sensitivity was examined by comparing results from schools with differing snack food policies, and by sex.

Method

Participants

Eight schools agreed to participate in the study, and were given a £50 donation to compensate for the disruption to school activities. At each of the schools, one class from either Year 5 or Year 6 (age 9–11) was selected to participate (both Year 5 and Year 6 classes in one school with small class sizes), and all children in that class were issued with a food diary to record all of the food that they consumed over a 24-h period (25–39 students per school). The diary included written instructions and a table for children to record items consumed. Verbal instructions on diary completion were also provided in class and children were given a letter for their parents, which asked them to assist their child in completing the diary during the evening and at breakfast time the following day. During school hours, teachers helped the children to record all dietary intake. The following day, all children completed a computerised fruit and snack intake questionnaire, without the aid of the food diary. In each school, 10–13 children were randomly selected to undertake a 24-h recall interview assisted by the food diary, based on a protocol that has been validated for children aged 8–9 y (Lytle, 1993). The interview included prompts for drinks, fruit and snacks and was administered by researchers who had been trained by a dietician. At one school, the letters to parents and food diaries were not distributed on the correct day, so the recall interviews were not undertaken. The computerised questionnaire was completed by 207 children, of which 78 also completed the recall interview. Half of these 78 children completed the computerised questionnaire before the interview, with the other half doing the interview first. All eight schools were then visited again 7 days after the first data were collected. At this follow-up visit, food diaries were not distributed. All 221 children present on day eight in the selected classes were asked to complete the computerised questionnaire for a second time; 195 children completed the computerised questionnaire on both occasions.

The sensitivity analysis took place as part of a wider evaluation of the impact of school fruit tuck shops on children's snacking behaviour (Moore *et al*, 2000). For this study, primary and junior schools in eight local education authorities in south-west England and Wales were contacted. If the school had an existing tuck shop, selling any type of food, or if the proportion of children entitled to free school meals was below the national average of 17%, the school was excluded. The remainder were invited to participate in the study, 43 of whom volunteered and were each given a £50 donation to compensate for disruption to school activities. At baseline, before any intervention activities took place in any of the schools, the computerised questionnaire was completed by children in one Year 5 class (aged 9–10 y) and one Year 6 class (aged 10–11 y) in each school. This resulted in a total of 1902 questionnaires, of which 12 were not fully completed and excluded from further analysis. Five of the schools ($n=203$) did not allow children to bring in any food for morning break ('no food' policy), 12 schools ($n=507$) only allowed children to bring in fruit for morning break ('fruit only' policy) and 26 schools ($n=1180$) had no restrictions regarding food at morning break ('no restrictions' policy).

Procedure

Approval for the study was provided by the board of governors at each school. The letters sent to parents with the food diary invited them to contact the school if they did not wish their child to participate. No parents chose to do this.

Children completed the computerised questionnaire in groups of four to five. Laptop computers were set up in each school for this purpose and two researchers were present to assist children with any difficulties they had.

Computerised 24-h recall questionnaire

The aim of the computerised questionnaire was to identify the number of servings of (i) fruit, (ii) sweets, chocolate, biscuits and (iii) crisps consumed by each child during the previous 24-h period. For each of six time periods (1, before school; 2, morning break; 3, lunchtime; 4, after school and before tea; 5, teatime; 6, after tea), children were initially asked an activity related question (eg how they had travelled to school). They were then asked if they had eaten any food during that period. If they answered 'no', they proceeded to the next period. If they answered 'yes', they were presented with a list of eight different snack items (crisps, sweets, biscuits, chocolate, chips, ice cream, milk, fruit juice) and were asked to indicate how many servings of each they had consumed. For each item children could select either zero, one or two servings, defined in terms of the usual serving for that item (eg bags of crisps, handfuls of sweets, number of biscuits, bars of chocolate, glasses of fruit juice). Children were then asked if they had eaten any fruit during that period. Fruit was defined as 'apples, bananas, kiwi, oranges, grapes, dried and tinned fruit'. If they answered 'no', they proceeded to the next time period. If they answered 'yes', they were presented with a list of eight different types (apples, bananas, grapes, oranges, kiwi, dried fruit, tinned fruit, any other fruit) and were asked to indicate how many servings of each they had consumed. For each item children could select either zero, one or two servings which were

defined in terms of whole pieces (apples, bananas, oranges), handfuls (grapes), boxes (dried fruit), bowls (tinned fruit) and a little/a lot (other fruit). If a child had eaten less than one serving of any item, they were asked to record that item as one serving. All items on the questionnaire were closed and children answered each one by clicking on the appropriate response. If a child later remembered a missed item, this was recorded by the researcher at the end of the questionnaire. The questionnaire was designed to be visually appealing to children and the majority of children were able to complete it in approximately 10 min.

