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The reliability and relative validity of a diet index score for 4–11-year-old children derived from a parent-reported short food survey

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Abstract

Objective: To assess the reliability and relative validity of a diet index score derived from a Short Food Survey (SFS).
Design: The thirty-eight-item SFS was designed to assess recent dietary intake of 4–11-year-olds to enable calculation of the Dietary Guideline Index for Children and Adolescents. Reliability was assessed based on two online administrations of the SFS, one week apart. Relative validity was assessed by comparing intakes derived from the SFS with those from the mean of three 24 h recalls. Intra-class correlations, Bland–Altman plots and estimated biases were assessed. Cohen's κ coefficients were used to determine the level of agreement between the two methods.
Setting: Adelaide, Australia.
Subjects: Sixty-three parents reported on their children's intake (mean age 7·1 (SD 2·1) years).
Results: The intra-class correlation for reliability ranged from 0·43 for dairy foods to 0·94 for beverages, and was 0·92 for total diet index score (all $P < 0·01$). The intra-class correlation for validity ranged from 0·04 for meat and alternatives to 0·41–0·44 for fruit, beverages and extra foods, and was 0·44 for the total diet index score. The SFS overestimated the mean diet index score by 16 %, and the bias was consistent across levels of compliance. The percentage agreement into tertiles of index scores was 84% between the administrations of the two SFS, but only 43 % when comparing the SFS with the mean of the recalls.
Conclusions: The SFS can provide a consistent estimate of overall compliance to dietary guidelines for children aged 4–11 years, but overestimated the total diet index score by 16 % across all levels of compliance.

Keywords
Short food survey
Diet questionnaire
Diet index
Reliability
Validity

National dietary guidelines provide information about the kinds of foods the population should choose each day to promote good health[1]. Efforts to improve nutritional status and prevent diet-related disease involve promoting food habits which are consistent with dietary guidelines. To monitor population compliance with guidelines we need to be able to measure dietary intake accurately and reliably via methods that are feasible in large research studies and population surveys.

Diet indices have been developed to allow comparisons of overall dietary intake against dietary guidelines. One Australian example is the Dietary Guideline Index for Children and Adolescents (DGI-CA)[2]. This index comprises eleven components including the five core food groups (vegetables, fruit, bread and cereals, meat and alternatives, dairy), healthy fats, water and energy-dense, nutrient-poor 'extra foods', as well as food choices such as choosing reduced-fat milk and wholegrain bread, and dietary variety. Importantly, the composition of the index represents all aspects of the Australian dietary guidelines[3], allowing simultaneous assessment of compliance with the dietary guidelines. The development and validation of the DGI-CA score were based on food intake data averaged from two 24 h recalls[2]. In this format the DGI-CA is not appropriate for use in larger research studies or population surveys for assessing children's compliance with the guidelines.

Assessment of dietary intake is complex, and the appropriate method will depend on the measurement objectives and the dietary outcomes of interest[4]. Methods such as 24 h recalls and weighed food records require trained administrators, can be time consuming

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and inconvenient for participants and time consuming and costly to deploy and analyse. For large research studies and population monitoring, such intensive methods of dietary assessment are not always feasible. The FFQ is a common alternative for dietary assessment as it is relatively easy to administer and less expensive than other methods, yet still can provide estimates of both food and nutrient intakes.

Foods included in FFQ may be chosen for a specific purpose (e.g. to estimate Ca intake) and may not adequately assess total diet. The number of questions included in FFQ can vary widely, up to 350 in the most comprehensive versions, but there are generally about eighty questions[5]. A questionnaire of this length takes a considerable amount of time to complete, which has led to the emergence of shorter dietary assessment tools to measure intake. Short tools also vary in their purpose and composition. Some tools measure discrete food groups such as fruit and vegetables, while others assess total diet and cover up to fifty different foods and beverages. Few short dietary assessment tools have been validated[4]. A recent review identifying tools appropriate for use in large populations found eleven tools with validation studies, six measuring children's intake[4].

Two short dietary assessment tools have been developed and validated in Australian children. The Child Nutrition Questionnaire measures food intake, attitudes, environment and knowledge of children aged 10–12 years[6]. This fourteen-item questionnaire is child-reported and covers intake of extra foods, sweetened beverages, water, fruits and vegetables. The second Australian tool is the Children's Dietary Questionnaire[7]. This twenty-eight-item tool was developed to measure children's compliance with selected dietary guidelines with a focus on obesity-related food habits. The tool measures four aspects of diet: fruit and vegetables, fat from dairy foods, sweetened beverages and extra foods. The limitation with both of these examples is that only selected food groups are measured and therefore simultaneous compliance with all dietary guidelines cannot be evaluated.

Therefore, the aim of the present study was to explore the reliability and relative validity of the DGI-CA score for young children, derived using parent-reported food intake data from a newly developed Short Food Survey (SFS).

Methods

Parents of children aged 4–11 years were recruited via public advertising and word of mouth. Inclusion criteria were: parents of healthy children, living in Adelaide, Australia and willing to be involved in five assessments, with adequate written and spoken English. Parents of children with pre-existing medical conditions affecting their intake such as food allergies or intolerances were excluded. Each parent could only have one child participate. Parents provided informed written consent. The study was approved by the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Human Research Ethics Committee (11/06).

