Public Health Nutrition: 15(11), 2091–2099 doi:10.1017/S1368980012001012

Development and validation of a Meal Index of dietary Quality (Meal IQ) to assess the dietary quality of school lunches

Marianne S Sabinsky[1,*], Ulla Toft[2], Klaus K Andersen[3] and Inge Tetens[1]
[1]Department of Nutrition, National Food Institute, Technical University of Denmark, Mørkhøj Bygade 19, DK-2860 Søborg, Denmark: [2]Research Centre for Prevention and Health, Glostrup University Hospital, Glostrup, Denmark: [3]The Danish Cancer Society, Copenhagen, Denmark

Submitted 18 April 2011: Final revision received 31 January 2012: Accepted 27 February 2012: First published online 27 April 2012

Abstract

Objective: School lunch programmes are one strategy to promote healthier dietary habits in children, but better evaluation tools for assessing the dietary quality of such programmes are needed. The aim of the present study was to develop and validate a simple index to assess the dietary quality of school lunches for children aged 7–13 years.
Design: A Meal Index of dietary Quality (Meal IQ) was developed to consist of seven components (nutrients and food groups) based on dietary issues for children aged 7–13 years, which were identified in a national dietary survey. The Meal IQ was validated against calculated nutrient contents of school lunches both provided by the school and brought from home.
Setting: At eight public schools from all over Denmark, data were collected on 191 individual lunches brought from home (which is most common in Denmark) and thirty-one lunches provided as part of a school food programme. In addition thirty-two lunches provided at eighteen other public schools were included.
Subjects: A total of 254 school lunches.
Results: A higher Meal IQ score was associated with a higher overall dietary quality, including lower contents of fat, saturated fat and added sugars, higher contents of fibre, various vitamins and minerals, and more fruits, vegetables and fish.
Conclusions: The Meal IQ is a valid and useful evaluation tool for assessing the dietary quality of lunches provided by schools or brought to school from home.

Keywords
Diet assessment
School meals
Packed lunches
Score

The school has been recognized as an important setting for health promotion, especially eating habits among children(1). In Denmark, it has been common practice for most children to bring their lunch to school from home, but more recently several initiatives with school food programmes have been introduced, one of the main objectives being to improve the dietary habits of school-aged children.

To investigate if school food programmes actually improve children's dietary intake at school, it is important to have appropriate tools for evaluating such health promotion initiatives. However, one of the challenges with regard to diet is the lack of simple and valid dietary assessment tools to monitor possible differences in the dietary quality between lunches provided as part of a school food programme and lunches brought from home.

Dietary quality indices have received increased attention and may be used as a simple and quick assessment of overall diet quality in order to evaluate adherence to dietary guidelines or guidelines for the prevention of a specific disease, as well as to monitor dietary changes(2).

A variety of dietary indices have been developed to assess overall dietary quality based on different assessment methods and data for a varying number of days. The dietary indices have mainly been proposed for adults(3–10), but indices specifically for children have also been developed. The Preschoolers Diet–Lifestyle Index (PDL-index)(11) and the Revised Children's Diet Quality Index (RC-DQI)(12) focus on pre-school children. The Youth Healthy Eating Index (YHEI) has been developed and used for children and adolescents(13).

Most indices assess the dietary quality of the total diet, whereas indices reflecting the nutrient quality of single meals, including school lunches, remain limited. A Simple Healthy Meal Index (SHMI) was developed to reflect the nutrient profile of single meals provided by canteens for adults(14). Kremer *et al.* developed a school food checklist, with food and beverage categories, which was designed to estimate children's average energy intake from foods and beverages available in a school setting(15). There, the focus was on the quantity, measured in the energy content of the meal, and not on the quality.

*Corresponding author: Email masab@food.dtu.dk

However, there is a need for a tool for scientific purposes where the focus is on the dietary quality of a single meal for school-aged children. The requirements for such a tool are that it has to be simple; it must be flexible with regard to the different types of meals; and it must also be sensitive enough to measure relevant differences when children eat lunches provided by the school instead of lunches brought from home.

The aim of the present study was to develop and validate an index for assessment of dietary quality of school lunches, either brought from home or provided by the school.

Experimental methods

Study sample

Data for the validity study came from a school food programme intervention study in which eight schools from all over Denmark participated. A standardized digital photographic method[16] was used to collect data on the lunches brought from home by students in the second and third grades (7–10 years) and fifth and sixth grades (10–13 years). The digital images were used to assess typical lunches among schoolchildren in Denmark in the present study. A sample of 191 lunches brought from home was selected randomly out of a total of 6061, taking into consideration the school and age of the children. To validate the developed Meal IQ, it was necessary to have weighed food records. Based on digital images of the lunches brought from home, an identical double portion of the meal was produced and the weight of the lunches' various food items was recorded. In the intervention schools, thirty-one different lunches provided by the schools were served. Recipes and product specifications for these lunches were collected. Two of each of the school meals were bought and the food items were weighed and registered in order to obtain the weighed food records. The data were collected during August–December 2008 and February–April 2009.

