Considerations and choice of a suitable diet assessment method for 8-10 year old children in the OPUS school intervention project

DTU Food
National Food Institute

Considerations and choice of a suitable diet assessment method for 8-10 year old children in the OPUS school intervention project

An OPUS Report

OPUS is an acronym for: ”Optimal well-being, development, and health for Danish children through a healthy New Nordic Diet” and is supported by a grant from the Nordea Foundation

Prepared by

Anja Biltoft-Jensen

National Food Institute
Division of Nutrition

Considerations and choice of a suitable diet assessment method for 8-10 year old children in the OPUS school intervention project

1. edition, June 2010

Photo: Colourbox
ISBN: 978-87-92158-78-9

This report is available at
www.food.dtu.dk

National Food Institute
Technical University of Denmark
Mørkhøj Bygade 19
DK-2860 Søborg

Tel: +45 35 88 70 00
Fax: +45 35 88 70 01

Indholdsfortegnelse

Preface

This report describes the considerations made behind the decisions for choosing a dietary assessment method that is suitable to be used with 8-10 years old children in the OPUS (Optimal well-being, development, and health for Danish children through a healthy New Nordic Diet) school intervention project.

Due to the short time and the few resources, it has not been possible to undertake any formative research as the foundation for developing a suitable dietary assessment method. Therefore this report relies on research that has already been published and data already gathered. However, most of the published formative research has been done with children from USA and England where the food culture is somewhat different, and it is not known if the results are directly applicable to Danish children. The first part of the report describes the considerations about - and the requirements to a method in the OPUS school intervention project. The second part describes how such a method can be developed, and which considerations should be taken when the target group is children 8-10 years old.

Finally the reports give a suggestion to how the dietary assessment system could be validated.

This report was written within the OPUS Centre. The OPUS Centre is a Danish multidisciplinary Research Centre with a 5-year programme supported with a grant from the Nordea Foundation. OPUS is an acronym for: ”Optimal well-being, development, and health for Danish children through a healthy New Nordic Diet”.

Summary

This report was informed by a literature review, a series of focus groups and analysing dietary intake data already gathered by the Danish National Survey of Dietary Habits and Physical Activity,

The first part describes the considerations about- and requirement to a method suitable in the OPUS school intervention study, and results from these considerations points at that the dietary assessment method:

- Has to cover the whole diet and represent weekdays and weekend days. Furthermore, it has to be food and meal specific in order to measure the intake of the NND and relate results to biochemical risk markers of lifestyle diseases.
- Should be able to obtain information about specific dietary behaviors i.e. where the meal consumed came from and where it was eaten in order to confirm whether the eaten meals were New Nordic Diet school meals or not.
- Has to collect data at the individual level, however the number of days needed to determine usual intake of individuals is unrealistic. But it is realistic to be able to rank individuals by food or nutrient intake. But this level also requires multiple observations and optimal for 7 days.
- Has to take into account that dietary assessment of children 8-10 years old rely on, beside the children themselves, a second person (the parents).
- Should be accompanied by a background interview.

The heavy workload of the intervention study, with performing between 12000 - 33600 dietary assessments including data collection, reviewing, entering, processing and analyzing the data suggests a web-based data collection that saves data scanning/entering. This could be a feasible solution since almost all Danish families, and especially families with children, have a computer and internet access in their home.

These requirements exclude dietary assessment methods as Food Frequency Questionnaires (FFQ) and Diet History and 2 x 24 h recall. However, if a food record is filled out in the end of the day, it resembles very much the 24hr recall and a method that combines the record with a recall seems feasible within the OPUS school intervention set up. Furthermore, validation studies show that correlations between the reference method and dietary assessment tool were almost always higher for food recalls and food records than for FFQ.

On the background of the above reflections and considerations it is decided that the OPUS school intervention use a web-based 7-day record/recall dietary assessment method.

The rest of the report therefore assess how such a method should be tailored and therefore focus on food diaries, 24 h recalls and combination of these methods and the use of technology to assess the diet of children.

A web-based dietary assessment software system that assess the dietary intake among 8-10 year old children should include motivation factors, and try to motivate the children by the soft-wares functionality, content, aesthetics and setting. The OPUS setting and delivery of the dietary assessment software system to the children and parents e.g. by a professional interviewer, is essential for the motivation, trust and finally the response rate.
Accurate assessment of dietary intake in children is a challenge, because children are not used to perform the tasks remembering which foods they had for which meals. Furthermore, they do not have a common understanding for naming of all eating events (especially not snacks eaten in the afternoon),

naming of foods and their belonging to food categories. Furthermore, their spelling and reading competences are not yet fully developed. This leads to the conclusion that 8-10 year old children need support from their parents to complete a dietary assessment.
The web-based dietary assessment soft-ware system should therefore include:

- Appropriate cues and prompts that help memory retrieval. It can be considered that the children keep notes of what she or he has been eaten and these used as memory prompts.
- An audio function, so the questions and probes could be read out to the children and their parents as well.
- Rewarding of timely reporting. To avoid misreporting and intrusions it will be important that the reporting is done on the same day e.g. in the evening for the same day, and that the soft-ware system “reward” this behaviour.
- A meal based approach, since eating in the Danish food culture is still concentrated around breakfast, lunch and dinner. The challenge will be to give the appropriate prompts for the reporting of snacks – especially during the afternoon.
- A combination of search facilities since there is no single solution to the most obvious and easy way for children and parents to search and find and report the eaten food items in a software system.
- An clear and uncomplicated way to estimate portion size. This can be obtained by using fewer photos e.g. 4 instead of 6 or 8 for the portion size estimation and presenting a clear difference in portions and using a simultaneously presentation

Furthermore, during the intervention it will be essential that the schools/caterers provide the children with a menu plan, so both the children and parents have a chance to find and report the eaten dishes in the dietary assessment software system.

There is no single obvious way to validate the dietary assessment soft-ware system.
However, since the ”paradigm” for the ”New Nordic Diet” is ”More energy from plant foods and less from animal foods” the combination of carotenoids and flavanoids may provide a useful biomarker for fruit and vegetable intake. The combination of these biomarkers with a measure for total energy expenditure measured with a physical activity monitor and observation of the children’s school lunch may provide a solid validation of the dietary assessment tool.

It is concluded that the most suitable method for assessing dietary intake among 8-10 year old children in the OPUS project is a Web-based Dietary Assessment Software system for Children (Web-DASC). This method will be developed to be used at the end of the day to recall the children’s diet for that particular day. Ideally, the children will record the diet for 7 consecutive days before, under and after the intervention study with support from their parents.

Introduction

All over the industrialized world, the prevalence of overweight and obesity among children and adolescents has increased dramatically in recent decades [1,2]. Data from the Danish National Survey of Dietary Habits and Physical Activity shows, that between 1995 and 2000-02, the number of overweight children in Denmark has increased with 40.000[3]. Adult lifestyles, including overweight, are likely established during childhood, but are influenced during the whole lifespan [4,5].

In order to prevent the development of overweight and obesity in the Danish population a new centre - The OPUS center (Optimal well-being, development, and health for Danish children through a healthy New Nordic Diet) has been established by funds from the Nordea Foundation. The aim of the OPUS center is, for a five year period, to undertake research that will strengthen public health by focusing on child health, well-being and welfare.

One of the project's focus areas will be the development of a new meal concept to be introduced in the national school system. Inspired by the new Nordic cuisine movement and the internationally recognized achievements of Nordic chefs, the meals will draw heavily on sustainable ingredients native to the Nordic region. It is one of the visions of the research project to make the New Nordic Diet (NND) the twenty-first century's answer to the Mediterranean diet.

The intervention studies will be based on the New Nordic Diet that will be developed through a multidisciplinary interplay between the fields of gastronomy, nutrition, user-driven innovation, food sociology and economics. Through the intervention studies, the impact on health, learning, behavior, food economics and sustainability will be investigated.

The project includes a large school-based intervention study covering around 1000-1600 children in third and fourth grade (8-10 years old). The objective of this intervention study is to examine if the NND can influence cognitive performance, mood, well being, life-style factors such as diet, physical activity and sleep pattern, or body weight and composition, and risk markers for lifestyle disease such as type 2 diabetes, cardiovascular disease, osteoporosis and cancer.
Since the NND is the “Explanatory” variable it will be essential to measure the dietary intake in the participating children.

Measurement of the dietary changes resulting from the “cross-over design” intervention study among school children requires a valid measure of diet before (baseline), during (3 months) and after the intervention period (6 months). This is important in order to document and evaluate any dietary changes and adherence to the NND through the intervention and control periods. Furthermore accurate dietary assessment is critical for several other purposes including monitoring the nutritional status of children, examining associations between diet and health, and identifying dietary intake patterns and eating behaviors that are associated with unhealthy weight. Such information is critical for developing messages and behavioral targets for obesity prevention and to improve public health.

The purpose of this report is to consider and evaluate all pertinent issues related to the development of a suitable and feasible dietary assessment method for children between 8-10 years of age to be used in the OPUS school intervention study. The report is based on the scientific literature, ongoing projects, etc. to provide a solid background for the choice of the most suitable method for assessing dietary intake before, during and after the New Nordic Diet intervention study in school-children.

Part 1. Considerations of the dietary assessment method in relation to the primary research question

The choice of the most appropriate dietary assessment method for the intervention study depends on the primary research question. However, one should bear in mind that, there is no “one-size-fits-all” dietary assessment tool appropriate for any research goal, and there is always a trade-off with the choice of any diet assessment tool. Moreover, the measurement of food and nutrient intake in children is further complicated by a variety of factors, including reliance on the parents and a third person e.g. adult caregiver, teacher to report a child’s intake during the school-time.

Therefore the choice of the most appropriate dietary assessment method for this specific research question requires careful considerations about:

1. What is the purpose of the study and what is the primary research question?
2. What diet assessment measures have been used previously for this type of question in this specific population?
3. What are the most relevant aspects of dietary intake?
4. Does the information need to be meal specific or general?
5. Is the average intake of a group or the intake of each individual needed?
6. What is the number of days needed to obtain data on the desired level?
7. What time period is of interest (present, past or current/usual diet)?
8. Is information needed on specific dietary behaviors?
9. What kind of background and lifestyle information is needed from the target group?
10. Who is the target group – respondent characteristics?
11. What are the research constraints in terms of money, time, and staff?