Statistical analysis

Questionnaire validity, reliability and sensitivity were assessed in relation to intakes of (i) fruit, (ii) sweets, chocolate and biscuits, and (iii) crisps. Intake was calculated in terms of (i) number of time periods in which each food type was eaten, and (ii) number of servings of each food type. For all analyses, the results for the two measures of intake were similar, so we only report analyses of number of servings. For tests of validity and reliability, intakes of each of the three food types were examined: (i) for morning break and lunchtime only (ie periods 2–3) and (ii) for the whole day (ie periods 1–6). Validity was assessed in three ways: (i) by comparing mean number of servings from each method (paired *t*-test); (ii) individual level agreement was assessed by calculating kappa coefficients; (iii) individuals were designated either as matches (food type reported in both methods), intrusions (reported in computerised measure but not in recall interview) or omissions (reported in recall interview but not in computerised questionnaire). Kappa coefficients were interpreted using the guidelines given by Landis and Koch (1977) (0.00 = poor, 0.01–0.20 = slight, 0.21–0.40 = fair, 0.41–0.60 = moderate, 0.61–0.80 = substantial, 0.81–1.00 = almost perfect). Reliability was assessed by comparing mean number of servings on each occasion (paired *t*-test). For the sensitivity analysis, multivariable regression models were estimated for each food type (for morning break and lunchtime only, ie periods 2–3), using design weighted estimators that took full account of the clustered nature of the sample (Statacorp, 1999). In each model, the independent variables were country (Wales/England), year size (>40 pupils/<40 pupils), school policy (no food/fruit only/no restrictions) and sex (boy/girl).

Results

Questionnaire validity

Questionnaire validity was assessed using data from the subsample of 78 children (37 boys and 41 girls) who completed both the computerised questionnaire and the 24-h recall interview. Analysis showed that the order in which children completed these measures had no effect on the results. However, initial data screening revealed that the mean and range comparisons between the questionnaire and interview measures were particularly discrepant. This was due to a small number of extremely high values in the questionnaire data set. Six observations were therefore excluded, representing six children who reported consuming between 8 and 17 servings of fruit during the previous 24-h period.

Table 1 shows the descriptive statistics for the remaining sample for the six outcome measures, for both the computerised questionnaire and the diary-assisted recall interview. Compared to the recall interview, the computerised questionnaire gave higher estimates of fruit and crisp intake, but slightly lower estimates of sweet, chocolate and biscuit intake. The size of these discrepancies varied by both food type and time period. For example, mean fruit intake differed

Table 1 Comparisons between the computerised questionnaire and diary-assisted recall interview in terms of the number of servings consumed (mean, median and range) and the number of consumers *vs* nonconsumers (kappa, matches, omissions and intrusion) for each of the three food types for time periods 2–3 and 1–6 ($n = 72$)

	Computerised questionnaire			*Recall interview*							
	Mean	*Median*	*Range*	*Mean*	*Median*	*Range*	*Difference between means (P-value)*	*Kappa coefficient*	*Match rate[a] (%)*	*Omission rate[b] (%)*	*Intrusion rate[c] (%)*
Periods 2–3											
Fruit	0.35	0	0–3	0.22	0	0–2	−0.13 ($P = 0.06$)	0.29	81	7	12
SCB[d]	1.06	1	0–4	1.36	1	0–16	0.30 ($P = 0.28$)	0.25	65	17	18
Crisps	0.81	1	0–2	0.61	1	0–2	−0.20 ($P = 0.02$)	0.22	69	11	20
Periods 1–6											
Fruit	2.13	1	0–7	0.90	0	0–9	−1.23 ($P < 0.001$)	0.06	60	13	27
SCB[d]	4.28	4	0–12	4.46	3	0–22	0.18 ($P = 0.78$)	0.00	65	17	18
Crisps	1.67	1	0–8	1.00	1	0–3	−0.67 ($P < 0.001$)	0.03	75	7	18