To increase the number of lunches provided by schools and thereby ensure greater representativeness, another thirty-two provided school meals were included in the study sample. These meals were collected in another Danish study in eighteen public schools, representative for Danish schools in terms of degree of urbanization and size (numbers of pupils)[17]. Weights of the food items in the lunches provided at the schools were recorded and recipes and product specifications were collected. These data were collected during November 2007–April 2008.

In total, the study sample consisted of weighed food records for 254 school lunches: 191 lunches brought from home and sixty-three lunches provided by schools.

Development of the Meal Index of dietary Quality

Overall model selection

The Meal Index of dietary Quality (Meal IQ) scoring system was developed to provide a simple measure of dietary quality of school lunches for children aged 7–13 years. The steps in the development of the Meal IQ were inspired by a nutrient profiling approach[18] and included: selection of variables; selection of measures for assessing the variables; definition of scoring systems and thresholds; and validation of the Meal IQ (Fig. 1).

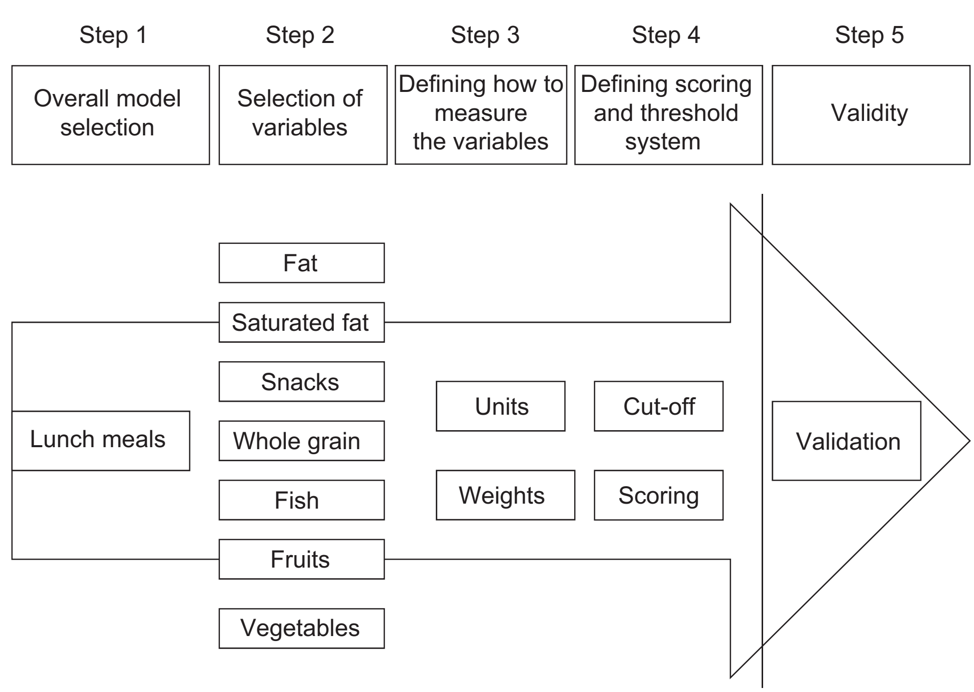

Fig. 1 Steps in the development and validation of the Meal Index of dietary Quality (Meal IQ). Modified from Verhagen and van den Berg[18]

https://doi.org/10.1017/S1368980012001012 Published online by Cambridge University Press

Selection of variables

The selection of variables was based on the dietary issues that are particularly relevant to the lunches and general food intake of children aged 7–13 and also on knowledge of the association between nutrients/food groups and chronic diseases.

Data from the Danish National Survey of Dietary Habits and Physical Activity revealed that to meet the official nutrition recommendations[19] and the dietary guidelines[20], Danish children should eat less fat, especially saturated fat, and less added sugar. Furthermore, children should increase their intakes of fruits, vegetables, whole grain and fish[21–23]. These considerations led to a Meal IQ consisting of seven components, which reflect the following nutrients and food groups: fat, saturated fat, sweet snacks as a proxy for added sugar, whole grain, fish, fruits and vegetables.

Measurement of variables

The Meal IQ components, i.e. fruit, vegetables and fish, were estimated in grams. To estimate total fat, saturated fat, whole grain/potatoes and snack products in the lunch meals, unit sizes were defined in terms of household measures such as slices, cups and pieces[14]. For validation purposes, weights in grams were assigned to each of the units; and from the weighed food records, the different number of units could be estimated.