Parents were required to report their child's food intake on five different occasions (as summarised in Fig. 1). Young children have limited ability to conceptualise and recall food consumed over a period greater than one day, so parents were used as proxy reporters[8,9]. The test method for this study was the SFS; therefore it was administered before the comparison method (24 h recall) to minimise any potential influence participation in a dietary recall would have on completing the short survey[5].

The SFS was administered online via Survey Monkey (http://www.surveymonkey.com/). It was administered twice, approximately one week apart (mean 7 (SD 2·1) d, range 2–13 d). Following the completion of the second SFS questionnaire parents were required to attend a

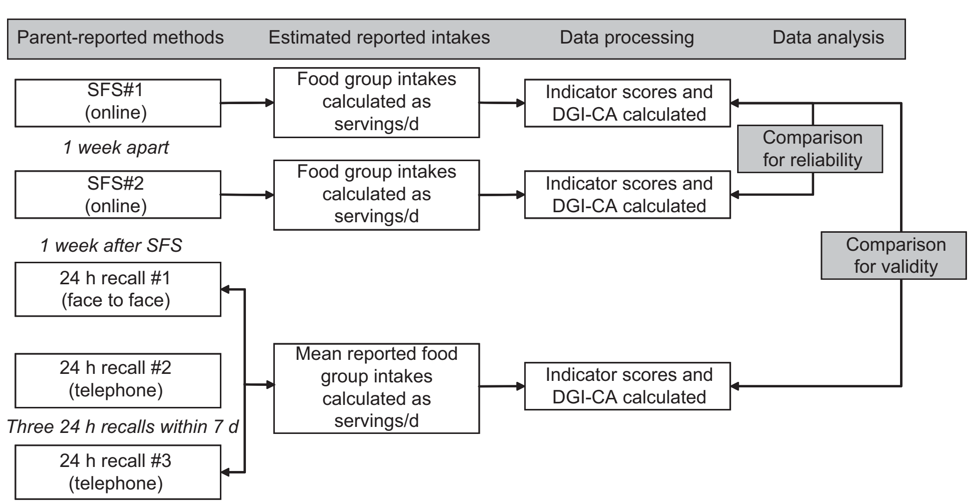

Fig. 1 Summary of the study methodology (DGI-CA, Dietary Guideline Index for Children and Adolescents; SFS, Short Food Survey)

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central city clinic on one occasion. At this visit parents completed a three-pass 24 h recall with a dietitian, as well as responding to a demographic questionnaire regarding their family circumstances (relationship, employment and education status, annual income) and child characteristics including height and weight. Parent-reported height and weight measurements are considered not to be as accurate as those that are independently measured[10], but measurement error for boys and girls is considered acceptable and self-report reduces the burden of participation for families. Following the clinic visit, parents completed another two 24 h recalls via telephone.

Short food survey

The SFS consisted of thirty-eight items capturing information on children's food group intakes and food choices (see Appendix). Questions were chosen to enable a DGI-CA score to be calculated from the SFS. Twenty-seven items estimated usual consumption of the five core food groups, extra foods and beverages. Core food groups were based on the national dietary guidelines[3] and included fruit (two items), vegetables (three items), breads and cereals (three items), meat and alternatives (including legumes/lentils, five items) and dairy foods (three items). Extra foods included (non-core) food items such as salty savoury snacks, confectionery, soft drinks, and biscuits and cakes (eight items). Beverages included all fluids (three items) except dairy fluids (these were included in dairy) and 100 % fruit juice (included in fruit). Parents were asked to report children's usual intake, in servings, per day, week or month. The reference period was specified as over the last week in order to capture 'usual' short term intake, similar to the intended period captured in the multiple 24 h recalls. Four food choices questions asked about the type of milk and spread usually consumed, as well as the frequency of wholemeal/wholegrain breads and trimmed meats eaten. Seven items were related to food variety. These focused on the variety within core food groups over a defined period; for example, the number of different types of fruit eaten in the past 48 h (response options of 0 to 5+; see Appendix). The SFS was piloted with a small sample of parents (*n* 4) for feedback about readability, clarity and comprehension.

Twenty-four-hour recalls

In children of this age, multiple-pass, 24 h recalls (which cover at least three days, including weekdays and weekends) are considered to be a feasible and acceptable dietary assessment method of known performance against doubly labelled water[11]. In the present study a dietitian conducted one face-to-face recall at the clinic visit, followed by two telephone recalls, scheduled within seven days and including one weekend day. Briefly, a multiple-pass recall involves developing a quick list of foods and beverages consumed on the previous day, the second pass collects detailed information on the amount, type, brand and cooking methods and the third pass allows for additional information to be recalled. Parents were provided with a food model booklet, which was adapted from the US Department of Agriculture's Food Model Booklet[12] and used in the Australian National Children's Nutrition and Physical Activity Survey[13]. This was used during all three recalls to assist with portion size estimates. Data were entered by the research dietitian into FoodWorks Professional software version 7. Food groups were created using the hierarchy of food codes in the 2007 AUSNUT Australian food composition database[14] and grams consumed was converted to reference servings based on information contained in the national food selection guide[1].