[a]Match rate = (number of children reporting consumption on both measures + number of children reporting nonconsumption on both measures/total number of children) × 100.
[b]Omission rate = (number of children reporting consumption on the recall interview but not on the computerised questionnaire/total number of children) × 100.
[c]Intrusion rate = (number of children reporting consumption on the computerised questionnaire but not on the recall interview/total number of children) × 100.
[d]Sweets, chocolate and biscuits.

by 0.13 servings when measures were restricted to morning break and lunchtime, but by 1.23 servings for the whole day. Conversely, intake of sweets, chocolate and biscuits differed by 0.30 servings when restricted to morning break and lunchtime, but by 0.18 servings for the whole day. The difference between these means was statistically significant ($P<0.05$) for fruit and crisps during periods 1–6 and for crisps during periods 2–3.

Table 1 also shows the kappa coefficients, which in periods 2–3 indicated higher levels of agreement for fruit consumption (0.29) than consumption of sweets, chocolate and biscuits (0.25) or crisps (0.22). For periods 1–6, there was very little agreement between the two measures, with all three coefficients being less than 0.07. Fruit consumption during periods 2–3 showed the highest match rate (81%) and the lowest omission and intrusion rates (7 and 12%, respectively). Match rates for consumption of other foods and time periods were lower and ranged from 60% (fruit, periods 1–6) to 75% (crisps, periods 1–6).

Questionnaire reliability

Initial data screening revealed that 17 children reported consuming eight or more servings of fruit: 13 on the first occasion only, two on the second occasion only and two on both occasions. These children were excluded from the analysis leaving a total of 178 children (91 boys and 87 girls) who completed the questionnaire on both occasions.

Table 2 shows the differences in mean intake between the two occasions for each of the six measures. These differences were very small for data relating to periods 2–3 (ranging from 0.00 to 0.06). For data relating to periods 1–6, differences were larger (ranging from −0.34 to −0.78) and were all negative, indicating that children were reporting lower levels of intake on the second occasion. These declines were statistically significant for all the three food categories.

Questionnaire sensitivity

Further analyses were conducted to determine whether the computerised questionnaire was sufficiently sensitive to detect relationships between food intake during school hours and both sex and school food policy. Based on data from the National Diet and Nutrition Survey (Department of Health, 2000b) and the DILQ validation (Edmunds & Ziebland, 2002), it was hypothesised that girls would show higher intake of fruit than boys. It was anticipated that children in schools with fruit only policies would show higher intakes of fruit compared to schools with no food policies or no restriction policies. It was also anticipated that children in schools with no restriction policies would show higher intakes of sweets, chocolate and biscuits and higher intakes of crisps, compared to schools with fruit only or no food policies, and higher intakes of fruit compared to schools with no food policies. Of the 1890 pupils completing questionnaires, 258 were excluded since they reported consuming eight or more servings of fruit. This left a total of 1632 children (795 boys and 837 girls). The results of the multivariable models are displayed in Table 3.

Table 3 shows that, as expected, girls had higher fruit intakes than boys (0.24 servings, 95% CI: 0.13, 0.35). Also as anticipated, children in schools with no restrictions showed significantly higher intakes of sweets, chocolate and biscuits and significantly higher intakes of crisps, compared to schools with fruit only or no food policies. They also showed significantly higher intakes of fruit compared to schools with no food policies. Children in schools with fruit only policies showed significantly higher intakes of fruit compared to schools with a no food policy, but no greater fruit consumption than those in schools with no restrictions.

Questionnaire acceptability

The computerised questionnaire was popular with the children and held their attention in a way that a traditional paper-based questionnaire would not. The vast majority of children were familiar with computers and in the use of a mouse, and were pleased to be using a laptop computer with a colour screen, which many had not used before. The teachers also welcomed the opportunity to expose the children to the technology.