In the development of the Meal IQ, nutrition criteria such as balance, moderation and adequacy were used to ensure the recommended macronutrient distribution within the meal. As a measure of the relative content of fat in the meal, fat units were combined with the number of starchy food units to ensure the right balance. The number of fat units was subtracted from the number of starchy food units. A fat unit was defined as 5 g of fat. This corresponds to approximately 50 g of a medium-fat product with about 10 % fat (e.g. chicken with skin, meat used for skewers); 20 g of a high-fat product (e.g. liver pâté, sausage, feta cheese: approximately 25 % fat); 10 g of a very-high-fat product (e.g. bacon, pepperoni, regular vinegar/oil salad dressing: approximately 50 % fat); or 5 g of solid fats and oils (e.g. butter, oil, mayonnaise: 80 % or more fat). Low-fat products (e.g. lean ham, cottage cheese: 5 % fat or less) do not contribute to the fat unit accounts. Furthermore, fish and plain nuts were not counted as fat units, regardless of fat content, as these foods are considered part of a healthy diet. A starchy unit corresponded to 50 g of bread, 75 g of pasta or rice, 150 g of potatoes, 300 g of vegetables, 200 g of fruits and 35 g of dried fruits, which corresponded to an energy content of about 400–500 kJ (about 25 g of starch per unit).

If the fat units were animal-based they were counted and used as an approximation of the content of saturated fat in the meal. Whole grain and potatoes were combined in the same score, since potatoes (cooked, baked or mashed) are a common accompaniment to hot meals as an alternative to rice or pasta, and it is recommended to eat potatoes several times weekly[20]. The number of starchy food units, which consist of a wholegrain product or potatoes, was counted to reflect the content of healthy starch units (whole grain) in the meal. A wholegrain product was defined as containing ≥51 % DM[23] (e.g. rye bread, wholemeal pasta and brown rice). Snack products were used as a proxy for the content of added sugar. A snack product was defined as having a nutrient content beyond the following limits: fat >10 g/100 g and/or saturated fat >4 g/100 g and/or added sugar >10 g/100 g[24]. The starchy units in snack products often consist of more added sugar. The starchy units in snack products were counted separately, and this assessment was relevant for the differentiation of the score for this component of the Meal IQ. The contribution of fat units and saturated fat units from the snack products was also counted, and was added to the total fat units.

To make the assessment of fat units, saturated fat units and starchy units from snack products as simple as possible, lists were made to support the process. The lists for assessment of fat units contained the most common fat-containing products, with information on the fat content per 100 g of the product and the quality of the fat; and the list of the most used snack products contained information about the contents of starch and fat and fat quality of one snack product or 100 g of the product.

Defining scoring systems and thresholds

Each of the seven components of the Meal IQ was scored from 0 (lack of compliance) to 4 (full compliance) with intermediate scores reflecting level of attainment towards dietary recommendations[19,20], but intake level in the population was also taken into consideration, especially when cut-offs for the components, which build on units, were defined. However, for snack products, the score was assessed somewhat differently. If no snack product was present in the meal, 4 points were given. If the meal contained a snack product, then the score 0 or 2 could be given, depending on the contribution of starchy units it contained. If the contribution of starchy units was ≥0·5 units, the score would be 0, but if the content of starchy units was <0·5 units then the score of 2 was given. The value 0·5 units was used to define the cut-off because it represents a relatively high contribution of starch from the snack product, about 10 % of the energy content of the meal. If most of the starch is added sugar, the content of added sugar meets the maximum level, according to the official nutrition recommendation[19]. The total score for the Meal IQ ranged from 0 to 28. The construction and criteria for scoring each component are listed in Table 1.

Validation of the Meal IQ

The Meal IQ was tested on 254 calculated meals (191 lunches brought from home and sixty-three lunches provided by schools) for its ability to assess dietary quality.

Table 1 The Meal Index of dietary Quality (Meal IQ) scoring criteria for each of the seven components

	0 point	1 point	2 points	3 points	4 points
1. Total fat (units)	Starch – fat ≤ −1	−1 < Starch – fat < −0·25	−0·25 ≤ Starch – fat ≤ 0·25	0·25 < Starch – fat ≤ 1	Starch – fat > 1
2. Saturated fat (units)	SFA > 3	3 ≤ SFA < 2	2 ≤ SFA<1	1 ≤ SFA < 0	SFA = 0
3. Whole grain and potatoes (units)*	Whole grain = 0	0<Whole grain ≤ 0·5	0·5<Whole grain ≤ 1	1 < Whole grain ≤ 1·5	Whole grain > 1·5
4. Snack products (Yes/No) (units)†	Yes and starch units > 0		Yes and starch units = 0		No
5. Fish (g)	0	0–10	10–20	20–30	>30
6. Fruits (g)	0	0–17‡/0–25§	17–33‡/25–50§	33–50‡/50–75§	≥50‡/≥75§
7. Vegetables (g)	0	0–17‡/0–25§	17–33‡/25–50§	33–50‡/50–75§	≥50‡/≥75§