1. What is the purpose of the study and what are the primary research questions?
The aim is to conduct a 6 month, cross-over dietary school intervention trial with the NND vs. the current situation (packed lunch from home and/or school canteens/small shops) (Figure1) among 1000-1600 school children in the age group 8-10 years old.

The primary research question of the intervention study is to measure if body composition (based on DXA), bone mineral content (based on DXA), blood pressure and several biochemical risk markers for life style related diseases change during the intervention period.

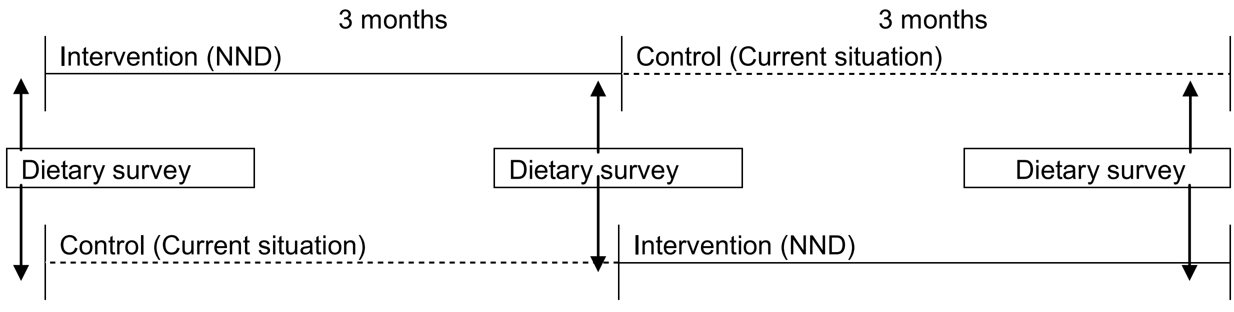

Figure 1. The design of the school-intervention

The design (Figure 1) has several weaknesses. First of all, it is not likely, and from a public health perspective not desirable, that the first intervention group will be a good control group after the intervention. In order to be a suitable control group they have to return to the dietary habits they had before the intervention and thereby forget everything they have been accustomed to the past 3 months. Furthermore, the cross over design was partly chosen because it increases the power and thereby cutting down the intervention period from 5 to 3 months. But three months is a very short intervention period and this makes it possible that only few changes in biochemical risk markers will be detected - especially because the NND is only provided for a part of the day and only on school days (lunch and 1 or 2 snacks). Finally, there is no guarantee that the children will eat the served food.

The weaknesses mentioned above make it even more important to conduct a well designed dietary survey, because the dietary data might be the only proof that the children have changed their diet in the intervention period. Finally, the design demands that the children have to be tested on three occasions, which add a lot of burden on the children and the researchers.

The **goal** for the dietary assessment before, during and after the intervention period is to assess and document the dietary intake before the intervention and dietary changes caused by the intervention.

The ***ambition*** is to measure an improvement in the diet of the children from baseline to the intervention compared to the official dietary guidelines 2005 and Nordic Nutrition Recommendations 2004. Furthermore, to associate the dietary changes to social background and biochemical risk markers.

In healthy children it is uncertain whether any dietary changes over a 3 month intervention period will result in measurable changes in biochemical risk markers. However, changes in dietary habits that are sustainable over a longer term may have the desired effects on selected risk markers.

The ***specific goal*** of the NND[6] is an increase in the individual intake of wholegrain (rye(bread), barley oats), fruits and vegetables (coarse vegetables, pulses, cooked and baked potatoes, cabbage, herbs, apples, berries, nuts) and fish and shellfish in exchange of white bread, fried potatoes, fatty meat and dairy products, confectionary, chocolate, cake and similar. Further the goal is to limit the intake of saturated fat and added sugar and increase intake of dietary fibre.

As can be seen from table 1, when the sample size is as large as 1000 children it is possible to measure even small changes in the dietary habits. Even if a part of the population will drop out of the dietary assessment, it will still be possible to measure relatively small changes. But if it is only the lunch that is changed, maybe the total changes in dietary intake won’t be large.

Table 1. Dietary intake, Dietary guidelines goals, and detectable difference in the diet of children 8-10 years when the sample size is 1600 and 800 children.

New Nordic Diet Foods/Nutrient	Intake of children 8-10 years 2000-08 g/dag (std)	Intake of children 8-10 years 2000-08 g/10 MJ (std)	Dietary guideline goal g/10 MJ	Detectable difference (g/day) at α = 5% (when n= 1000)	Detectable difference (g/day) at α = 5% (when n= 800)
Whole grain	30 (23)	35 (24)	75	2,0	2,3
Rye bread	47 (35)	55 (40)	125	3,0	3,4
Oats	6 (13)	7 (14)		1,1	1,2
Cooked and baked potatoes	44 (45)	52 (53)	140	3,9	4,4
Vegetables	127 (70)	149 (79)	250	6,2	6,9
Coarse vegetables	36 (38)	42 (44)	125	3,4	3,8
Pulses	0,5 (5)	0,4 (4)	None specific	0,5	0,5
Cabbage	2 (7)	2,6 (8)	None specific	0,6	0,7
Mushrooms	0,3 (1,5)	0,3 (4,3)	None specific	0,1	0,1
Fruit	183 (130)	214 (79)	250	11,4	12,8
Apples	46 (49)	70 (75)	None specific	4,3	4,8
Berries	4 (14)	4 (15)	None specific	1,2	1,4
Nuts	0,5 (3)	0,5 (3)	Ca. 30	0,2	0,3
Fish and shellfish	12 (14)	14 (4)	35	1,2	1,4
Saturated fat E%	14 E% (2)	14 E% (2)	Max 10 E%	0,2	0,2

Based on the intake of 8-10 year old children in the Danish National Survey of Dietary Habits and Physical Activity 2000-2008.

It is planned to have a bus travelling around to the schools where the blood samples are taken and body composition are measured, however it will not be possible to perform the dietary survey from the bus, because of practical issues with measuring 25 children a day. But it will be essential to arrange the dietary survey around the time for the bus visits and when the blood samples are taken.

2. What diet assessment measures have been used previously for this type of question in this specific population?

Applications of dietary assessment methods on school aged children are summarized in Table 2. The table is adapted after McPherson et al, 2008[7]. As can be seen from Table 2, the validation standards used are often relative validation standards i.e. the different methods are used to validate the other methods (e.g. records for recalls and the other way around). This is often the only feasible option and adds to the understanding of how a method works in a particular research setting. Information from relative validation studies can be used to calibrate/adjust the method and in the intrepetation of the results from the overall study. However, one should be aware of that similar errors in both methods will artificially inflate the correlations between the two methods. In Table 2 observations were the most common validity standard for recall validity studies. However, observation is usually only feasible in institutional settings as with school lunch or in situations specially set up to allow unobtrusive observation of what people eat. It is almost impossible to observe, surreptitiously, what is consumed over even short periods as a whole day. Furthermore, there are no studies regarding the validity of this measure for assessing children's intake.

Total energy expenditure measured by doubly labelled water (DLW), has also been used in few validation studies (Table 2.). The main advantages of DLW method is that it makes minimal demands on the subjects and does not in any way interfere with normal daily activities and therefore their normal habitual level of energy expenditure. The main disadvantages is that the cost for each eatimate is exceedingly high and the method requires access to sophisticated laboratory equipment for analysis. Furthermore, it does not give any information about the dietary intake. It is possible that the energy intake measured with a dietary method equals energy expenditure measured by DLW, but the dietary method measure intake in a way that deviates substantially from the true intake.

Overall it can be seen from Table 2, that the Diet History method has not been used for intervention studies. The observation method is very resource demanding and has only been used for specific meals. It would be almost impossible to perform that method during the whole day for several days. The Food Frequency Questionnaire (FFQ) method is imprecise and performs with lower correlations compared to both Dietary Recalls and Food Records. However, FFQ are often used because they are inexpensive and practical for large scale nutrition research[8]. The FFQ is cognitive difficult to complete, especially for children because it demands that the respondent are capable of averaging intake over the day, week, month, and over the previous year. Furthermore, the parents will not be able to answer for the intervention period, when the children get served the NND in the school. Currently, there are too few validation studies in children to justify one particular method over another for any given study design, and as with adults, there is no perfect method of assessing dietary intake in children. Special considerations must therefore be given to the age and cognitive ability of the children. Both age and cognitive ability relate to the child's understanding of the method used and the thought processes that contribute to self-reporting of food-choices.