Calculating diet index scores

Food intake data from the SFS and the average of three 24 h recalls were converted to servings and usual food group intakes per day were calculated (Fig. 1). Daily intake was used to calculate diet quality (DGI-CA) from both the SFS and the 24 h recalls. The DGI-CA scoring criteria are described in detail elsewhere[2]. In summary, the DGI-CA comprises eleven components: five core food groups, wholegrain bread, reduced-fat dairy foods, extra foods (nutrient-poor, energy-rich foods), healthy fats/oils, water and diet variety. Usual daily intake was compared with recommendations set out in the national food selection guide[1] and indicator scores calculated based on the scoring criteria of the DGI-CA scoring matrix (see Appendix). Indicator scoring is such that one dietary recommendation or food group is allocated 10 points. Achievement of a maximum score indicates that an individual's intake met the recommendation or he/she had an optimal intake. Minimum scores were generally assigned to zero intakes, and in between scores were allocated as a proportion of the recommendation. The total DGI-CA score was calculated by summing the eleven indicator scores, with a total possible score of 100, and a higher score representing greater compliance with dietary guidelines.

Statistical analysis

Descriptive statistics (mean and standard deviation) are presented for food group intakes and DGI-CA indicator and total scores for the two SFS administrations and the mean of three 24 h recalls. The significance of the difference in mean estimates of intake was assessed using a paired-samples *t* test. Pearson correlation coefficients were calculated between the two administrations of the SFS (SFS#1 and SFS#2) and between SFS#1 and 24 h recalls. While it has been suggested that correlation coefficients can be a misleading indicator of agreement, they are useful to compare results with other studies that have not used alternative methods to assess agreement[15].

Reliability refers to whether a tool will give the same measurement when measuring the same thing, administered under the same conditions on two separate occasions[16]. Indicator and total DGI-CA scores were calculated and test–retest reliability assessed using intra-class correlations (ICC) using two-way random models. ICC were preferred over correlation coefficients which are commonly reported in other validation studies[6,7] because ICC provide an indication of the level of agreement between two measures whereas correlations show associations but do not provide information about agreement[17]. Level of significance for ICC was $P < 0{\cdot}01$.

Validity refers to how accurately a tool measures the actual quantity it is intended to measure. For diet it is difficult to measure usual intake and no method of assessment is free from error. Therefore in this context, validity refers to a tool's ability to perform relative to another method of dietary assessment of known performance that uses conceptually different methodology[18]. In the present study, relative validity is the comparison between the first SFS and the three 24 h recalls – a previously validated comparison method considered an accurate measure of intake at the group level with known bias (i.e. 7–11 % over-reporting compared with doubly labelled water in children)[16,19]. Relative validity was assessed by comparing indicator scores from SFS#1 and mean of three 24 h recalls using a number of approaches.

ICC using two-way mixed models were used to establish the association between the methods[20]. Bland–Altman plots were used to determine the agreement between absolute values from each method[21]. Bland–Altman plots were generated for all food group indicators, but only the overall DGI-CA plot is presented. Mean differences and limits of agreement (±2 SD) were calculated[21], with positive values suggesting the SFS overestimated the indicator score relative to the 24 h recalls. Mean differences indicate how well the SFS and 24 h recall agree at the study sample level. For each indicator, whether agreement between the methods was constant across the range of intakes was examined. Linear regression analysis was performed for each indicator (the regression of the average of the two methods *v.* their difference) to test if the slope of the mean bias was significantly different from zero[21]. A result different from zero suggests the bias is proportional, or varying across the range of indicator scores.

The ability of the SFS to rank individuals into tertiles of diet index scores was examined using the percentage of exact agreement (within the same tertile) and Cohen's κ coefficient. To quantify the level of error associated with the SFS, mean DGI-CA scores from the 24 recalls were calculated for tertiles created according to SFS#1. One-way ANOVA was used to determine whether differences in mean index scores between tertiles were statistically significant[18].

All statistical analyses were conducted using IBM SPSS Statistics Version 20.

Results

Sixty-six parents were recruited, with sixty-three completing all dietary assessments. Parents were almost entirely female (97 %), married or living as married (95 %), had a tertiary degree (70 %) and were employed part-time (57 %); and their children were aged between 4 and 11 years with a mean age of 7·1 (SD 2·1) years. There were slightly more male than female children in this sample (56 % male) and almost 70 % of children were classified as normal weight (Table 1).