*Wholegrain products have a content of whole grain ≥51 % of DM[22].
†If no snack product is present in the meal, 4 points is achieved. If the meal contains a snack product, then the score 0 or 2 could be given; if the contribution of starchy units is ≥0·5 units the score would be 0, but if the amount of the snack product is so limited that the contribution of starchy units is <0·5 units then the score of 2 is given. A snack product is defined as having a nutrient content beyond the following limits: fat >10 g/100 g and/or saturated fat >4 g/100 g and/or added sugar >10 g/100 g[23].
‡Limits for children up to 11 years of age.
§Limits for children from 11 years.

The nutrient content of the meals was calculated from the weighed food records of the meals and the recipes and product specifications. The nutrient calculations were conducted using the computer program GIES (General Intake Estimation System; National Food Institute, Søborg, Denmark)[25]. First, the single components in the Meal IQ were tested to examine if the components correlated with the nutrient concerned. Then, the Meal IQ score was estimated from the weighed food record of the lunches and validated against the calculated nutrient content of these meals.

Statistical analysis

To investigate if the selected components in the Meal IQ reflected the nutrients of concern, correlation coefficients between the estimated components and the objective measures were assessed. Because the data on dietary intake were not normally distributed, Spearman's correlation coefficient was used[26]. The estimated components were classified into quartiles. Gross misclassification was defined as classification in the opposite quartile observed in the highest and lowest quartile. Correlations between the Meal IQ score and the calculations of the nutrient content were assessed. The sample was divided into four categories according to the total Meal IQ score; and mean values of energy and nutrient content of the meals were compared by ANOVA, after testing for equality of variances, or using the Kruskal–Wallis test[27,28]. Bonferroni correction was used to account for increase in type I error due to multiple comparisons[29]. Linear trends across the categories were tested by modelling the score as a continuous variable in the model and testing for model reduction[27].

All reported P values were based on two-sided hypotheses and compared with a significance level of 5 %. Statistical analyses were carried out using the SAS statistical software package version 9·2 (SAS Institute Inc., Cary, NC, USA).

Results

Correlation between the Meal IQ components and calculated nutrient content in the school lunches

Each of the components not measured in grams (total fat, saturated fat, whole grain/potatoes and snack products) was estimated from the weighed food records and validated against the relevant calculated nutrient content (Table 2). The component estimating fat content was highly correlated to the percentage of energy from fat ($r = -0{\cdot}77$). Numbers of saturated fat units were correlated to the percentage energy from saturated fat ($r = 0{\cdot}76$). The number of whole grain units was correlated to dietary fibre ($r = 0{\cdot}56$); and the snack component was correlated to added sugar in the meals ($r = 0{\cdot}57$).

The proportion of meals which were classified into the same or adjacent quartiles from the measured component

https://doi.org/10.1017/S1368980012001012 Published online by Cambridge University Press

Table 2 Correlations between the calculated nutrient content of the meal components and the nutrient components of the Meal Index of dietary Quality (Meal IQ; *n* 254)

Component		Correlation	
Calculated from weights of ingredients in the meals	Estimated values	Spearman correlation coefficient	*P* value
Fat (%E)	Starch units – fat units	−0·77	<0·0001
Saturated fat (%E)	Saturated fat units	0·76	<0·0001
Fibre (g)	Whole grain and potatoes units	0·56	<0·0001
Added sugar (%E)	Snack product score	0·57	<0·0001

%E, percentage of food energy.

Table 3 Correlations between energy and nutrient content of the meals and the total score of the Meal Index of dietary Quality (Meal IQ; *n* 254)

	Meal IQ score	
	Correlation	
	Spearman's correlation coefficient*	*P* value
Energy (kJ)	0·04	0·4844
Energy density (kJ/100 g)	−0·61	<0·0001
Fat (%E)	−0·58	<0·0001
Saturated fat (%E)	−0·63	<0·0001
Carbohydrate (%E)	0·52	<0·0001
Added sugar (%E)	−0·22	<0·0001
Fibre (g/MJ)	0·54	<0·0001
Vitamin A (μg RE)	0·13	0·0342
Vitamin D (μg)	−0·13	0·0447
Vitamin E (mg)	0·32	<0·0001
Vitamin K (mg)	0·49	<0·0001
Vitamin B_6 (mg)	0·30	<0·0001
Folic acid (μg)	0·38	<0·0001
Vitamin C (mg)	0·47	<0·0001
Ca (mg)	0·09	0·1174
Fe (mg)	0·19	0·0029
Fruits (g)	0·50	<0·0001
Vegetables (g)	0·48	<0·0001
Fish (g)	0·36	<0·0001

%E, percentage of food energy; RE, retinol equivalents.
*Spearman's correlation coefficient analyses are made using the 28-classed score.

and the nutrient of concern ranged from 91 % (whole grain units *v.* fibre) to 98 % (starch units in snack product *v.* added sugar). Gross misclassification was found in one of the 254 cases for the components measuring added sugar, saturated fat and total fat; and for the whole grain score correlated with fibre, misclassification was found in 2 % of the meals.