Table 2. **Summary of Dietary Assessment Methods for School-Age Children** (Adapted after McPherson et al, 2008[7])

Method and Number of Studies Reviewed	Ages Evaluated	Energy Validity[a]	Protein Validity[a]	Total fat Validity[a]	Energy Intake Compared with Standard[b]	Validation Standard	Study Design Applications	Advantages	Disadvantages
Food recall	4–14 years	0.27–0.87	0.42–0.91	0.25–0.85	−34%–18%	(15) Observation	Cross-Sectional	•Short administration time	•Recall depends on memory
Validity — 27	adult assistance					(3) TEE by doubly labelled water	Intervention	•Defined recall time	•Portion size difficult to estimate
Reliability — 4	needed for < 8 years					(1) 24 h recall , (1) 24 h MPR	Monitoring	•Intake is meal specific and can be quantified	•Trained interviewer required
						(4) 1 -3-7 day food record	Clinical	•Procedure have less influence on habitual dietary patterns	•Expensive to collect and code
						(1) Chemical analysis of food	Epidemiologic	•Low respondent burden	•Individual level data requires several recalls or 2 recalls Supplemented by a FFQ. This increase respondent burden
								•Can be telephone-administered	•The interview situation can influence what is reported
								•Procedure can be automated	•Data not obtained for all weekdays
								•Detailed information about food Intake	
Food record	6–19 years	0.52–0.71	0.56–0.82	0.58–0.82	−28%–31%	(5) TEE by doubly labelled water	Cross-Sectional	•Record do not rely on memory	•Recorder must be literate
Validity — 9	adult assistance					(2) Observation	Intervention	•Defined record time	•High respondent burden
Reliability — 0	needed for < 8 years					(1) Chemical analysis of food	Monitoring	•Intake is meal specific and can be quantified	•Procedure alters habitual dietary patterns
						(1) Biomarkers	Clinical	•Detailed information about food intake	•Validity may decrease as recording days increase
							Epidemiologic	•Procedure can be automated	•Expensive to collect and code
Food frequency	2–19 years	0.13–0.56	0.18–0.48	0.12–0.61	1%–87%	(18) 3-4-6-7-14-22 day food record	Cross-Sectional	•Trained interviewers not needed	•Recall depends on memory
Validity — 37	adult assistance					(11) 1-3-4, 24 h recall	Intervention	•Interviewer or self-administered	•Period of recall imprecise
Reliability — 22	needed for < 8 years					(2) TEE by doubly labelled water	Monitoring	•Relatively inexpensive to collect	•Quantification of intake imprecise
						(2) Biomarkers	Epidemiologic	•Procedure does not alter habitual dietary habits	•Specific food descriptions not obtained
						(2) FFQ		•Low respondent burden	•Cognitive difficult for the respondent and respondent must be literate
						(2) Food checklist		•Total diet or selected foods or nutrients can be assessed	•Data not obtained for meals or weekdays
								•Can be used to rank according to nutrient intake	
								•Procedure can be automated	
Diet history	5–16 years	n/a				(1) 7-day diet record	Monitoring	•Literacy not required	•Recall depends on memory
Validity — 1	adult assistance needed for all ages						Clinical	•Procedure does not alter habitual dietary habits	•Highly trained interviewers required
Reliability — 1							Epidemiologic	•Can obtain highly detailed descriptions	•Period of recall imprecise
								of foods and preparation methods	•Very high respondent burden
									•Requires long interview time
									•Quantification of intake imprecise
									•The interview situation can influence what is reported
									•Expensive to administer
Observation	8–10 years						Intervention	•Literacy not required	•Highly trained observers required
Validity — 0							Monitoring	•Procedure does not alter habitual dietary habits	•Requires long observation period over the whole day
Reliability — 1							Epidemiologic	•Procedure does not rely on memory	•Expensive to administer
								•Defined observation time	•Has only been used for specific meals
								•Intake can be quantified	
								•Multiple days give measure of individual or group intake	

a Pearson's and Spearman's correlations of nutrients both unadjusted and adjusted for percentage of kilocalories.

b Calculation of percentage = ([instrument−validation standard]/validation standard).

3. What are the most relevant aspects of dietary intake?
Because the NND meal concept to be tested in the OPUS study is based on specific foods native to the Nordic region it will be necessary to obtain information about specific foods, in order to measure the adherence to the NND. The NND paradigm is less energy from foods of animal origin and more from the vegetable kingdom and therefore also less saturated fat. The NND is based on foods such as meat from free-living stock (that feed on grass) and game, alternative protein sources as peas and beans, fish and shellfish, wild plants, cabbage, root vegetables and potatoes, sea weed, berries, apples, wholegrain (rye, oats and barley), nuts and rapeseed oil. The NND covers aspects of the whole diet and it will be relevant in later analysis to test if the intake of the specific foods in the NND will change during the intervention study, therefore a relative high level of detail is required.

The NND is only served during school day; this could argue for that dietary assessment could cover school-time only. However, it is highly relevant, to evaluate dietary intake and changes against the dietary guidelines 2005 and Nordic Nutrition Recommendations 2004[(9)] and the biochemical risk markers analyzed for which it will be necessary to obtain information about nutrient intake and therefore dietary intake of the whole diet.

Another important argument for assessing the dietary intake over the whole diet is that the implementation of Nordic ingredients in the diet may not by itself lead to a healthier diet. The Nordic ingredient may only replace similar ingredients in the present diet e.g. goutweed may be eaten in exchange of green salad etc. Compensation may also be another problem e.g. healthier school meals might lead the families to take less care to prepare a healthy dinner.

In addition the dietary assessment tool should also be able to include specific recipes since the NND also will be served in the form of mixed dishes and the recipes developed for the school intervention should be included in the foodlist so the children and their parents have a chance to find the eaten NND.

It will not, for any of the foods, be possible to measure origin, because the respondents seldom would know which country the eaten foods came from.

It will seldom be possible to know the complete details about ingredients in mixed dishes. Therefore it is important that the food/recipe list included in the system gives several choices for each mixed dish. Experiences from using EPIC-Soft in the EFCOVAL study, where parents assisted their 9-12 years old children completing a 24 h recall interview shows, that around ¾ of the parents find it unproblematic to recall recipes, but when they knew the recipe, they often did not remember the exact amounts but gave ingredients in units etc. (Trolle E, Personal communication).

It should also be mentioned that the food composition database that will be used for the calculation of the nutrient tntake, does not have information about many of the specific Nordic foods as gout-wheat etc.

4. Does the information need to be meal specific or general?
Since the dietary interventions is a school intervention trial, a method that is meal specific is necessary. The dietary effect from the NND, served at school, will be mixed up with the rest of the intake during the day i.e. breakfast, dinner and snacks. It is essential to be able to estimate what is eaten the rest of the day to ensure that any change in biochemical risk markers, is related to the NND or not some other dietary changes. The intervention with the NND can have positive or negative derived effects on the meal quality and quantity the rest of the day. But it is also uncertain if there is an effect. It cannot be expected that the families of the children participating in the intervention study, radically change their dietary habits during the intervention period and it is likely that the child will continue with (almost) his or

her diet as before the intervention study when eating out and at home. However, it will be relevant to investigate the effect of the intervention on the meals over the rest of the day and on dietary habits during the weekends. Meal specific data will also be necessary to measure and provide evidence for dietary- and meal patterns of the participating children.

5. Is the average intake of a group or the intake of each individual needed?

It is important to collect data at individual level in order to be able to associate the intake data with specific biological outcomes. Data collected at group level may be adequate for comparing mean nutrient intakes. The primary research question of the OPUS intervention study is to measure changes in several biochemical risk markers for life style related diseases during the intervention period. In order to be able to associate changes in the biochemical risk markers to changes in dietary intake towards the NND, data should be collected at individual level i.e. replicate measures of dietary intake are needed. If the usual intake of the individuals is required a very large numbers of measurement of days for each individual is required. If it is enough to have the relative intake of the individuals and e.g. rank the individuals according to intake, and e.g. perform cross classification with the biochemical markers, fewer days of repeated measurements, is needed.

6. What is the number of days needed to obtain the desired level?

The <u>number of days</u> needed to determine <u>usual intakes of individuals</u> can be calculated as suggested by Gibson (2005)[(10)]:

$$N = (Z_{\alpha} \times CV_w / D_0)^2$$

Where CV_w = the coefficient of variation (as a percentage) based on the within-subject standard variation s_w, Z_{α} = the normal deviate for the percentage of times the measured value should be within a specified limit (i.e. 1.96 in the example given in table 2), and D_0 = the specified limit (as a percentage of long-term true intake) (i.e. 20% in the example given in table 2).

The example given in Table 2 illustrates the number of days required to estimate the intake of selected foods and nutrients in Danish children 8-10 years (using food records) to within 20% of the true mean, 95% of the time. For this calculation the within-subject variation from the Danish National Survey of Dietary Habits and Physical Activity 2000-06 for 8-10 year old children is used.

However, the <u>relative "ranking level"</u> also requires multiple observations from each individual.
The number of days needed for this level can be calculated from equations suggested by Black et al. (1983)[(11)]:

$$\text{Number of days of diet records needed } (n) = (r^2/(1-r^2)) \times (s^2_w/s^2_b)$$

Where r = the unobservable correlation between the observed and true mean intakes of individuals over the period of observation and s^2_w and s^2_b = the observed within- and between-subjects variances respectively[(10)].

As an example, using the within- and between variance (s^2_w and s^2_b) from the Danish National Survey of Dietary Habits and Physical Activity 2000-06 for 8-10 years old (n=500). Assuming when subjects are divided into quartiles, > 60% should be correctly classified in the extreme fourths of intakes. This will require an r value of 0.75[(12)]. Then the number of days of diet record needed can be calculated, which has been done in Table 2 for selected nutrients and foods relevant for the NND.

Table 3. Number of days of diet records required to rank individuals by nutrient or food intake or to determine usual intakes of individuals, based on the within- and between variance from the Danish National Survey of Dietary Habits and Physical Activity 2000-06 for 8-10 years old (N=500).

Nutrient/Food	Number of days needed to determine the relative intake of individuals (ranking level)	Number of days needed to determine usual intakes of individuals
Energy	4	7
Fat, total	5	12
Saturated	5	13
Monounsaturated	6	14
Polyunsaturated	7	13
Carbohydrate	4	7
Sugar, added	7	37
Dietary fibre	3	12
Protein	4	8
Vitamin C	3	26
Vitamin A	7	33
B caroten	5	88
Vitamin D	21	78
Iron	4	9
Calcium	2	10
Fish and shellfish	25	241
Vegetables	5	44
Fruits	2	43
Wholegrain	-	-
Rye bread	11	56
Oats	3	131
Potatoes	24	165
Coarse vegetables	6	143
Pulses	***	***
Cabbage	30	600
Mushrooms	32	384
Appels	5	143
Berries	6	384
Nuts	16	311
Average number of days	**8**	**107**

***Too few ichildren with an intake

As can be seen in table 3, the number of days needed to determine usual intakes of individuals is impossible to obtain in a real life setting. Even the ranking level can be difficult to obtain. However, in the OPUS study, more weight should be put on the main foods as fruits and vegetables, wholegrain and fish and nutrients as macronutrients, rather than specific foods as cabbage, mushrooms and nuts. Therefore it is evaluated that a week of continuous recording should be adequate to obtain the ranking level. Furthermore, a week is ideal because it covers a complete circle of the human behaviour (including both weekdays and weekend days) [13].