Table 2 shows the mean food group intakes reported from each dietary assessment method. There were no

Table 1 Summary characteristics of child–parent dyads, Adelaide, Australia

	n	%
Child characteristics		
n	63	100·0
Age (years)†	7·1	2·1
4–7	42	66·7
8–11	21	33·3
Gender		
Male	35	55·6
Female	28	44·4
BMI *Z*-score†	−0·03	1·26
Underweight‡	9	14·3
Normal weight	44	69·8
Overweight or obese	10	15·9
Parent characteristics		
n	63	100·0
Age (years)†	39·5	5·0
Gender		
Male	2	3·2
Female	61	96·8
Relationship status		
Separated or divorced	3	4·8
Married or living as married	60	95·2
Highest level of education (parent)		
Completed high school or less	8	12·7
Technical, trade or TAFE qualification	11	17·5
Tertiary degree	44	69·8
Highest level of education (partner)		
Completed high school or less	12	19·0
Technical, trade or TAFE qualification	18	28·6
Tertiary degree	31	49·2
Not applicable	2	3·2
Employment status (parent)		
Full time	13	20·6
Part time	36	57·1
Full-time homemaker	12	19·0
Student	1	1·6
Unemployed	1	1·6
Employment status (partner)		
Full time	54	85·7
Other	9	14·3
Estimated annual household income		
<$AU 51 999	4	6·3
$AU 52 000 to $AU 114 399	21	33·3
>$AU 114 400	31	49·2
Prefer not to or did not answer	7	11·1
Cultural identity		
Australian	55	87·3
Other	8	12·7

†These data are presented as mean and standard deviation.
‡BMI *Z*-score was classified using the International Obesity Taskforce definition[26].

Table 2 Comparison of food intakes estimated from the two administrations of the SFS and the 24 h recalls: parent-reported food intake data of 4–11-year-old children (*n* 63), Adelaide, Australia

Food group	Intake (servings/d)						Difference in estimated intake between methods (servings/d)†				Correlation between methods‖	
	SFS#1		SFS#2‡		Dietary recalls§		SFS#1 *v.* SFS#2		SFS#1 *v.* recalls			
	Mean	SD	Mean	SD	Mean	SD	Mean	95 % CI	Mean	95 % CI	SFS#1 *v.* SFS#2	SFS#1 *v.* recalls
Fruit	2·41	1·03	2·34	1·11	1·84	1·42	0·07	−0·12, 0·26	0·57**	0·22, 0·93	0·69**	0·43**
Vegetables	2·61	1·43	2·50	1·39	1·77	1·85	0·11	−0·23, 0·44	0·84**	0·30, 1·37	0·73**	0·21
Breads and cereals	3·02	1·04	2·83	0·78	2·74	1·20	0·19	−0·04, 0·41	0·28	−0·12, 0·67	0·59**	0·08
Meat and alternatives	1·23	0·55	1·22	0·50	0·90	0·61	0·01	−0·11, 0·12	0·33**	0·15, 0·51	0·62**	0·07
Dairy	2·91	1·34	2·87	1·08	1·45	0·76	0·04	−0·22, 0·31	1·46**	1·13, 1·80	0·43**	0·24
Beverages	3·88	1·41	3·84	1·28	3·54	1·48	0·04	−0·27, 0·36	0·34	−0·05, 0·73	0·94**	0·44**
Extra foods	2·23	1·45	2·06	1·35	2·66	1·58	0·17	−0·03, 0·37	−0·44*	−0·86, −0·02	0·87**	0·44**

SFS, Short Food Survey.
*$P<0·05$, **$P<0·01$.
†Difference between methods assessed using the paired-samples *t* test.
‡The two administrations of the SFS were on average 7 d apart (range 2–13 d).
§Mean of three 24 h dietary recalls.
‖Pearson correlation coefficients.

significant differences between SFS#1 and SFS#2 for the number of servings reported for any food group. While the number of servings reported in SFS#1 was greater in every case, the difference in estimated mean intakes between administrations of the SFS was always less than 0·2 servings. The correlation between mean intakes on the two occasions of the SFS administrations was significant for all food groups ($r=0·43$–$0·94$, $P<0·01$). Mean food group intakes estimated from the dietary recalls were lower than from the SFS administrations for all core foods, but higher for extra foods. The difference between estimated intakes using the SFS#1 and the dietary recalls was not significant for breads and cereals (difference = 0·28 servings, $P=0·166$) and beverages (difference = 0·34 servings, $P=0·084$); however, it was significant for all other foods (differences ranged from 0·33 to 1·46 servings for core foods and was −0·44 servings for extra foods, all $P<0·05$). The correlation between SFS#1 and the 24 h recalls was significant only for fruit, beverages and extra foods ($r=0·43$–$0·44$, $P<0·01$).

Reliability of the diet index score derived using the short food survey

Table 3 shows the ICC for the DGI-CA indicator scores calculated from the two administrations of the SFS. The ICC for food groups ranged from 0·43 for dairy foods to 0·94 for beverages, and for the food choice indicators ranged from 0·77 for variety to 0·96 for reduced-fat dairy foods. The ICC for the total DQI-CA score was 0·92. All ICC were significant ($P<0·01$).

Relative validity of the diet index score derived using the short food survey

The ICC for the validity of the DGI-CA indicator scores was lowest for meat and alternatives (ICC = 0·04, $P=0·393$) and breads and cereals (ICC = 0·08, $P=0·279$) and highest for fruit, beverages and extra foods (ICC = 0·41–0·44, $P<0·01$, Table 3). The ICC for food choice indicator scores were generally higher than for the food group indicators. The ICC for wholegrain breads and cereals was lowest (ICC = 0·21), but all ICC for food choice indicators were significant (ICC = 0·21–0·47, $P<0·05$ or better). The ICC for the total DQI-CA score was 0·44 ($P<0·01$).