Correlation between the Meal IQ score and nutrient content

The results presented in Table 3 are based on comparisons of the assessed Meal IQ score from the weighed food records of the lunches brought from home or provided by the school. A higher Meal IQ score was significantly associated with lower intakes of total and saturated fat and sugar and with higher intakes of fibre, fish, fruits, vegetables and various vitamins and minerals. The Spearman's correlation coefficients between the score for Meal IQ and the nutrient content of the nutrient-calculated meals varied between dietary components and were highest for energy density ($r = -0{\cdot}61$) and lowest for energy ($r = 0{\cdot}04$) where no association was measured. The Spearman's correlation coefficients were calculated separately for the lunches brought from home and the lunches provided by the schools in order to examine if the results were similar. The separate analyses showed the same tendencies as the combined analysis of the lunches except for the association between the Meal IQ score and the energy density in the lunches provided by the school (results not shown). The correlation was not as strong ($r = -0{\cdot}13$) as seen in the lunches brought from home ($r = -0{\cdot}73$).

Table 4 illustrates the *P* values for trend across the Meal IQ categories and the *P* values for differences between the categories. The linear trend was highly significant for the percentage of energy from fat and saturated fat, fibre, vitamin E, vitamin K, vitamin B_6, folic acid, vitamin C, fruits and vegetables. There was also a trend for vitamin A ($P = 0{\cdot}0274$). The result of the analysis for trend showed no significance across the Meal IQ score for energy, energy density, percentage of energy from carbohydrate and added sugar, Ca, Fe and fish. The *P* values for the ANOVA showed a significant difference between the score categories for all the nutrient and food groups except energy and vitamin A, and after Bonferroni correction, there was no difference between the categories for Ca either.

Discussion

The results obtained in the present study indicate that the Meal IQ is a valid and useful tool for providing information on the dietary quality of school lunches brought from home or provided by the school, and thus a useful evaluation tool for school food programmes. The Meal IQ score is a good measure of dietary quality, as higher values of the score are strongly associated not only with the nutrient and food groups included in the index, but also with selected nutrients.

We found a linear trend across the Meal IQ categories for percentage of energy from fat and saturated fat, fibre, vitamin A, vitamin E, vitamin K, vitamin B_6, folic acid,

Table 4 Energy and nutrient contents of the meals by categories according to the total score of the Meal Index of dietary Quality (Meal IQ; *n* 254)

	Meal IQ score									
	0–7 points (*n* 26)		8–13 points (*n* 102)		14–19 points (*n* 105)		19–28 points (*n* 21)		*P* value for ANOVA or Kruskall–Wallis test	*P* value for trend
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Energy (kJ)	1549	631	1350	563	1358	568	1710	570	0·0539	NS
Energy density (kJ/100 g)	1032[a]	201	818[b]	256	595[c]	180	552[c]	121	<0·0001	NS
Fat (%E)	39·8[a]	6·53	33·7[b]	10·1	24·6[c]	9·17	22·1[c]	6·92	<0·0001	<0·0001
Saturated fat (%E)	15·8[a]	5·04	11·5[b]	4·63	7·00[c]	3·96	5·30[c]	3·00	<0·0001	<0·0001
Carbohydrate (%E)	46·7[a]	7·68	49·9[a]	11·4	60·3[b]	10·5	61·5[b]	9·38	<0·0001	NS
Added sugar (%E)	3·79[a]	5·69	1·06[b]	2·12	0·49[b]	1·41	0·08[b]	0·14	0·0009	NS
Fibre (g/MJ)	3·23[a]	1·56	4·26[a]	1·75	5·75[b]	1·98	6·41[b]	1·42	<0·0001	<0·001
Vitamin A (μg RE)	225	391	262	291	322	325	421	352	0·0966	0·0274
Vitamin D (μg)	0·23[a]	0·21	0·22[a]	0·36	0·19[a]	0·44	0·83[b]	1·26	0·0001	NS
Vitamin E (mg)	0·88[a]	0·61	1·19[a]	1·06	1·42[ab]	1·04	1·93[b]	1·01	<0·0001	<0·0001
Vitamin K (mg)	2·36[a]	3·85	10·3[ab]	15·9	14·1[b]	14·0	24·6[c]	13·1	<0·0001	<0·0001
Vitamin B_6 (mg)	0·19[a]	0·12	0·24[ab]	0·15	0·27[b]	0·13	0·39[c]	0·14	<0·0001	<0·0001
Folic acid (μg)	33·1[a]	26·0	54·1[b]	31·4	68·6[c]	37·3	90·0[d]	29·4	<0·0001	<0·0001
Vitamin C (mg)	9·27[a]	6·38	15·5[a]	17·8	25·4[b]	21·7	26·5[b]	16·4	<0·0001	<0·0001
Ca (mg)	128[a]	151	83·5[a]	82·6	83·4[a]	62·7	122[a]	110	0·0234	NS
Fe (mg)	2·15[a]	1·55	1·95[a]	0·95	2·16[a]	1·12	3·36[b]	2·15	0·0012	NS
Fruits (g)	0·58[a]	2·94	8·03[a]	28·7	41·5[b]	67·8	52·6[b]	55·2	<0·0001	<0·0001
Vegetables (g)*	5·00[a]	11·3	41·3[b]	50·1	64·6[c]	48·9	90·6[c]	42·1	<0·0001	<0·0001
Fish (g)	1·08[a]	5·49	0·90[a]	6·06	4·40[a]	14·0	21·8[b]	28·2	<0·0001	NS