The variance ratio (within-subject to between-subject ratio) of most nutrients is higher in children and adolescents (5-17 years) than in adults. Variability is lowest for nutrients eaten regularly and highest for foods eaten in large amounts only occasionally[(14)].

The number of days needed depends on how frequently the food is consumed and how stable the portion sizes, that are eaten, are. The less frequent intake and the more variation in portion size, the larger number of days are needed. Especially, it requires a large number of days to estimate infrequently eaten foods compared to nutrients, since the same nutrients are derived from many foods and therefore do not vary that much.

Because of the study design and the necessity to conduct the dietary survey 3 times (for ideally at least 7 days), it is relevant to look into if the respondent burden can be decreased, by shorter term measurements. In principle there are two different ways to assess usual intake. The obvious way is to apply dietary assessment methods like a food frequency questionnaire (FFQ) or a diet history that are designed to assess the long term average intake directly by the study participants. However, these methods lack dietary details, are not quantitative precise or meal specific and FFQs are cognitive difficult for the respondent and not suitable for children. Therefore, the FFQ may not be the most appropriate method to use in intervention studies as they may not be sensitive enough to detect sometimes quite subtle dietary changes. The other possibility is to conduct repeated short-term measurements like 2 times 24 h dietary recalls or food records supplemented by a comprehensive FFQ. Here the variance of reported intake is inflated by additional day to day variation of individual dietary intake. To estimate usual intake the within-subject variability of the data must be reduced by an appropriate statistical procedure. Furthermore, the frequencies from the FFQ are added as covariates in order to estimate individual usual intake of episodically consumed foods and their distributions. Such an adjustment can be performed by an approach developed by Nusser et al. (1996)[(15)] using the program C-side or the German approach developed by the German Institute of Human Nutrition called the Multiple Source Method (MSM)[(16)] or other similar methods.

The U.S. subcommittee on criteria for dietary evaluation recommended using randomly selected independent days for replicating the measurements of 1-d nutrient intakes to reduce any effect of autocorrelation between intakes on adjacent days[(10,17)].

Table 4. Intake of selected foods by children 8-10 years measured by 2 random days*, and adjusted by the MSM method§, and by the MSM method and a FFQ - compared to 7 consecutive days (n= 427)

	2 random days only		MSM –method		MSM incl. FFQ†		7 days	
Food group	Mean	Std	Mean	Std	Mean	Std	Mean	Std
Ryebread	49,2	84,6	47,4	29,7	47,4	30,1	46,3	35
Fish	11,3	36	11,1	11,9	11,1	11,7	10,4	15,4
Meat	55	57,3	55,6	23,4	55,5	23,6	55,4	29,8
Milk	378	330	374	214	376	216	375	237
Fruit	139	175	137	89,6	138	90,3	134	114
Vegetables, total	80,8	102	77,8	38,2	78,4	40,6	80,1	66,5
Coarse vegetables	37,4	64,6	37,1	26,1	37,1	26,4	36	38
Potatoes	49,0	105	50,8	43,2	51,3	38,8	46	45,2
Cabbage	3,0	17,8	3,3	10,2	3,2	7,3	2,5	7,2
Pulses	0,7	8,5	0,8	8,2	-	-	0,5	5,7
Apples	44,4	77,8	44,3	35,4	44,2	35,8	44,6	47,8
Oat	6,3	20,4	6	11,8	6	10,3	5,8	13
Nuts	0,4	3,6	0,4	2,4	0,3	1,5	0,5	2,5
Berries	3,0	19,9	3	10,9	2,9	7,5	3,4	13,7
Soft drinks	165	287	164	90,6	164	79	174	157

*The random days are drawn from 8-10 year old children participating in the Danish National Survey of Dietary Habits and Physical activity 2000-2008.

§ The Multiple Source Method(16)

† The FFQ is estimated from the Danish National Survey of Dietary Habits and Physical activity 2000-2008.

The MSM method was developed to estimate usual dietary intake distributions in a three step procedure. In the first step, the probability of eating a certain food on a random day is estimated for each individual. Secondly, the usual amount of food intake on a concumption day is estimated. The resulting figures from step one and two are finally multiplied by each other to estimate the usual daily intake. In Table 4, the figures presented in the first column is the result from having 2 random days only. These 2 random days are drawn from a sample of 427 children, who has completed a weeks food registration (The Danish National Survey of Dietary Habits and Physical activity 2000-2008). The random days are chosen so that on group level there is an equal representation of weekdays.
As can be seen from Table 4 the standard deviations are really large, having only these to days. In column 2. the MSM-method is applied in order to shrink the standard deviations. This is done in the MSM programme by applying a linear regression to get the residuals which are transformed to normality by a two-parameter Box-Cox transformation. The transformed residuals are employed to estimate the inter- and intraindividual variance, which is employed to shrink the mean food intake of an individual to a grand mean. The quantities calculated in this shrinkage are back-transformed to original scale and added to the linear regression model, resulting in an estimate for usual food intake of an individual on a consumption day. These data (in column 2) however, suffer from inadequately measures of usual intakes of episodically consumed foods (and are therefore not true individual intake). Therefore information about the individual probability of consuming a certain food is added to the model (results in column 3). In this case the FFQ were constructed from the same sample of children, as described above, that completed a weeks food registration. Results from the FFQ was obtained by counting how many times each individual consumed certain foods during the day and/or week. These frequencies/probabilities are used as covariates when estimating estimating the usual intakes. As can be seen from Table 4 the standard deviations are reduced significantly by the MSM statistical adjustment method, both with and without the FFQ, and resembles the standard deviations from the 7-

days of registration in column 4. It is highly recommended to collect and make use of information from FFQ to assess the intake of rarely consumed foods more accurately to obtain a “true” individual level[18].

However, with the present study design, it is not possible to conduct 2 random selected 24 h dietary recalls supplemented by an FFQ. Firstly, because the FFQ is not a suitable method when 8-10 year old children are the respondents and their parents would not be reliable reporters of their intake at school during the intervention period. There is also the risk of that the FFQ periods would overlap in memory and therefore it is not so suitable for a cross-over intervention study. Furthermore, the FFQ has to be quite extensive, because it has to cover a large variety of “infrequently” eaten foods. In the American National Health and Nutrition Examination Survey the FFQ covers 140 questions and takes over 1 hour to complete. Secondly, it would be logistically and resourcewise very difficult and costly to plan and implement. The respondents would have to complete 2 different dietary assessment methods – the 24 h recalls and the FFQ, both have to be validated. The participants would have to complete 6 times 24 h dietary recalls and a comprehensive FFQ 3 times. The 2 x 24 h recalls would have to be situated around the blood tests (if any biomarkers is going to be correlated with dietary intake) and be within the baseline, control and intervention period. This would deviate from the principle of random selection of the days.
Furthermore, if the recalls are based on interview as is most frequently seen, the respondents would have to be contacted in person, either face-to-face or by telephone, that is 6-9 personal contacts with each participant.

The most feasible method for this intervention has to be self-administed, either a dietary recall or a food record method, or a combination. It has been investigated if the recording period can be cut down from 7 to 4 days. The results showed that the ratio between energy intake and calculated basal metabolic rate (EI/BMR) was the same for 4 and 7 recording days. However, the proportion of consumers (those who had eaten something) of selected food items increased with the number of recording days and was 10-20% higher for 7 days compared to 4 days. It would be possible to cut down to 4 days; however there would be a loss of information about consumers of specific foods[19].

7. What time period is of interest (past or present diet)?
Measurement of the effect of the school-intervention with the NND requires a valid measure of diet before, during and after the intervention period. Before as a baseline, during to measure the adherence to the NND, and after as a control to the other intervention group. At the 3 measuring points, before, during and after the 3 month intervention, it is not the past diet but the present diet that is of interest.

As described in section 4. it is essential that the dietary assessment covers the whole diet.

Results from the Danish National Survey of Dietary habits and Physical Activity show that there is a large difference in dietary habits on week days compared to weekend days, and for many the weekend, in terms of eating habits, start on the Friday[20]. In order to compare school days to non-school days i.e. days where they are not exposed to the NND, it will be necessary to capture dietary intake on weekend days as well as weekdays.

8. Is information needed on specific dietary behaviors?
In relation to nutrient intake it is necessary to obtain data for specific dietary behaviors such as supplement use. Since 74% of Danish children age 4-10 years use a daily or almost daily multivitamin/mineral supplement this might influence their blood levels and depots of vitamins and minerals which might have relevance in relation to the biochemical risk markers[21].

Within the dietary assessment it is necessary to obtain specific infomation about the intake of the NND on that particularly day, i.e. where the lunch came from (home, school canteen other) and where it was consumed in order too add a personal verification of the intake and adherence to the NND. Furthermore, it could be relevant to ask some qualitative questions, within the dietary assessment, about the acceptance of the meal to qualify any non-adherence to the NND.

9. What kind of background and lifestyle information is needed from the target group?
To evaluate the food intake data effectively it is important to collect sufficient additional data to allow individuals to be identified, not only by age and gender but also BMI, physical activity and social background since the OPUS project focuses on the lowest social groups where prevalence of obesity is often highest(22). Therefore, it is important to be able to relate dietary intake to social background and other lifestyle factors.

In the National Survey of Dietary habits and Physical Activity background information about age, gender, employment status, occupational status, education, household income, family status, smoking habits, health status and attitudes to and knowledge about food is obtained from the parents and about age, gender, height, weight, physical activity for the children.

It will be relevant to obtain data about the parent's intentions to eat healthy, since behavioral intentions have shown to be highly correlated with behavior(23). The parent's intentions to eat healthy may influence the childs dietary assessment i.e. if the parents have strong intentions to eat healthy themselves, they might influence the childs dietary habits and report in a healthier direction during the assessment period. It will also be relevant to obtain data about avoidance of specific foods. This is especially relevant if the participating children have other ethnic background than Danish and might explain why specific foods are not eaten.
These questions and others are included in the background interview in the Danish National Survey of Dietary Habits and Physical Activity. It is recommended to include the same background interview in the OPUS dietary assessment, in order to be able to compare results with a random sample of Danish children. Although, the background interview may need to be modified (cut down, since it is very long (app 40 minutes).