The total DQI-CA score derived from the SFS tended to overestimate the total DQI-CA score calculated from the 24 h recalls by an average of 16 points (out of 100), and the Bland–Altman plot shows that the total DGI-CA score derived using the SFS ranged from 39 % above to 7 % below the total DGI-CA score derived from the 24 h recall data (Fig. 2). The slope of this bias was not significantly different from zero (that is, the bias was consistent across the range of diet index scores). The greatest bias, within the food groups, was observed for extra foods and vegetables where the SFS overestimated the indicator score by 2·12–2·40 points (out of 10), but the slopes of

Table 3 Reliability and validity of DGI-CA total and indicator scores calculated using the SFS and 24 h recalls: parent-reported food intake data of 4–11-year-old children (*n* 63), Adelaide, Australia

	SFS#1		SFS#2		Dietary recalls†		Reliability‡		Validity§					
Indicator (/possible score)	Mean	SD	Mean	SD	Mean	SD	ICC‖	95 % CI	ICC	95 % CI	Bias¶	95 % LOA††	Slope of bias	*P* value
Total DGI-CA score (/100)	77·56	10·0	78·13	10·5	61·61	12·0	0·92**	0·88, 0·95	0·44**	0·22, 0·62	15·95	−7·42, 39·32	−0·163	0·109
Food groups														
Fruit (/10)	9·84	1·26	9·52	1·78	9·14	1·80	0·65**	0·48, 0·77	0·41**	0·18, 0·59	0·70	−2·69, 4·10	−0·290	0·002
Vegetables (/10)	7·04	2·59	6·77	2·55	4·64	3·26	0·73**	0·59, 0·83	0·21*	−0·04, 0·43	2·40	−5·02, 9·81	−0·141	0·071
Breads and cereals (/5)	2·81	0·81	2·68	0·74	2·55	1·09	0·58**	0·40, 0·73	0·08	−0·17, 0·31	0·25	−2·36, 2·86	−0·155	0·023
Meat and alternatives (/10)	9·72	0·79	9·71	0·82	8·01	3·16	0·62**	0·44, 0·75	0·04	−0·21, 0·28	1·71	−4·70, 8·12	−0·456	<0·001
Dairy (/5)	4·77	0·50	4·79	0·47	3·29	1·31	0·43**	0·20, 0·61	0·16	−0·09, 0·39	1·49	−1·07, 4·05	−0·445	<0·001
Beverages (/10)	9·14	1·28	9·08	1·33	8·36	1·67	0·94**	0·90, 0·96	0·43**	0·20, 0·61	0·77	−2·42, 3·96	−0·224	0·024
Extra foods (/20)	14·66	7·17	15·74	6·87	12·54	8·04	0·87**	0·80, 0·92	0·44**	0·21, 0·62	2·12	−14·05, 18·29	−0·101	0·322
Food choices														
Whole grains (/5)	4·48	1·11	4·40	1·25	2·37	1·53	0·79**	0·67, 0·86	0·21*	−0·04, 0·43	2·11	−1·25, 5·47	−0·194	0·013
Reduced-fat dairy (/5)	1·94	1·88	1·98	1·91	2·08	1·63	0·96**	0·93, 0·97	0·47**	0·26, 0·64	−0·14	−3·75, 3·47	0·132	0·215
Healthy fats (/10)	6·67	2·73	6·98	2·81	6·95	3·65	0·85**	0·76, 0·91	0·41**	0·18, 0·60	−0·28	−7·28, 6·72	−0·239	0·014
Variety (/10)	6·49	1·15	6·45	1·35	7·84	2·11	0·77**	0·64, 0·85	0·40**	0·17, 0·59	−1·34	−5·08, 2·39	−0·450	<0·001

DGI-CA, Dietary Guideline Index for Children and Adolescents; SFS, Short Food Survey; ICC, intra-class correlation; LOA, limits of agreement.
$^*P<0·05$, $^{**}P<0·01$.
†Mean of three 24 h dietary recalls.
‡ICC calculated using a two-way random model, type: consistency.
§ICC calculated using a two-way mixed model, type: consistency.
‖All $P<0·001$.
¶Positive value for difference means that SFS is higher than 24 h recall (SFS overestimates); negative value means that SFS is lower than 24 h recall (SFS underestimates).
††95 % LOA = ± 2 SD, slope of bias is regression.