Table 2 Mean intake of three food types at first completion of the computerised questionnaire (95% confidence interval) and mean change at second completion (95% confidence interval) ($n=178$)

	Fruit	*SCB*[a]	*Crisps*
Periods 2–3			
First completion	0.40 (0.29, 0.59)	1.08 (0.95, 1.22)	0.84 (0.73, 0.95)
Change	0.00 (−0.11, 0.11)	0.06 (−0.11, 0.23)	−0.03 (−0.13, 0.07)
P-value	1.0	0.47	0.58
Periods 1–6			
First completion	2.12 (1.78, 2.46)	4.32 (3.92, 4.72)	1.63 (1.44, 1.83)
Change	−0.78 (−1.10, −0.45)	−0.57 (−1.03, −0.11)	−0.34 (−0.54, −0.13)
P-value	<0.001	0.02	<0.001

[a]Sweets, chocolate and biscuits.

Table 3 Parameter estimates (95% confidence intervals) from multivariable models of the difference in intake at school of three food types, by (i) school policy on snack food items that children can bring to school and (ii) children's sex.

	Fruit	*SCB*[a]	*Crisps*
No restrictions *vs* fruit only	0.07 (−0.07, 0.22)	0.20 (0.04, 0.36)	0.41 (0.15, 0.66)
No restrictions *vs* no food	0.25 (0.08, 0.43)	0.49 (0.25, 0.73)	0.34 (0.20, 0.47)
Fruit only *vs* no food	0.18 (−0.03, 0.39)	0.29 (0.05, 0.53)	0.06 (−0.25, 0.38)
Joint test of significance of school policy	$P=0.019$	$P<0.001$	$P<0.001$
Girl *vs* boy	0.24 (0.13, 0.35) $P<0.001$	0.02 (−0.13, 0.18) $P=0.79$	0.04 (−0.03, 0.12) $P=0.22$

[a]Sweets, chocolate and biscuits.
Estimates obtained from design weighted regression models, with country and school size as additional covariates. $N=1632$ in each of the three models.

Discussion

The computerised questionnaire showed the highest levels of validity and reliability when it was used to assess intake during periods 2–3 (morning break and lunchtime). For intake of fruit during these periods, the data showed fair agreement with data from the recall interview. Analysis of test–retest reliability also showed good agreement between the two measurement occasions, with identical mean estimates of intake. In addition, the computerised questionnaire was sufficiently sensitive to detect statistically significant differences at a group level in intake of fruit according to students' sex and school policy.

Intake of crisps, and sweets, chocolate and biscuits during time periods 2–3 also showed good levels of reliability, and fair agreement with the recall interview. In addition, the sensitivity analysis indicated that the computerised questionnaire was able to detect statistically significant differences in intake of crisps, and sweets, chocolate and biscuits according to school policy.

Although levels of agreement were not as high as they might have been, validity assessment was conducted at the individual level. As discussed previously, the computerised questionnaire was designed to provide group (school) level data. Thus although data from this instrument would contain a certain amount of individual level measurement error, the results suggest that in a sufficiently powered study, the questionnaire would be able to detect differences in food intake in schools, at the school level.

For periods 1–6 (the whole day), the computerised questionnaire showed lower levels of validity and reliability. Intake of fruit and crisps were overestimated compared to the recall interview and there was little agreement between the two measures. Conversely, for intake of sweets, chocolate and biscuits, estimates of mean intake were similar across the questionnaire and interview measures but again there was little agreement between the two measures.

Analysis of test–retest reliability showed moderate agreement for all three food categories, but when children completed the questionnaire for the second time, they reported lower intakes. Given that the validation exercise showed that the computerised questionnaire resulted in higher estimates of fruit and crisp intake compared to the recall interview, it seems likely that children were overestimating their intake the first time they completed the questionnaire and providing estimates that were more accurate on the second occasion.

Thus to summarise, the results indicate that the computerised questionnaire showed higher levels of validity and reliability when used to assess intake at school compared to intake throughout the whole day. In relation to fruit intake, it is possible that the types of fruit listed in the questionnaire corresponded to those that children were eating at school, but were too limited to accurately reflect consumption at home. It is also possible that the validity and reliability of data relating to sweet and savoury snacks, as well as fruit, may have been effected by differences in levels of snacking. For example, at school, children normally have just two opportunities to eat, morning break and lunchtime. However, outside of school, children have access to food from home, from friends' houses and from local shops and may eat substantial amounts of food in between meals (Davidson *et al*, 1986). These items may be more easily forgotten (Davidson *et al*, 1986; Poppitt *et al*, 1998; Livingstone & Robson, 2000; Novotny *et al*, 2001), or when they are remembered, the child may have difficulty recalling or estimating the number of servings consumed, especially if foods are shared with others or eaten directly from a larger packet (Thompson & Byers, 1994; Chambers *et al*, 2000). Such factors may have reduced both the validity and reliability of the data relating to the whole day compared to the data relating to morning break and lunchtime. Thus, further research is needed to determine whether the questionnaire can be modified to improve the accuracy with which children report the items they have eaten outside of school, perhaps by the introduction of probes, or more detailed questions regarding the child's activities (Thompson & Byers, 1994).