10. Who are the target group – respondent characteristics?
The primary target group in the OPUS project is 8-10 years old school children. The cognitive abilities required to self-report food intake include an adequately developed concept of time, a good memory and attention span, and knowledge of the names of food. These abilities develop rapidly from age 8 years and studies in the early 1990s provided evidence that by age 10 years (fourth grade), children can report their food intake for the previous 24 hours reliably. However, the average age at which children develop the cognitive skills relevant to self-reporting of diet intake differs cross-culturally and between individuals, and the minimum age at which children gain the ability to conceptualize the time frame used in dietary instruments (24 hours, 1 week, 1 month) is not well established. The ability of children younger than 10 years to give valid responses to food frequency questionnaires covering periods greater than 1 day is questionable because of their inability to conceptualize frequency and averaging. Therefore parents and primary caretakers remain the surrogate reporters of children's intake until their cognitive and literacy skills are sufficiently developed to permit independent reporting of their own food intake. The need for adult assistance in dietary reporting is also driven by the limited scope of the child's experience and knowledge of food preparation. Children may be inattentive to aspects of food and drink that are of interest to interviewers (e.g., brand names, fat content of milk)(24).

The dietary survey method will be developed in Danish. This can make it more difficult for other ethnic groups to participate if they don't speak Danish and if their food culture is quite different.

11. What are the research constraints in terms of money, time, staff.

The resources available, both financial and human also influence the choice of method. But they should not be the primary consideration. The method used should be determined by the questions to be answered. If the method needed to answer the research question is beyond the resources available it is better to redefine the question than to collect inadequate data. 1 PhD. student + help from TAP personel is allocated to develop and validate the method for the OPUS school-intervention.

The resources of the intervention study for the data collection and processing require appropriately trained personnel for data collection, review, entries and analyzing the data. This is a timely process for 3 x 4-7 x 1600 = 12000 - 33600 dietary data collections. This suggests that the system developed should be electronic (saving the scanning or entries of data).

In 2009, 86% of all Danish families had a computer in their home and it is especially families with children that have a computer in their homes. 98% of all couples with children have access to a pc in their home, and almost all (97%) of these have access to the internet. For singles with children the figures are 93% (pc access) and 91% (internet access)[(25)]. Furthermore, a computer allows standardization of questions and questioning sequence, and an American study suggests that dietary methods that incorporate technology may improve cooperation and accuracy among children and adolescent[(26)]. Children and adolescent are also the most eager in terms of adopting new technology.

In a Belgian study that evaluated the feasibility of collecting data from parents about their pre-school children's diet using an online dietary assessment tool 73% of the parents preferred the 3-day online food record compared to 12% preferring the 3-day paper and pencil method[(27)].

It has not been clarified how many resources that will be available for the dietary assessment. A personal and professional delivery of the dietary assessment to the families where a background interview and a careful instruction of the participants can take place, is considered essential.

Summary of the above considerations

The dietary assessment method has to cover the whole diet and represent weekdays and weekend days. Furthermore, it has to be food and meal specific in order to measure the intake of the NND and relate results to biochemical risk markers for lifestyle diseases.

The dietary assessment method should be able to obtain information about specific dietary behaviors i.e. where the meal consumed came from and where it was eaten. It might also have to include qualitative questions about avoidance of foods and the acceptance of the lunch meal as well.

Data at the individual level is preferred, however the number of days needed to determine usual intake of individuals is unrealistic. But it is realistic to be able to rank individuals by food or nutrient intake. But this level also requires multiple observations and optimal for 7 days.

Furthermore, the diet assessment method has to take into account that dietary assessment of children 8-10 years old rely on, beside the children themselves, a second person (the parents) and might involve a third person (e.g. an adult caregiver, teacher etc.) to report the child's intake.

The heavy workload of the intervention study, with performing between 12000-33600 dietary assessments including data collection, reviewing, entering, processing and analyzing the data suggests an electronic (web based) data collection that saves data scanning/entering. This could be a feasible solution since almost all Danish families have a computer in their home and it is especially families with children that have a computer in their homes and internet access.

The dietary assessment method should be accompanied by a background interview, preferable a shortened version of the background interview used in the Danish National Surveys of dietary Habits and Physical Activity 2010, in order to be able to relate the child to social class, parent's education, health focus etc and compare to a random sample in the Danish population.

These requirements exclude dietary assessment methods as:

- Food Frequency Questionnaires (FFQ), because many details of the diet are not measured and it is not quantitatively precise. The FFQs are not meal specific and can't estimate the combination of foods in a meal. The estimation task required for an FFQ is cognitively complex and difficult especially for children because it requires the ability to averaging the intake over the day and further over the time that is covered by the FFQ. Furthermore, it is not applicable when a third person may be needed to estimate the foods eaten away from home.
- Diet History, because it is averaging intake out over time to obtain information about past diet (like the FFQ). It is not quantitatively precise. However, it is more meal and food specific than the FFQ. Like the FFQ it is cognitively complex and it is not applicable when a third person may be needed to estimate the foods eaten away from home. The original Diet History included a 3-day food record to crosscheck the history. All together, the process is very time consuming and requires a highly educated interviewer and do have high investigator burden.
- 2 x 24 h recall alone or combined with FFQ. The 2 x 2x h recall alone is not suitable for analysing dietary data at the individual level and without or combined with the FFQ the method it is not feasible with the target group or the present cross-over design.

For a food record, respondents are instructed to report information at the time of consumption to reduce error caused by lack of memory; but little information is available regarding actual participant behaviour, and respondents may vary with respect to when they complete food records. If a food record is filled out in the end of the day, it resembles very much the 24 h recall, and a method that combines the record with a recall seems feasible within the OPUS school intervention set up.

Validation studies show that correlations between the reference method and dietary assessment tool were almost always higher for food recalls and food records than for FFQ[24].

On the background of all the above reflections and considerations it is decided that the OPUS school intervention use a web-based 7-day record/recall dietary assessment method.

The rest of this report will therefore try to assess how such a method should be tailored and will therefore focus on food diaries, 24 h recalls and combination of these methods and the use of technology to assess the diet of children.

Part two: A web-based Dietary Assessment Software System for Children – specific considerations for tailoring a web-based dietary assessment software to the study population

This part of the report is an update of the scientific literature about the different elements included in dietary assessment when the method is either a food diary- or a recall method and the study population is 8-10 year old children. Furthermore, it includes pertinent considerations for specific needs for handling different elements in different dietary assessment methods, with special emphasis on methods involving the use of new technology. Therefore, this part also includes a section about the use of different technologies in dietary assessment methods to give a short description of advantages/disadvantages and use and development of different dietary assessment technology to date.

Method

A computer- and web based dietary assessment method is the use of an instrument/computer to facilitate dietary registration in a more motivating, manageable and effective way compared to the use of pencil and paper. However, many of the challenges are still the same as using a pencil and paper method. Therefore this review involves both electronic and more conventional methods as pencil and paper.

This chapter builds on several recent, comprehensive reviews of dietary assessment literature (NCI Dietary Assessment Literature Review conducted by The National Cancer Institute, among school age children (6 to 12 years) covering literature through December 2003[24], Livingstone, Robson and Wallace 2004[28]; McPherson et al, 2008[7]; Sherwood, 2008[29]; Ngo J et al, 2009[30]. The purpose of the above reviews has been to describe validated instruments for assessing usual food or nutrient intake, while the present report focuses on literature that has also investigated specific aspects of the elements included in either a food diary- or a recall method or a mixture. Therefore the present report has another structure and purpose than the above reviews and includes other literature as well.

Studies were identified by Web of science, Scifinder (including Medline/Pub Med), and DADS (Digital Article Database Service) using the following keywords: food intake, diet, nutrition, eating, nutrient intake, assessment, evaluation, monitor, methods, method, methodology, validation, validity, valid reproducibility of results, children, adolescent, diet record, food record, food diary, diet diary, diet recall, food recall, 24 h recall (2003-2009). Additional articles were identified by cross referencing from author reference list. Titles and abstracts were evaluated to select articles.

Use of technology in dietary assessment

The fundamental methods of dietary assessment, i.e. a recall / FFQ, or a record will still use the same idea/construct, even if different methods are combined or an electronic dietary assessment tool is used to gather the data, and they are also likely to underpin dietary assessment methodology in the future. The use of technology just offers different possibilities on how dietary data may be collected. Adaptions of technology have led to extensive changes in how dietary assessment is collected. The most common objective has been to reduce the costs, researcher and participant burden and harmonizing both the collection and processing of dietary intake information due to the amounts and complexity of data usually involved[31]. The present chapter describes a few of the present technology-driven methods.

Table 5. Advantages and disadvantages of a self-administered web-based dietary method compared to a self-administered paper and pencil method.

Advantages	Disadvantages
•Standardization of the questioning sequence	•Expensive to develop
•Easy processing, ensures that data processing is automated – reducing human error in data entry	•Risk of social divides in access and use of the internet which can induce sample bias
•Data can be automatically validated if a data value is entered in an incorrect format, the program can return an error message requesting the respondent to enter the data correctly	•Risk of non-response bias
•Increased flexibility i.e. possible to make conditioned questions	•Long interactions compared to flipping a page. Interactions have to be quick to avoid that respondents drop out because of boredom
•Easy and fast update	•Various technical problems can occur. The server may crash (especially if the questionnaire is long and complicated). There is also technical variance in computers, browsers and internet connections
•Superior questionnaire interface	•Limited clarity, depending on the screen size
•Can include skip patterns for ease of navigation	•A certain level of computer expertise is required
•Can include platforms to provide more information about the project	•Takes effort to start up the computer, type in the URL address and get acquainted with unknown software.
•Can include prompts if respondent skip a food	•Data security is also important to protect the anonymity and confidentiality of the respondent.
•Can include audiovisual stimuli	
•Potential to track how respondents interact with the questionnaire	
•Possible to view submitted responses/following response rate	
•Engaging to children and younger adults	

Technology offers many opportunities for the development of novel methods to collect dietary data and enhancing the quality of this data. Table 5 describes the advantages and disadvantages of using web-based technology. Advantages of using technology for dietary assessment include standardization of the questioning sequence, fast and easy processing, immediate results, increased flexibility, and easy and fast update. The disadvantages include the need for reading, typing skills and computer/technology literacy[32]. Web-based or computer assisted questionnaires, recalls or diaries are becoming increasingly common. The use of technology to collect dietary intake data is especially engaging to children, adolescents and younger adults who are familiar with the technology in their daily lives. Perceptions of “enjoyable” and “easy to use” are rated highly in many computerized diet programmes[33].