%E, percentage of food energy; RE, retinol equivalents.
[a,b,c,d]Mean values within a row with unlike superscript letters were significantly different after Bonferroni correction for multiple comparisons ($P < 0·05$).
*Excluding potatoes.

vitamin C, fruits and vegetables. But we did not find a trend for all nutrient and food groups. The missing trend for sugar and fish might be explained by the fact that a high content of added sugar was found only in the meals with low scores, and fish was mainly present in the lunches with high Meal IQ scores. This was also the result of the ANOVA after Bonferroni correction for multiple comparisons, where a significant difference was found between the content of added sugar in the category for meals with the lowest Meal IQ score and the other three categories. The same picture was seen when analysing the content of fish in the four categories, where the meals with the highest Meal IQ score had a significantly higher amount of fish compared with the other three categories. This could also explain the absent trend for vitamin D, as this micronutrient is highly present in fish. The content of Ca in the meals did not show either a trend or any differences between the categories. The reason for this might be that all types of meals contain cheese, for example, and the one scoring lowest also contains spread and cheese snacks which all contribute to the Ca content; and the meals with high scores also contain Ca from vegetables. The lack of trend for Fe is due to the content of Fe in meat, which is present in most of the lunches, but the amount of fat in the meat may vary. Fortification could have had an influence on the results of trends across the categories for micronutrients, but in Denmark fortification is not common. The non-significant trend across categories for energy density was unexpected, but it may be due to a wide variation in energy content. The ANOVA showed a highly significant P value ($P < 0{\cdot}0001$) for the general difference among the categories for energy density. Pair-wise differences between the categories after Bonferroni correction showed a significant difference between all the groups ($P < 0{\cdot}05$) except for the last two. Lassen *et al.*[14] did not do a trend analyses when analysing the energy density across categories for the score of the SHMI, but they found a significant difference between categories in the total score of the SHMI for energy density using ANOVA; after Bonferroni correction, however, there was no difference between the two middle categories.

Because nutrient intake is positively correlated with energy intake, a diet quality index could overrate high-energy diets, especially if nutrient adequacy is weighted more heavily than moderation[30]. Several indices show an association between the score and total energy intake[4,8,10]. In the Meal IQ, both nutrient adequacy and moderation are represented among the chosen components. We did not find any correlation between the Meal IQ score and total energy intake. This should be noted as an advantage, because the Meal IQ can assess diet quality independently of diet quantity. Another methodological issue concerning dietary indices is how to combine the different components into one measure[2]. Often the components incorporated in the indices are considered equally important. In the Meal IQ, we attempted to focus more on fruits and vegetables and fat by dividing fruits and vegetables into two components, and also having separate components for total fat and saturated fat. Another issue is the scoring of each component (binary, proportional or other)[2,31]. In the Meal IQ, we have mainly used a proportional approach on the assumption that the difference from 0 to 1 is the same as from 1 to 2. This may not be completely true. If total fat goes from 25 to 20 % of energy, the effect is not the same as from 40 to 35 % of energy. Future study could do further work on differentiations in the single component scores in the Meal IQ, and also on different strategies for scoring of the variables. For instance, the correlation with regard to total fat may be better described by a U-shaped relationship than by the proportional approach.

Not all aspects of nutritional recommendations are implemented in the Meal IQ. Beverages were not included as a component in the Meal IQ, because the relationship between energy density and macronutrient content in beverages is more complex than in individual foods or meals[32]. Besides the focus was on developing a tool for assessing differences between lunches brought from home and lunches provided by the schools, and since beverages are not part of the school food programme in Denmark, this component was not included. Beverages may contribute significantly to total energy intake, but data from the Danish National Survey of Dietary Habits and Physical Activity show that more than half of school-aged children (7–13 years) drink water or low-fat milk for lunch at school[22]. Incorporating beverages as a component in the Meal IQ could be relevant in future studies. In addition, the index does not deal with salt content, which should be developed and tested for future extension of the Meal IQ. Further research is needed to determine the dietary elements that are most related to health among children/youth.