However, it is also possible that the recall interviews provided a less accurate assessment of periods 1–6 than periods 2–3. This could have occurred in part due to differences in snacking, as described above, but may also have been the result of differences in food diary completion. For periods 2–3, teachers ensured that all children completed their diaries. However, for periods 1,4,5 and 6, diary completion relied on children and parents. Thus, diary completion for these latter periods may have been less consistent and less accurate. This in turn may have resulted in inaccuracies in the data collected during the recall

interview. If these errors differed from those that occurred for the computerised questionnaire, they would have reduced the agreement between the two measures and thus resulted in an underestimate of the validity of the computerised questionnaire.

Another important finding from the study was that analysis of test-retest reliability showed that for periods 1–6, there was a substantial decline in the number of servings of food reported on the second occasion that children completed the questionnaire. Studies evaluating the reliability of FFQs among children also tend to show a decline in reported levels of consumption on the second administration (McPherson *et al*, 2000); a finding often interpreted as being due to questionnaire fatigue (eg Domel *et al*, 1994). However, in the present study, results from the recall interview suggest that children were overestimating consumption on the first occasion and providing more accurate estimates on the second occasion. This may have been the result of a learning effect. Alternatively, the novelty of the computerised questionnaire may have meant that on the first occasion children were particularly keen to report on the various different foods, which in turn resulted in intrusions. In particular, the screen on which children reported fruit consumption did not appear unless the child reported that he or she had eaten fruit during that period. Thus, a child who had eaten no fruit throughout the day may have incorrectly reported that they had eaten fruit in order to have the opportunity to view and complete this screen. Indeed, this was the food category that showed the largest difference in levels between time 1 and time 2 and the highest intrusion rate (periods 1–6). On the second occasion that children completed the questionnaire, they would have been familiar with its contents and thus such intrusions may have been reduced. If this was the case, it may be possible to modify the questionnaire in order that children get the opportunity to report on all items regardless of what they have eaten. Alternatively, the introduction of a habituation or 'practice' trial could help eradicate this problem. However, where an evaluation is concerned with levels of change in consumption, rather than with estimating exact levels of intake, such bias may be deemed unproblematic given that one would expect it to occur to the same extent in both experimental and control schools. Nevertheless, the results highlight the importance of assessing reliability when developing measures of intake.

Although the results reported here are promising, it is important to bear in mind the limitations of the study. First, as stated previously, the questionnaire was designed to provide group (school) level data. However, since only seven schools participated in the study, validity tests were conducted at the individual level. Further research employing a larger number of schools would allow for analysis at the group level and thus provide a better assessment of the questionnaire.

Second, since the computerised questionnaire was compared with recall interviews rather than a 'gold standard' measure, it is not possible to determine the extent to which differences were due to inaccuracies on the part of the questionnaire or on the part of the interview. Indeed, as described above, the results may underestimate the validity of the computerised questionnaire in relation to time periods 1–6 due to inaccuracies on the part of the recall interview. However, it is also possible that the results overestimate the validity of the questionnaire due to shared method variance with the recall interview. In particular, since both measures relied on children's self-reports, they would both have been subject to the inaccuracies and biases associated with this method (eg intrusions, omissions, social desirability bias), which may have inflated the levels of agreement between the two measures. Overestimations may also have occurred as a result of the food diary enhancing the accuracy of the child's responses on the computerised questionnaire, since completion of the food diary required children to both attend to and rehearse the items they consumed which may have improved their recall when completing the questionnaire (eg see Craik & Lockhart, 1972).

And third, it is important to bear in mind that the computerised questionnaire was tested in the absence of any intervention. It is possible that it would show lower levels of validity when employed in the context of an intervention due to increases in social desirability bias (Herbert *et al*, 1995; Kristal *et al*, 1998).