It is important to bear in mind that not all individuals may have the skills such as the ability to use the keyboard, mouse and/or menus of a computer system and furthermore participants may not read the screen instructions correctly or at all, and this needs to be considered when developing a programme and determining its usability.

Web-based assessments

Web-based questionnaires offer many advantages. They are quick, easy and cheap to administer. They include internal checks to flag missing, incomplete or implausible answers. They may allow summarisation of answers and immediate feedback to the respondent. A number of web-based questionnaires has been assessed and found to be feasible and acceptable to respondents[34-36].

Moore et al (2008)[37] developed a new web-based piece of software Synchronised Nutrition and Activity Program (SNAP™) to assess dietary intake and physical activity simultaneously in children 7-15 years. Dietary intake was assessed using 'counts' for 21 foods and then compared to dietary data obtained by a 24 hour multiple pass dietary recall. The authors concluded that it provides a quick, accurate, low-burden and cost-effective estimation of dietary intake. Following on from this work, the team at Durham University, UK has developed a version of the software for use with adult populations - Synchronised Nutrition and Activity Program in Adults (SNAPA™).

Researchers at Baylor College of Medicine (Houston, Tx) developed the Food Intake Recording Software System (FIRSSt) which was the first software program, designed for use with fourth-grade children, that uses interactive multimedia to facilitate a child's self-report of diet by simulating a multiple pass 24 h recall. This development work reports on the formative cognitive research of how children categorize and label foods to facilitate food search in the system[38-42]. The FIRRSt gave in the validation study similar results compared to a dietician-conducted 24 h recall[43].

Building on experience of the United States Department of Agriculture (USDA) Automated Multiple Pass Method and the FIRSSt, Subar et al (2007) have developed a computer-based, self-administered 24-hour dietary recall for use in adults (ASA24). This development work reports on the formative cognitive and usability testing of two versions of recalling food intake; they tested two versions of a 'quick list' for remembering foods consumed the previous day: 'unstructured' and 'meal-based' approach. The latter was strongly preferred by respondents; this has implications for interviewers undertaking dietary recalls[8].

Portion size estimation

Researhers at Newcastle University, in the UK have developed a computer program to assist in portion size estimation in children using photographs based on child portions; the tool in use is known as the Interactive Portion Size Assessment System (IPSAS). Pilot work showed encouraging results. Three methods, the IPSAS, food photographs and food models were all compared against direct observations of children's intakes. Children were served specific weights of foods and the leftovers were weighed. Estimations using the three methods were then compared with the known quantities[44]. The accuracy and precision of estimates made using the photographs and IPSAS were comparable. Currently the IPSAS is developed into a children's self-administered 24 h dietary recall.

Use of Personal Device Assistants and mobile phones

The future of dietary assessment may lie with the technology available in Personal Device Assistants (PDAs) or mobile phones. A study in children and adolescents has shown that capturing food intake by PDAs or disposable cameras was preferred to pen and paper methods[(26)].

Dr Carol Boushey and colleagues from many disciplines at Purdue University in the US are undertaking pioneering work in dietary assessment. The team is developing a computing device which will include digital images, a nutrient database, and image analysis for identification and quantification of food consumption. Mobile computing devices provide a unique vehicle for collecting dietary information that reduces the burden on record keepers. Using image calibration, acquisition, and image segmentation, methods are being developed to automatically estimate the volume of the foods consumed from images captured with a mobile device[(45)]. The technology is based on that used to estimate the height of mountains in cartography.

DietMatePro integrates PDA and web technologies to provide a comprehensive system for monitoring individuals' dietary intake. It is based on the USDA Nutrient Database and includes data on approximately 6,600 food items. Food intake is recorded in real-time and can be transmitted to a health care professional via a palm device or a computer using a web server application. The system was validated by comparing 3 days continuous recording to 24 h recalls obtained a day later, and an observed lunch. Results showed significant correlations between methods[(46)].

In Japan, the Wellnavi-instrument (Matsushita Electric Works, Ltd, Osaka, Japan) has been developed, in which a camera captures a photo of a meal, the names of the ingredients can be added for clarification, and then a mobile phone card transmits the digital photo to a dietician who then returns the calculated nutrient intake. Validation studies on the instrument have been undertaken that have found correlations to weighed diet records and 24 h recalls between 0,46 and 0,93[(47)].

The food Intake Visual and Voice Recognizer will capture a photographic record of food intake and will capture additional detailed information using voice record and recognition data[(48)].

Level of detail

The literature has become more specific on at what age children can self-report their diet [(24)] but there is hardly any literature about to what detail children can self-report about their food intake.

From the literature dealing with the use of children in surveys in general, a general rule is that children can answer many questions that are directly relevant for themselves. On the contrary they usually don't have any insight or knowledge into other people's doings [(49)]. This means that most children can report what they are eating (taking from the plate or glass and put into their mouth). If the children are not involved in cooking and shopping they would have very little knowledge of food preparation and trade names of the food/products and would be unable to answer questions concerning this. Less than 3% of Danish families include their children in the daily cooking (Danish National Survey of Dietary Habits and Physical Activity 2005-08, unpublished results), this means that in general Danish children would have very little knowledge about how the food they ate were prepared.

In surveys it should not be decisive if only a few children have the knowledge to answer specific questions. All of the children in a survey (or nearly all) should have the necessary knowledge to answer a specific question before these questions can be asked about[(50)] .

If the researchers ask about more details than the children can give, the children often skips the complicated thinking and makes up an answer alternative that may not be true but is less demanding for the child. Other techniques is to choose the first and best answer alternative that is presented or the most neutral answer alternative[49].

Double questions i.e. asking about to different things in one question is also complicated for children to answer[51], and therefore it is important to make sure only to ask one question at a time[49].

The experience from the Danish National Surveys of Dietary Habits and Physical Activity, that is a self-administered food record, shows that participants are able to report the type of food that they ate, but not many related qualities as e.g. how it was preserved, packed, prepared and origin. However, for some foods – they will be able to tell brand/trade names typical examples are Coca cola, Kellogg's Cornflakes, and M&M etc.

This implies that the level of detail that can be obtained in a self-reported web-based system is somewhat the same. The children/parents will register the type of food e.g. rye bread, skim milk, lasagne, fish filet but not related qualities as which recipe was used and how it was prepared, preserved, packed etc. and only in specific situations, where it is important for respondents to tell, the brand/trade name e.g. Coca Cola, Mathilde Cocoa Milk, Heinz tomato ketchup etc.

In figure 2. the most basic steps included in a dietary assessment system that assesses food intake to this basic level of detail is described together with the consequences for a web-based method when respondents are 8-10 year old.

Steps in dietary assessment	Elements involved for the respondent	Problems related to the elements when respondent is 8-10 years	Consequences for a web-based software system when respondent is 8-10 years
Overall premise 1: Motivation	•Relevance •Trust	•Low relevance to the child •Long and boring •Low trust to OPUS project •Low trust to dietary assessment system	•Intuitive software system •Clear and quick functionalities •Simple and clear content – in audio as well •Appealing aesthetics and elements of surprise •Delivered and explained in a personal and professional way
Overall premise 2: Competence	•Ability to recall foods eaten (memory in relation to foods). •Reporting willingness. •Reading competences. •Writing competences.	•Memory problems especially relating to snacks, beverages and accompaniments •Report foods not eaten •Social desirability •Poor reading/writing abilities	•Recall/record should be completed in the evening for the same day •Several ways to enhance the memory of and register what was eaten. E.g. prompts, automated loops, internal checks to flag missing, incomplete or implausible answers. •Rewarding the accuracy of the children's records. •Bogus pipeline. •Enhance the memory during the day by taking notes, photos or talking to a Dictaphone. •A good and clear tutorial and instructions and questions in audio as well.
Step 1. Day of the week and time	•Time recognition and time conception. •Knowledge about week days and activities during the week.	•No clear conception of when they have eaten what •No clear conception of weekday	•In build facility to register and report intake by weekday. •Prompts for type of day (if it is a school day or not). •Prompts for activities to provide a context for recalling food intake •Clear structure.
Step 2. Eating occasion Before breakfast snacks Breakfast Mid-morning snacks Lunch Afternoon snacks Supper Evening snacks **Step 3. Conditions for the meal** Duration of meal Who prepared the food? Where was it eaten?	•Knowledge/memory of eating occasions •Naming of eating occasions •Knowledge of time span for eating occasion •Knowledge/naming of eating place •Knowledge of where the meal was prepared	•Don't remember unstructured eating occasions (snacks) (Especially a problem after school when engaging in other Activities) •Not used to keeping track of Time in relation to eating •Don' know/remember where the meal was prepared.	•Several recall strategies for unstructured eating by prompting for activities (i.e. at sports activities, together with friends). •A meal-based approach that "forces" respondent through every eating occasion •Photographs of the meals to enhance recall. •Very simple facility to register time and who and where the meal was prepared. Not applicable for snacks.
Step 4. Searching and registering the food eaten **1. Searching by categories** **2. Search free text** **3. Open answer option.**	•Knowledge of specific foods eaten and type •Ability to search/find the foods in different structures •Spelling competence.	•Do not always know what the food/dish is called. •Do not have developed good spelling competences. •Not used to categorize foods in a "three-level" system.	•A specific and comprehensive food data base that use terms that are simple, understandable and place foods in more than one category. •A category search that use professional, child and meal labelled food categories to make foods easy to find •A quick search facility that can take into account spelling mistakes. Like a phonetic algorithm (Soundex/Metaphone). •A facility for writing open answers for foods not otherwise found. •Photographs of food categories to enhance understanding of food categories.
Step 5. Choosing portion size Use of food photographs, food models or household measures	•Perception of amounts eaten •Evaluation and memory of own portion size eaten	•Foods mixed together on the plate •Can't remember •Undeveloped abstraction level	•Age appropriate portion size measures and fewer choices than for adults. •Photos are found to be preferred over food models. The difference between photos should be clear. •Number of photographs: Only an uneven number if child should be offered an easy (neutral) answer alternative • Clear, simple and quick portion size estimation procedure.