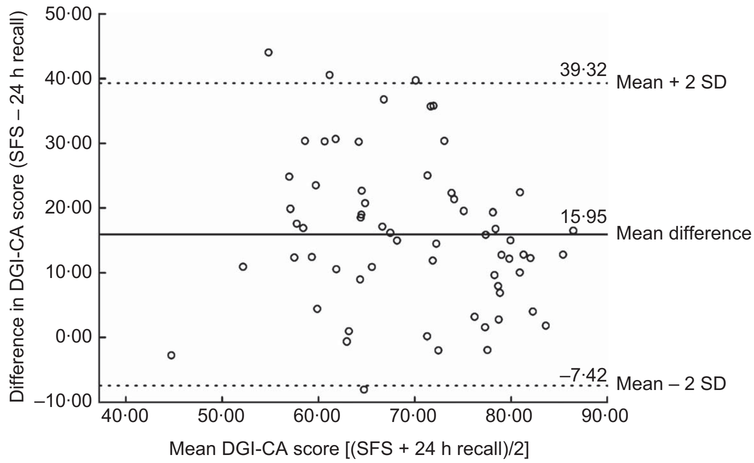

Fig. 2 Bland–Altman plot showing agreement between total DGI-CA scores calculated by the SFS and 24 h recalls. —— represents the mean difference between the two methods; – – – – represent the 95 % confidence interval (DGI-CA, Dietary Guideline Index for Children and Adolescents; SFS, Short Food Survey)

Table 4 Agreement between methods by allocation to tertiles: parent-reported food intake data of 4–11-year-old children (*n* 63), Adelaide, Australia

	DQI-CA from SFS#1		
	Percentage agreement†	κ	*P* value
DQI-CA from SFS#2	84·1	0·762	<0·001
DQI-CA from 24 h recalls	42·9	0·143	0·109

DGI-CA, Dietary Guideline Index for Children and Adolescents; SFS, Short Food Survey.
†Exact percentage agreement for tertile allocation.

these biases were not significant. The biases for dairy foods and meat and alternatives were also relatively high in the context of the overall indicator score (1·49–1·71 points out of 10) but these food groups demonstrated proportional bias (that is, the bias decreased as the indicator score increased).

Percentage agreement between methods

In 84 % of cases the DGI-CA score derived from the two administrations of the SFS placed an individual in the same tertile for the diet index score (Table 4). The Cohen's κ value suggests substantial agreement between the two administrations of the SFS ($\kappa = 0{\cdot}76$, $P < 0{\cdot}001$). The level of agreement between SFS#1 and the 24 h dietary recalls would be considered less acceptable ($\kappa = 0{\cdot}14$, $P = 0{\cdot}109$), with only 43 % of individuals being placed in the same tertile of the index score using the different methods (Table 4).

To assess the measurement error of the SFS, DGI-CA scores from the 24 h recalls were calculated for tertiles of DGI-CA score created according to SFS#1. There was a progressive increase in DGI-CA score with SFS tertile ($P < 0{\cdot}001$, Table 5).

Discussion

The present paper describes the performance of a diet index, the DGI-CA, when index scores are derived using dietary intake data assessed using the SFS. Overall, the thirty-eight-item SFS demonstrated good reliability for all eleven indicators of the diet index. The level of agreement analysis showed that the SFS tended to overestimate intake of core food groups and underestimate the intake of extra foods compared with multiple 24 h recalls. The SFS was able to produce a reliable estimate of overall compliance with dietary guidelines, but overestimated the diet index score (DGI-CA) by 16 % relative to recalls. Its ability to correctly classify children into tertiles of compliance was less than 50 %, but comparable to another Australian study validating an FFQ against 3 d food diaries[15].

The performance of the SFS compared with multiple 24 h recalls was below an acceptable level for several aspects of guideline compliance (e.g. vegetables, breads and cereals, dairy and meat), but not unlike other short dietary assessment tools validated in Australian populations. The Children's Dietary Questionnaire is most similar to the current study in its attempt to measure compliance with dietary guidelines, but only includes four aspects of children's diet. The relative validity using a 7 d food checklist as the reference method, based on Spearman correlations, ranged from 0·31 for extra foods to 0·60 for fat from dairy products[7]. A second questionnaire, the Child Nutrition Questionnaire, differed from the SFS in that children reported their own intake and estimated intake was compared with 7 d diet diaries, but correlation coefficients were similar (ranging from 0·36 for non-core foods and vegetables to 0·48 for fruit)[6]. So while the SFS builds on previous studies as a comprehensive measure of diet in children from which compliance with dietary guidelines can be estimated, its performance relative to a

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Table 5 Mean diet index score from the 24 h recalls for tertiles from the SFS: parent-reported food intake data of 4–11-year-old children (*n* 63), Adelaide, Australia

	Tertile of DGI-CA score from SFS#1					
	Tertile 1		Tertile 2		Tertile 3	
	Mean	SD	Mean	SD	Mean	SD
Mean DGI-CA score from 24 h recalls†	55·36	8·82	61·94	13·88	67·54	9·87

DGI-CA, Dietary Guideline Index for Children and Adolescents; SFS, Short Food Survey.
†Comparison between groups using ANOVA, significant difference and significant linear trend $P<0·01$.

more established method of dietary assessment needs to be improved.