In conclusion, the results of the present study showed that the computerised questionnaire provided reasonably valid and reliable measures of children's consumption of fruit in school (which was the main purpose of the subsequent related trial). However, measures of sweet and savoury snack consumption, and of consumption of fruit throughout the whole day, showed lower levels of validity and reliability. For this reason, the questionnaire is not ready for widespread adoption elsewhere. Nevertheless, the research suggests that this method of data collection has the potential to be a very effective way of measuring children's food intake for the purpose of RCTs, where the crucial issue is not necessarily to obtain valid estimates of the intake of individuals, but to be able to obtain an unbiased estimate of the difference in intake between two groups. The questionnaire was cost-effective, easy to implement and could be completed by a relatively large number of children within a short space of time. It did not require complex cognitive tasks and was popular with children and acceptable to teachers and parents. If we are to conduct rigorous evaluations of school-based interventions aimed at changing children's diets, it is vital that resources are put into the development and testing of such measures.

Acknowledgements
Claire Paisley advised on the validation methodology. We gratefully acknowledge the cooperation of all schools participating in this study.

References

Bakker I, Twisk JWR, van Mechelen W, Mensink GBM & Kemper HCG (2003): Computerization of a dietary history interview in a running cohort; evaluation within the Amsterdam Growth and Health Longitudinal Study. *Eur. J. Clin. Nutr.* **57**, 394–404.

Baranowski T, Islam N, Baranowski J, Cullen KW, Myres D, Marsh T & de Moor C (2002): The food intake recording software system is valid among fourth-grade children. *J. Am. Diet. Assoc.* **102**, 380–385.

Baranowski T, Smith M, Baranowski J, Wang DT, Doyle C, Lin LS, Hearn MD & Resnicow K (1997): Low validity of a seven-item fruit and vegetable food frequency questionnaire among third-grade students. *J. Am. Diet. Assoc.* **97**, 66–68.

Baxter SD, Thompson WO & Davies HC (2000): Prompting methods affect the accuracy of children's school lunch results. *J. Am. Diet. Assoc.* **100**, 911–918.

Byers T, Treiber F, Gunter E, Coates R, Sowell A, Leonard S, Mokdad A, Jewell S, Miller D, Serdula M & Strong W (1993): The accuracy of parental reports of their children's intake of fruits and vegetables: validation of a food frequency questionnaire with serum levels of carotenoids and vitamins C, A, and E. *Epidemiology* **4**, 350–355.

Campbell M, Fitzpatrick R, Haines A, Kinmonth AL, Sandercock P, Spiegelhalter D & Tyrer P (2000): Framework for design and evaluation of complex interventions to improve health. *Br. Med. J.* **321**, 694–696.

Chambers E, McGuire B, Godwin S, McDowell M & Vecchio F (2000): Quantifying portion sizes for selected snack foods and beverages in 24-hour dietary recalls. *Nutr. Res.* **20**, 315–326.

Craik F & Lockhart R (1972): Levels of processing. *J Verbal Learn. Verbal Behav.* **11**, 671–684.

Cullen KW, Baranowski T & Baranowski J (1998): Computer software design for children's recording of food intake. *J. Nutr. Educ.* **30**, 405–409.

Davidson FR, Hayek LA & Altschul AM (1986): Towards accurate assessment of children's food consumption. *Ecol. Food Nutr.* **18**, 309–317.

Department for Education and Employment (2000): *Regulations and Guidance for Nutritional Standards and School Lunches*. London: DfEE Publications Centre.

Department of Health (2000a): *The National School Fruit Scheme*. London: The Department of Health.

Department of Health (2000b): *National Diet and Nutrition Survey: Young People Aged 4 to 18 years. Volume 1: Report of the Diet and Nutrition Survey*. London: The Stationery Office.

Domel SB, Baranowski T, Davis H, Leonard SB, Riley P & Baranowski J (1994): Fruit and vegetable food frequences by fourth and fifth grade students: validity and reliability. *J. Am. Coll. Nutr.* **13**, 33–39.

Edmunds LD & Ziebland S (2002): Development and validation of the Day in the Life Questionnaire (DILQ) as a measure of fruit and vegetable questionnaire for 7-9 year olds. *Health Educ. Res.* **17**, 211–220.