Figure 2. Basic steps, included in a dietary assessment method, and consequences for a web-based software system.

Overall premises motivation and competences

A high degree of cooperation is required from children for food records and 24 h recalls. Therefore it is essential that the children be motivated to participate and be cognitively able to complete the records /recalls or be provided assistance. Among the participants in a dietary survey the motivation and their competences is the most important factors for the quality of the answers. Respondents who are interested in the subject will concentrate more than others. And the more the children know about their eating habits, the better foundation for giving the correct answers. Therefore the challenge is to cause and maintain interest for the subject and give the children (a feeling of success) an experience of that they possess the needed competences.

Overall premise 1: Motivation

It is essential that a self-reported dietary assessment software system is intuitive, simple and clear. Ideal children 8-10 years should be able to use the system without reading instructions. In relation to creating this intuitiveness, relevance is an important parameter. Relevance indicate, which meaning a given phenomenon attributes to the individuals life situation[52].

In relation to relevance the key challenge is to make the questions essential, relevant and meaningful for the respondent so they will be motivated to give the answers. Therefore the challenge is to ask just the essential questions and as many (and no more) to obtain the detail required to answer the research question. The interface of a computer makes it possible to ask a lot of detail about the consumed foods. Some self-administered computer based dietary assessment systems e. g the National Cancer Institute's Automated Self-Administered 24 h recall (ASA 24) have 3 questions about the size of drinks (container type, container size, and then adjusting the portion). However, it is not known if these additional questions increase the precision of the estimated portion size.

Consequences for a software system

The process in a dietary assessment is very complex – to remember what was eaten, when and where, and describe what was eaten – remember and estimate the right amount. There are many steps where the respondent's attention can get lost due to burden/complexity. Therefore it is important to work with all aspects of the web-based dietary assessment system in order to avoid that this happens. In figure 3 a working model that includes 4 main parameters in a web-based system is described. A web-based dietary assessment system can be described by its functionality, contents, aesthetics and setting. When children use these dimensions they also use different sides of themselves. They will use and judge the functionalities (Homo faber) e.g. they will judge if the interactions are slow, and if they easily can find the food they ate. They will also evaluate and reflect over the content (Homo sapiens) e.g. are the questions relevant and does it all make sense to me. As modern children they will also expect to be entertained (Homo ludens) e.g. a nice and clear design and an element of surprise (so they won't judge the system outdated) and other motivators like feedback. They are also social beings and interact in the OPUS setting (Homo socius). In that connection it will be essential to get the system delivered and explained to the children in a personal and professional way in order to create "trust". Trust is the emotional component that enable corporation between the child and researcher despite separation in time and place[52]. A personal and professional contact is also important for the response rate[53,54].

In order for the web-based system to be motivating it has to stimulate and tackle all these dimensions in the children.

It is also be important for the motivation of children to give a reward. A reward can be more important than the value of it. Cinema tickets have been found to be a good reward in surveys among children both in international studies[49], and in several studies conducted with children at the Danish National Food Institute, Department of Nutrition.

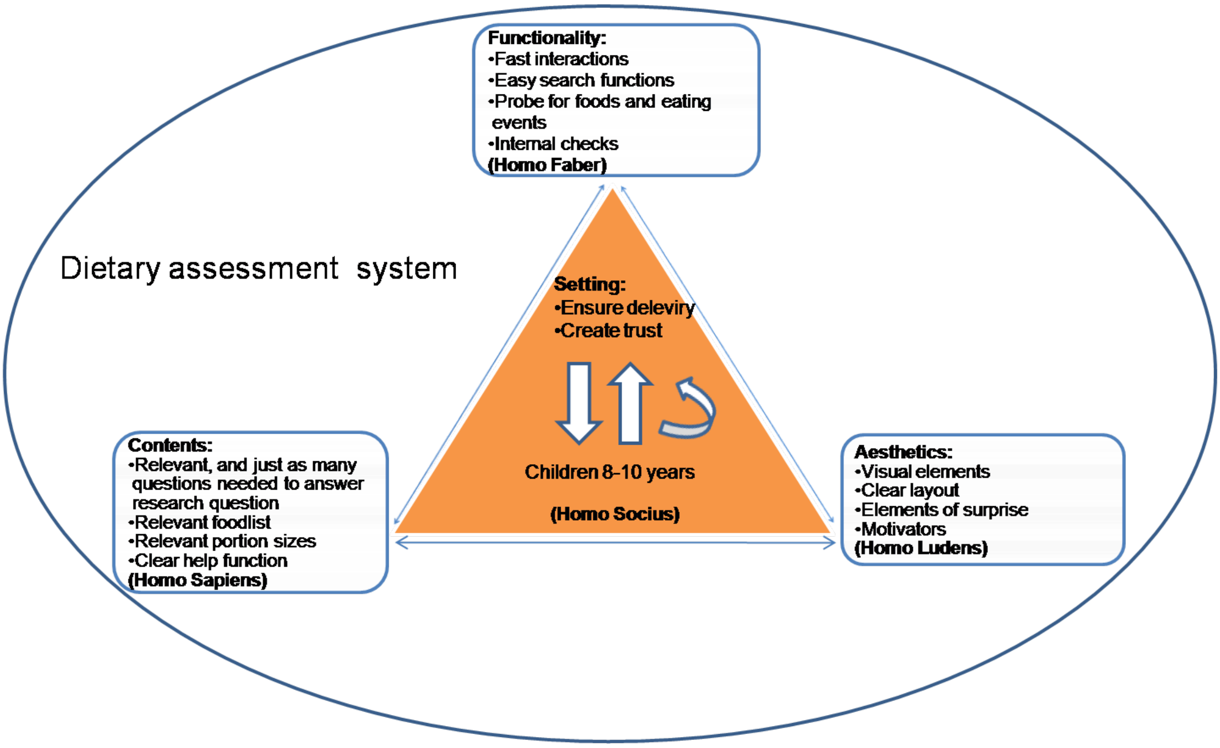

Figure 3: A working model for developing a web-based dietary assessment system including 4 main parameters.

Overall premise 2: Competence

Dietary surveys based on recall rely on memory. The limited research on children's recall of food intake shows that the errors include both under-reporting (missing foods) and over-reporting (phantom foods/intrusions) and incorrect identification of foods because of a lower level of knowledge of foods and their preparation(55). Under-reporting and over-reporting can also be a result of the participants limited ability to use- and report in the dietary assessment tool.

The four competences general needed to participate in a survey is 1. The ability to, on the time of an (eating) event, to observe facts (what was eaten) accurately 2. The ability to remember and maintain the (eating) event, and the observed facts (what was eaten) independently. 3. The ability to distinguish between true and false, and 4. The ability to communicate what they remember about the (eating) event and the facts (eaten food)(51).

In mid childhood (6-12 years) the abilities of children to think in concrete operational ways is developed and they gain ability of conservation (e.g. 1 litre of water is still 1 litre independent of if it comes in a tall slim glass or in a low wide glass), classification (construct logic hierarchy) and combination. However there is great difference between children and cultures at what age these abilities are gained(51).

For younger children (<7 yrs) the ability to cooperate in dietary assessment is limited and the ability of the parents to recall their children's food intake is vital. Dietary recall studies which have compared the results of direct observations of children's food intake with 24 h recalls by parents, suggest that parents can be reliable reporters of their children's food intake in the home setting. In general, there will often be a lack of agreement between the child and parents respond in a survey(51). And parents are less reliable reporters of their children's food intake out of home(56). Given that most Danish parents work out-of-home, the suitability of parents to be the only informants of their child's intake is limited.
Some questions has also been raised about the ways parents may either provide biased information or negatively influence a child's report of intake(28).

A Finnish study showed that parents were more likely to report health behaviours that are more in line with recommended and desired behaviours than children do[57], and a Dutch study indicated a low level of agreement between parental reporting of fruit and vegetable intake on the individual level, but were acceptable for fruit consumption studied at the group level[58].

Factors affecting the accuracy of parent assisted child reports also include children's concern about parental judgement regarding amount of food consumed and specific types of food, social desirability on the part of the parent and lack of knowledge due to the fact that children often eat breakfast, lunch, and after-school snacks outside the home[29]. Other caregivers may be involved, but it is likely that they will approach the task with varying levels of engagement. For some children 10 years and older, assistance from parents is seen as an intrusion[28].

Studies suggest that children are able to provide reliable reports on their food intake by the age of 10 years, but only for the immediate past and for no longer than the previous 24 hours and provided that the time period under investigation is not subject to irregular events and/or eating pattern[14]. This has been questioned by a study by Domel Baxter [59] who found that 10 years old children only reported 67% of items observed at school breakfast and lunch the previous day, and 17% of items reported were not observed. In another study less than half of the items observed eaten were reported accurately, and almost 40% of what the students reported eating was not observed[60]. Most validity and reliability studies among children younger than age 9 years have included adult assistance providing information on the child's intake[24]. A study by Eck et al (1989) found that a consensus recall provided by the mother, father and child yielded better estimates of observed intake of a single meal by children 4-10 years, than did recalls from either the mother or father alone[61].