A study from Belgium describes a similar process to validate a diet quality index score for children, but using data derived from an FFQ[22]. This index also compares children's intake with food-based dietary guidelines. The reported reliability was slightly lower than ours (Pearson correlation $r=0·88$), and validity relative to a 3 d record ranged from 0·39 to 0·74 for the different components of the index and was 0·82 overall. The mean difference between diet index scores derived from their test and reference methods was 5 %, compared with 16 % reported for the SFS. The agreement of classification into tertiles for repeat administrations was higher for our study (84 % *v.* 69 %), but lower between test and reference methods (43 % *v.* 60 %)[22]. Both studies showed progressive increases in diet index score with tertiles created using the test method. The Belgium FFQ is also parent-reported but is longer (forty-seven items) and includes frequency of meals and dietary moderation, which may be more habitual behaviours than food intake and partially explain the better relative validity results. Also, their validation was conducted in younger children for whom parents have more control over intake. Evidence suggests that parents are reliable reporters of their children's intake within the home, but not as good at reporting foods consumed outside the home[8].

The ability of the SFS to estimate breads and cereals, meat and alternatives, and dairy indicator scores, compared with the mean of three 24 h recalls, was poorer than for other indicators. This may reflect the questions within the SFS, parents' accuracy in reporting intake of these food groups or real day-to-day variation in children's eating habits. If daily variation in children's intake is high, parents may find it more difficult to estimate usual intake over the past week. In addition, pasta, rice and meat, for example, are often consumed within composite dishes, making estimating amounts consumed more difficult. Consumption of meat was asked as a frequency (where one serving was assumed to be consumed per eating occasion). The use of frequencies as an indication of portions has been validated in Australian adults[23], but results from the present study suggest that for some food groups this may not be the best way to ask parents to report their children's usual intake.

Also, the number of questions included is important. Fruit intake was estimated in one question, whereas for vegetables parents were asked to think about cooked, salad and starchy vegetables in separate questions. The level of agreement between the two methods for fruit was much higher than the level of agreement for vegetables. Fruit consumption might be more habitual and usually eaten as one piece (e.g. banana for breakfast), whereas vegetables are eaten in a range of ways and may be more difficult for parents to estimate. The questions associated with these poor-performing indicators need to be refined to better capture children's intake within the defined time period. Previous studies have not measured children's intakes of meat and bread and cereals, possibly because it has proved too difficult.

Mean bias indicates that compared with 24 h recalls, the SFS overestimates indicator scores for all food groups but underestimates extra foods, healthy fats, reduced-fat dairy and diet variety scores. Overestimation of intake of 'desirable' or healthy aspects of diet is commonly reported[22]. The type and the size of the bias in the context of the possible score need to be considered. Extra foods and vegetables were the two food groups with the greatest degree of bias, but in both cases the regression analysis revealed no significant difference between the slope of the bias line and zero; therefore this bias is considered to be consistent across the range of intakes and can be adjusted for more easily. In contrast for meat and dairy the bias was proportional, meaning it varied over the range of intakes, and therefore is more difficult to adjust for. The SFS overestimated the DGI-CA score derived from 24 h recalls by about 16 %, but the bias was similar regardless of the level of compliance. Ideally a questionnaire would have no bias, but all dietary assessment methods have some bias or error associated with them, so it is useful to know the magnitude of bias associated with the SFS and that, for the diet index score at least, the amount of bias is consistent across the study population.

When designing validation studies, it is important to note that the most accurate results are reported when the reference method and test tool cover the same period of time[16]. It is likely that estimates of DGI-CA derived from the SFS underestimate the relative validity of the SFS because data from the survey were collected prior to the period that the 24 h recalls were collected. The SFS asked parents to think about their children's usual intake over the past week. In this analysis we assumed that three days of recall within the following week would also reflect usual food group intake and therefore be a comparable point of reference to estimate validity. However, it is possible that three days of recall is not enough to capture children's usual intake, particularly given the choice and diversity in the Australian food supply. Results of this study suggest that the test and reference methods may not have captured the same period of time, contributing to poor agreement between the two methods[5].

The strength of the present study is that the SFS allows whole-of-diet quality and compliance with dietary guidelines to be determined in a relatively short questionnaire. Previous questionnaires have included a selection of food groups or dietary guidelines but here we have attempted to capture the guidelines in their entirety. This ability to feasibly measure compliance with guidelines will be useful for larger population studies. However, to allow monitoring of compliance with guidelines at a population level, the ability of the SFS to detect change in diet quality over time would need to be tested. The sample size was considered sufficient to adequately determine reliability and validity[5,24]. In terms of weight status distribution, these children were similar to the broader Australian population[13]; however, the mean diet index score was higher than the national average[2].

The SFS is not immune to the errors and biases associated with most self-reported dietary assessment methods. The accuracy of the SFS to estimate compliance with guidelines relies on the estimation of food groups using the SFS to be as similar as possible to the reference method. Significant differences were observed between the SFS and 24 h recalls for five of seven food groups, which indicates limited ability of the SFS to estimate absolute intakes. Social desirability is a common phenomenon which may explain the over-reporting of healthy foods and under-reporting of extra foods seen here and in similar studies[22]. Children in the present study were from well-educated, high-income, traditional families[25], so generalisability of the results to the whole population and lower socio-economic groups should be with caution. Finally, it has been suggested that by age 10 years, children have the ability to be the primary source of recall[8]. Future research could evaluate the SFS performance for child- *v.* parent-reported data.