Gaziano JM, Manson JE, Branch LG, Colditz GA, Willet WC & Burring JB (1995): A prospective study of consumption of caretenoids in fruit and vegetables and decreased cardiovascular mortality in the elderly. *Ann. Epidemiol.* **5**, 255–260.

Gillman MW, Cupples LA, Gagnon D, Posner B, Ellison RC, Castelli W & Wolf P (1995): Protective effect of fruits and vegetables on development of stroke in men. *JAMA* **273**, 1113–1117.

Glasgow City Council (2002, July): *Fruit for Schools Initiative [On-line]* Available:http://www.glasgow.gov.uk/html/council/dept/educ/fruits.htm.

Hackett AF, Jarvis SN & Flanaghan GH (1989): The feasibility of using school-based micro-computers to collect information on the health-related behaviour of children. *Health Educ. J.* **48**, 39–42.

Herbert JR, Clemow L, Pbert L, Ockene IS & Ockene JK (1995): Social desirability bias in dietary self report may compromise the validity of dietary intake measures. *Int. J. Epidemiol.* **24**, 389–398.

Johnson B & Hackett AF (1997): Eating habits of 11-14-year-old school children living in less affluent areas of Liverpool, UK. *J. Hum. Nutr. Diet.* **10**, 135–144.

Key TJA, Thorogood M, Appleby PN & Burr ML (1996): Dietary habits and mortality in 11 000 vegetarians and health conscious people: results of a 17 year follow up. *Br. Med. J.* **313**, 775–779.

Krebs-Smith SM, Heimendinger J, Subar AF, Patterson BH & Pivonka E (1995): Using food frequency questionnaires to estimate fruit and vegetable intake: association between the number of questions and total intakes. *Soc. Nutr. Educ.* **27**, 80–85.

Kristal AR, Andrilla CHA, Koepsell TD, Diehr PH & Cheadle A (1998): Dietary assessment instruments are susceptible to intervention-associated response set bias. *J. Am. Diet. Assoc.* **98**, 40–43.

Landis JR & Koch GG (1977): The measurement of observer agreement for categorical data. *Biometrics* **33**, 159–174.

Livingstone MBE & Robson PJ (2000): Measurement of dietary intake in children. *Proc. Nutr. Soc.* **59**, 279–293.

Lytle LA, Nichaman MZ, Obarzanek E, Glovsky E, Montgomery D, Nicklas T, Zive M & Feldman H (1993): Validation of 24-hour recalls assisted by food records in third-grade children. *J. Am. Diet. Assoc.* **93**, 1431–1436.

McPherson RS, Hoelscher DM, Alxander M, Scanlon KS & Serdula MK (2000): Dietary assessment methods among school-aged children: validity and reliability. *Prev. Med.* **31**, S11–S33.

Moore L, Paisley C & Dennehy A (2000): Are Fruit Tuck Shops in Primary Schools Effective in Increasing Students' Fruit Consumption? A randomised controlled trial. *Nutr. Food Sci.* **30** (1), 35–38.

Novotny JA, Rumpler WV, Judd JT, Riddick H, Rhodes D, McDowell M & Briefel R (2001): Diet interviews of subject pairs: how different persons recall eating the same foods. *J. Am. Diet. Assoc.* **101**, 1189–1193.

Poppitt SD, Swann D, Black AE & Prentice AM (1998): Assessment of selective under-reporting of food intake by both obese and non-obese women in a metabolic facility. *Int. J. Obes. Relat. Metab. Disord.* **22**, 303–311.

StataCorp (1999): *Stata Statistical Software: Release 6.0. User's Guide*. College Station, TX: Stata Corporation.

Steinmetz KA & Potter JD (1996): Vegetables, fruit and cancer prevention: a review. *J. Am. Diet. Assoc.* **96**, 1027–1039.

Thompson FE & Byers T (1994): Dietary resource assessment manual. *J. Nutr.* **124**, 2245S–2317S.

US Department of Health and Human Services (1996): *Healthy People 2000: Midcourse Review and 1995 Revisions*. Washington, DC: Public Health Service.

Williams C (1997): Recommendations and current consumption patterns: how big is the gap? In *At Least Five a Day. Strategies to Increase Fruit and Vegetable Consumption* ed. I Sharp, pp. 19–34. London: The Stationery Office.