The Meal IQ focuses on the overall dietary quality of a meal. The official recommendations are valid for the average intake for a longer period, at least a week, since the dietary composition may vary from meal to meal and from day to day[19]. It is therefore a challenge to establish dietary guidelines for a single meal, but this was done by defining cut-off points for the Meal IQ components based on the official recommendations and dietary guidelines. When defining the official recommendations, the current food consumption patterns were taken into account. This was also done when defining the Meal IQ scoring system for whole grain: if the starting point was that children should receive 25 % of their daily energy needs from the lunch they eat at school, then the upper cut-off for whole grain should be about 25 % of the recommended intake. But for whole grain, the limit was set above 25 % of the recommended daily intake because Danish children eat rye bread at lunch[23], which is an important source of whole grain; therefore, it is likely that the lunch would provide more whole grain. From this point of view, it would be appropriate to develop specific indices for the different types of meals and for specific target groups.

A limitation of using the Meal IQ is the need for recipes and product specifications, especially when assessing the Meal IQ components for hot meals, for which it can be difficult to assess the content of e.g. fat and the amounts of vegetables. It is relatively easy to get information on the lunches provided by the schools, because recipes are available and the meals are often standardized.

One of the advantages of the Meal IQ is that the score is easily obtained through a simple evaluation process. The seven components incorporated in the Meal IQ can be determined from a weighed food record. There is no need for calculations of the nutrient content, which would make the calculation of the total score more complex and labour-intensive as in the Healthy Eating Index (HEI)[4] and the RC-DQI[12], among others.

In conclusion, the new Meal IQ is an easily applied evaluation tool for assessing the dietary quality of lunches provided by schools or brought from home. The method is valid, simple, flexible and sensitive. The Meal IQ is a tool that can be used by health professionals at various levels to evaluate health promotion interventions in schools.

Acknowledgements

The project is part of the EVIUS study funded by Danish Food Industry Agency, DTU National Food Institute and Department of Nutrition, National Food Institute. The authors declare no conflict of interest. All the authors contributed to the study concept and design, interpretation of data and preparation of the manuscript. The authors thank all participants of this study. They also thank Bent Egberg Mikkelsen, Food, People & Design, Department of Development and Planning, Aalborg University and Anne Dahl Lassen, DTU National Food Institute for advice and manuscript comments.