Conclusion

Accurate and consistent measurement of dietary intake is important when evaluating public health efforts to improve diet. The SFS can provide a consistent estimate of overall compliance to dietary guidelines for children aged 4–11 years but the accuracy of the tool at both the individual and group level needs improvement. The SFS consistently overestimated diet quality by 16% across all levels of compliance, suggesting adjustment would be necessary when estimating diet index scores in future research.

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Appendix

Details of the Short Food Survey (SFS): questions, responses and Dietary Guideline Index for Children and Adolescents (DGI-CA) scoring criteria

Indicator	Question	Response	Criteria for minimum	Criteria for maximum score		Score allocated
				4–7 years	8–11 years	
Fruit	How many servings of fruit does your child usually eat (per time frame†)?	Number of servings	0 servings	≥1	≥1	10
	How many servings of 10 % fruit juice does your child usually drink (per time frame)?					
Vegetables	How many servings of starchy vegetables (not including hot chips) does your child usually eat (per time frame)?	Number of servings	0 servings	≥3	≥4	10
	How many servings of salad vegetables does your child usually eat (per time frame)?					
	How many servings of cooked vegetables does your child usually eat (per time frame)?					
Breads and cereals	How many times‡ does your child usually eat bread (per time frame)?	Number of times	0 servings	≥5	≥6	5
	How many times does your child usually eat pasta, rice, noodles or other cooked cereals (per time frame)?					
	How many times does your child usually eat breakfast cereals (per time frame)?					
Meat and alternatives	How many times does your child usually eat red meats (per time frame)?	Number of times	0 servings	≥0·5	≥1	10
	How many times does your child usually eat white meats (per time frame)?					
	How many times does your child usually eat meat products (per time frame)?					
	How many times does your child usually eat legumes or other meat alternatives (per time frame)?					
	How many times does your child usually eat eggs (per time frame)?					
Dairy	How many cups of milk does your child usually have (per time frame)?	Number of cups	0 servings	≥2	≥2	5
	How many times does your child usually eat cheese (per time frame)?	Number of times				
	How many times does your child usually eat yoghurt or custard (per time frame)?					
Beverages	How many times does your child usually have soft drink, cordial or sports drinks (per time frame)?	Number of times	No water consumed	100 % water	100 % water	10
	How many times does your child usually have soft drink, cordial or sports drinks (per time frame)?					
	How many cups of water does your child usually drink (per time frame)?	Number of cups				
Extra foods	How many times does your child usually have meals or snacks from these takeaway food stores (per time frame)?	Number of times	>4 servings	≤2	≤2	20
	How many times (per time frame) does your child usually eat oven baked potato gems/chips/hash browns, hot chips/French fries, wedges, fried potatoes?					
	How many times (per time frame) does your child usually eat savoury snacks such as crisps, pretzels or plain/flavoured crackers?					
	How many times (per time frame) does your child usually have sweet biscuits/cakes/buns/muffins/doughnuts?					
	How many times (per time frame) does your child usually eat savoury pastries?					

Appendix *Continued*

Indicator	Question	Response	Criteria for minimum	Criteria for maximum score		Score allocated
				4–7 years	8–11 years	
	How many times (per time frame) does your child usually eat snack type bars?					
	How many times (per time frame) does your child usually have chocolate or lollies?					
	How many times (per time frame) does your child usually have ice cream or ice-blocks?					
Variety	How many different types of fruit has your child eaten in the past 48 h (2 d)?	Number of different types	<0·5 servings over 2 d	2 points for each of the 5 core food groups		10
	How many different types of vegetables has your child eaten in the past 48 h (2 d)?					
	How many different red or orange vegetables has your child eaten in the past 48 h (2 d)?					
	How many different green vegetables has your child eaten in the past 48 h (2 d)?					
	How many different types of dairy foods has your child eaten in the past 48 h (2 d)?					
	Which of the following meat or alternatives has your child eaten over the past 7 d?	List provided				
	Which of the following breads and cereal foods has your child eaten over the past 24 h?	List provided				
Food choices	How often is the bread your child eats wholegrain/wholemeal?	Always/usually/sometimes/never/doesn't eat bread	Never or doesn't eat bread	Always/usually consume = 5 Sometimes = 2·5		5
	What type of milk does your child usually have?	Whole, reduced, skimmed, soya, reduced-fat soya, other, doesn't have milk	Whole milk	Skimmed = 5 Low/reduced = 2·5		5
	How often does your child have meat that was trimmed before cooking?	Always/usually/sometimes/never/doesn't eat meat	Never trimmed meat	Always/usually trimmed meat		5
	What type of spread does your child usually have?	Butter, table margarine, unsaturated margarine, doesn't have spread	Butter	Unsaturated margarine		5
					DGI-CA score	100

†Each question was prefaced by the following question to establish the appropriate time frame: 'How often does your child usually eat (indicator food)?' Response categories: Each day/each week/each month/doesn't eat.
‡Amount consumed per occasion of eating was assumed to equal one serving when times per day were reported.