References

1. World Health Organization (2009) *Interventions on Diet and Physical Activity: What Works. Summary Report.* Geneva: WHO.
2. Fransen HP & Ocke MC (2008) Indices of diet quality. *Curr Opin Clin Nutr Metab Care* **11**, 559–565.
3. Haines PS, Siega-Riz A & Popkin BM (1999) The Diet Quality Index Revised: a measurement instrument for populations. *J Am Diet Assoc* **99**, 697–704.
4. Kennedy ET, Ohls J, Carlson S *et al.* (1995) The Healthy Eating Index: design and applications. *J Am Diet Assoc* **95**, 1103–1108.
5. Patterson RE, Haines PS & Popkin BM (1994) Diet Quality Index: capturing a multidimensional behavior. *J Am Diet Assoc* **94**, 57–64.
6. Huijbregts PP, Feskens EJ, Räsänen L *et al.* (1998) Dietary patterns and cognitive function in elderly men in Finland, Italy and The Netherlands. *Eur J Clin Nutr* **52**, 826–831.
7. Trichopoulou A, Costacou T & Bamia C (2003) Adherence to a Mediterranean diet and survival in a Greek population. *N Engl J Med* **348**, 2599–2608.
8. Toft U, Kristoffersen LH, Lau C *et al.* (2007) The Dietary Quality Score: validation and association with cardiovascular risk factors: the Inter99 study. *Eur J Clin Nutr* **61**, 270–278.
9. McCullough ML, Feskanich D, Stampfer MJ *et al.* (2002) Diet quality and major chronic disease risk in men and women: moving toward improved dietary guidance. *Am J Clin Nutr* **76**, 1261–1271.
10. Biltoft-Jensen A, Fagt S, Groth MV *et al.* (2008) The intake of saturated fat and dietary fibre: a possible indicator of diet quality. *Br J Nutr* **100**, 624–632.
11. Manios Y, Kourlaba G, Grammatikaki E *et al.* (2010) Development of a diet-lifestyle quality index for young children and its relation to obesity: the Preschoolers Diet-Lifestyle Index. *Public Health Nutr* **13**, 2000–2009.
12. Kranz S, Hartman T, Siega-Riz A *et al.* (2006) A Diet Quality Index for American preschoolers based on current dietary intake recommendations and an indicator of energy balance. *J Am Diet Assoc* **106**, 1594–1604.
13. Feskanich D, Rockett HRH & Colditz GA (2004) Modifying the healthy eating index to assess diet quality in children and adolescents. *J Am Diet Assoc* **104**, 1375–1383.
14. Lassen AD, Biltoft-Jensen A, Hansen GL *et al.* (2010) Development and validation of a new simple Healthy Meal Index for canteen meals. *Public Health Nutr* **13**, 1559–1565.
15. Kremer PJ, Bell AC & Swinburn BA (2006) Calibration and reliability of a school food checklist: a new tool for assessing school food and beverage consumption. *Asia Pac J Clin Nutr* **15**, 465–473.
16. Sabinsky MS, Toft UN, Andersen KK *et al.* (2010) *Ernæringsmæssig evaluering af skolemads betydning for elevers kostindtag til frokost* (*Nutritional Evaluation of the Impact of School Lunches on the Dietary Quality of School Children's Lunch*). Soeborg: Technical University of Denmark, National Food Institute.
17. Christensen LM, Hansen KS & Sabinsky M (2009) *Kvalitet af skolefrokost – undersøgelse af skoleelevers frokostmåltider* (*Quality of School Lunch – Survey of Pupils' Lunch Meals*). Soeborg: Technical University of Denmark, National Food Institute.
18. Verhagen H & van den Berg H (2008) A simple visual model to compare existing nutrient profiling schemes. *Food Nutr Res* **52**, DOI: 10.3402/fnr.v52i0.1649.
19. Nordic Council of Ministers (2004) *Nordic Nutrition Recommendations 2004. Integrating Nutrition and Physical Activity. Nord 2004:13*, 4th ed. Copenhagen: Nordic Council of Ministers.
20. Astrup A, Andersen NL, Stender S *et al.* (2005) *Kostrådene 2005* (*Dietary Guidelines 2005*). Copenhagen: Danish Institute for Food and Veterinary Research and Danish Nutritional Council.
21. Pedersen AN, Groth MV, Christensen T *et al.* (2010) *Danskernes kostvaner 2003–2008 Hovedresultater* (*Dietary Habits in Denmark 2003–2008 Main Results*). Soeborg: Technical University of Denmark, National Food Institute.
22. Fagt S, Christensen T, Groth MV *et al.* (2007) *Børn og unges måltidsvaner 2000–2004* (*Dietary Habits of Children and Adolescents 2000–2004*). Soeborg: Technical University of Denmark, National Food Institute.
23. Mejborn H, Biltoft-Jensen A, Trolle E *et al.* (2008) *Fuldkorn. Definition og vidensgrundlag for anbefaling af fuldkornsindtag i Danmark* (*Wholegrain. Definition and Scientific Background for Recommendations of Wholegrain Intake in Denmark*). Soeborg: Technical University of Denmark, National Food Institute.

24. Mejborn H, Biltoft-Jensen A, Ygil KH *et al*. (2009) *Development of A Valid, Yet Simple and Easy Nutrition Profiling Model*. Soeborg: Technical University of Denmark, National Food Institute.
25. Andersen NL, Biltoft-Jensen A, Christensen T *et al*. (2002) *Om kostundersøgelsen* (*About the Survey of Dietary Habits and Physical Activity*). Soeborg: Technical University of Denmark, National Food Institute.
26. Brown MB & Benedetti JK (1977) Sampling behavior of tests for correlation in two-way contingency tables. *J Am Stat Assoc* **72**, 309–315.
27. Altman DG (1991) *Practical Statistics for Medical Research*. London: Chapman & Hall.
28. Kruskal WH & Wallis WM (1952) Use of ranks in one-criterion variance analysis. *J Am Stat Assoc* **47**, 583–621.
29. Abdi H (2007) Bonferroni and Šidák corrections for multiple comparisons. In *Encyclopedia of Measurement and Statistics* [NJ Salkind, editor]. Thousand Oaks, CA: Sage; available at http://www.utdallas.edu/ ~ herve/Abdi-Bonferroni2007-pretty.pdf
30. Guenther PM, Reedy J, Krebs-Smith S *et al*. (2008) Evaluation of the Healthy Eating Index-2005. *J Am Diet Assoc* **108**, 1854–1864.
31. Waijers PM, Feskens EJ & Ocke M (2007) A critical review of predefined diet quality scores. *Br J Nutr* **97**, 219–231.
32. Crowe TC, LaFontaine HA & Gibbons CJ (2004) Energy density of foods and beverages in the Australian food supply: influence of macronutrients and comparison to dietary intake. *Eur J Clin Nutr* **58**, 1485–1491.