Four focus group interviews conducted at Danish schools in 2009 with 8-10 year children showed that children were able to remember the outline of their lunch yesterday, but were less likely to remember the details as beverages, miscellaneous and condiment. The children stated that the reason for their lack of memory of the details was because they were not used to, and had never before been asked to perform this task[62]. The tendency by children to forget secondary food items as condiments is also seen in a study by Baxter et al (1997)[63]. Other studies have shown that the salience of the food items in the diet, such that main course items may be easier to remember than secondary items, or common foods are more easily recalled than less common foods[14]. Perceived importance of food also affects recall ability in children[24].

In a self-reported dietary survey it is also necessary to take into account the reading competences of the children. Most children by the age of 7 can read short words and about the age of 10 longer words. Around 15% of a class year have great difficulties in reading and understanding a question[51].

Reporting willingness and social desirability

Biased reporting may be due to one or more of the following factors: a failure to record because it is time consuming and inconvenient; a need for social approval; subconscious memory lapses overall or towards specific foods as snacks; intrusions (uneaten items reported eaten); undereating/dieting in the reporting period resulting in accurate but unrepresentative food data.

Social desirability has been found to bias reports of diet and confound associations between BMI and energy intake. A study found that socially desirable responses are more frequently given by younger than by older children[64], and another study found that the number of reported items for breakfast was negatively associated to social desirability[65].

Age is clearly an important variable that affects compliance in dietary reporting. The overall trend is increased under-reporting with age(14). This is also seen in the Danish National Survey of Dietary Habits and Physical Activity. In Danish children 8-10 year old under-reporting, using a record method does not seem to be a large problem. The EI/BMR is 1,69 in the age group of 8-10 year old children and 3% is defined as under-reporters using Goldberg's cut-off limit EI/BMR ≤ 1,1. This is in agreement with validation studies that suggest that the diet record and 24 h recalls, may provide more accurate group estimates of EI in younger children (6 to 9 years)(14). Probably because the parents have overall control of food intake and the responsibility for reporting.

Parents may also have a tendency to report what they believe their child should/did eat, rather than what they actually did eat – leading to overreporting/mis-reporting.

Obesity, dieting and weight consciousness have been identified as having the most frequent and consistent associations with mis-reporting. Reporting accuracy may also be compromised by parental obesity status and/or by the extent to which parents perceive that such information is a reflection of their child's weight(28). In a study by Baranowski and colleagues the children (9 to 11 years) were asked to provide a hair sample and told, "We can tell some of what you eat from a chemical analysis of your hair" (43). Obtaining a hair sample reduced the omission rate and increased the match rate for 24 h recalls versus observation(43) . This finding suggests that a small part of the inaccuracy of children's self report is wished for or wilful and thereby subject to correction by a bogus pipeline procedure(24). A bogus pipeline informs children that there is another method for ascertaining the truth of their self-report.

In the OPUS project a blood test is taken in the participating children at three time points which follow the dietary assessment. It could be worthwhile considering if these blood samples could be used as a "bogus pipeline" in an ethical way.

Children also have a tendency to report uneaten items (intrusions), suggesting that children can have difficulties separating in their memory what was available on their tray at the meal (stretches) and what was eaten(66). Intrusions increase with long retention interval (elapsed time between when the meals happens and the recall occurs), suggesting that investigators should use as short retention interval as possible(65).

Consequences for a software system

The above suggests that children 8-10 years may not have the competences needed to self-report their dietary intake and they may need support from their parents and it would be important to have the questions in audio as well and read out loud to the children(49). But even with parents support they need to be "directed" to remember the true intake, especially for the time during the day when they were not together with the parents. Therefore, it will also be very important that the participating children are provided with a list with the names of the dishes they have at school, so they are able to report them correctly together with their parents.

Probing is a technique that is used to help the respondents to give the "true" answers. Usually they are supplementing questions that that will help the child to remember what was eaten. Probing in general plays an important role in surveys among children(49). A study by Baxter et al (2000) showed that for fourth-graders, specific prompting with food categories yielded small gains in accuracy with minimal increases in error(67).

Appropriate cues and prompts may aid memory retrieval, but should at the same time be careful not to run the risk of eliciting socially-desirable responses. Research has shown that giving too many prompts to children may increase inaccuracy and cause phantom foods (not eaten foods) to appear(7). Another study showed that simultaneously prompting fourth-grade students for food items imposed too heavy a cognitive burden on the children and in increased inaccuracy[68].

Food list or food-photographs may act as memory prompts, but recognition problems could occur. Recall errors are also likely to be reduced if children are encouraged to reconstruct the context in which the food is eaten (events, activities, people, meals) and the information is then used to cue what was eaten[14].

An American study has shown that the most usual retrieval-mechanism employed by children were visual imagery (appearance of the food, colour, shape, consistency), usual practice (familiarity with eating the food previously), behavioural chaining (associations to other food items or activities during the meal or day), preference (like, favourite food)[68]. Subsequent studies have led to a set of consensus retrieval categories that could be used as cues to help children remember what they have eaten[69]. In the study by Baxter et al (1997) they found that fourth-grade students used “taste/smell/texture” and “visual” as retrieval categories were more accurate in assessing previous day’s lunch[69]. In a European computer program YANA-C (Young Adolescent’s Nutrition Assessment on Computer) the program takes the participants through a range of sequential activities to provide a context, which helps to recall what they ate[70,71].

24 h recalls of structured days have been shown to be more accurate for children compared to periods of longer duration or more irregular behaviour[37]. Children’s memory could also be assisted by them taking photographs of their foods. This approach was tried in connection to four Danish focus groups that investigated 8-10 year old children’s attitudes and opinions in relation to the different task involved in dietary assessment. The day before the focus groups, the children were instructed to take a photo of their school lunch, set on a special designed placemat, while the researcher observed. The children found the unpacking of foods for the photo taking disruptive. This was not the way they usually eat their packed lunch which also in many cases includes food for the rest of the school day. After they had taken the photo, they exchanged foods. This exchange was not captured by the photographs, neither on the photographs of the leftovers. However, they were very enthusiastic about the photo taking and took photographs of everythingelse as well, which could make it burdensome to sort the relevant photos afterwards.

In the American study by Boushy et al, the children also took photographs of their food with a disposable camera. Most of the children indicated that they were comfortable about it[26]. In a study by Small et al (2010) the parents took photos of their 4-5 year old children’s food intake. The photo taking enhanced the parents recording of their children’s intake. However, the method demanded additional resources in form of a standard plate and a clear cup that should be used for all photos and two disposable cameras. The study did not mention how this was handled when the child did not eat together with their parents[72]. In a study by Martin et al (2006) they also tested the reliability and validity of measuring 6th grade children’s food intake with the digital photography method in a school cafeteria setting. They found the method reliable and valid. However, in this study it was the researchers taking the photos[73]. So far, no one has investigated the reliability and validity of children using digital photos to self-report their food intake. A record-assisted 24-hour dietary recall has been used in several studies with children[74]. The child keeps notes of what she or he has eaten and then uses these notes as memory prompts in a later 24 h recall. A study by Lindquist (2000) investigated if a self-reported tape-recorder technique would yield valid dietary assessment among 6-12 years old compared to energy expenditure assessed by doubly labelled water. However, the tape-recorder method revealed poor agreement and weak linear association with energy expenditure[75]. In the study by Boushey et al, 2009 the adolescent indicated that they would be embarrassed by talking out loud about their food intake[26].

Step 1. Time

"When" has been shown to be a poor cue for retrieving information about an event from memory and a time interview format may not be suitable for children[76].

The minimum age at which children gain the ability to conceptualize time frame used in dietary assessment (24 hours, 1 week) is not well established. The ability of children younger than 10 years to give valid responses for periods greater than 1 day is questionable[24]. A study has found that using the prior 24 hours as the target period yielded better performance than using the previous day [55]. In a study by Baxter et al (2008) the likelihood that reported items were intrusions increased 1.9-3.3 times (from evening interviews about the same day's intake to morning interviews about the previous day's intake)[66]. Another study by Baxter has shown that accuracy was better for same-day recalls obtained in the evening[55]. The results showed that omission rates were lower by about one-third, intrusion rates by about one-half and total inaccuracy by about one-third[77]. This suggests that it is better to use the 24 h immediately preceding the interview and conducting interviews in the evening so they are on the same day as most meals in the 24-hour period[78].

Consequences for a software system

The research done by Baxter et al, suggests that the dietary assessment should be completed in the evening for the same day, in order to lower omission-, intrusion rates and overall inaccuracy among the children.

Results from Danish focus groups shows that children do not have a completely clear memory of when they did eat what. A number of children reported food for lunch that they had for a mid-morning snack and for several children the first they remembered about food was when they last time had their favourite food. Their focus had to be directed to what specific meal they were registering in order to get their memory on the right track[62].

Another aspect in relation to time is the time it takes to complete the dietary assessment. Other researchers that have conducted interviews with children, point out that their interest is easily lost and recommend that different interviewing techniques is used during an interview in order to keep the focus of the child[49].

Step 2 and 3. Eating occasion and conditions for the meal

A study by Subar et al (2007) reports on the formative cognitive and usability testing of two versions of a "quick list" for remembering foods consumed the previous day the "unstructured" and "meal based" approach. The latter was strongly preferred by respondents[8]. A study by Baxter et al (2003) found that total inaccuracy was significantly lower for an open format interview than for a meal format, but those results were based on interviews and not self-reports[76].

The meal based approach was also preferred in a bilingual interactive multimedia dietary assessment tool (IMM)[79]. Results from focus groups shows that Danish 8-10 year old children quite easily remember the main eating occasions during the day as breakfast, lunch, dinner. If they are asked or reminded they also remember the more formal mid-morning and afternoon snack in school. These focus groups also showed that the eating occasions that were very hard to get any information about was snacks eaten between finishing school and dinner. In that time period, many Danish children take up sports; play at mate's houses, or at home. Any eating in connection to these activities are irregular, non-formal, and connected to activities where the prime focus are other activities than eating[62].

A study found that for children 9-11 years, questions about timing was harder to understand than other questions, especially if the questions refer to a time period and frequency questions as with an FFQ. However the duration of a happening, was better understood by the children[51].

Consequences for a software system

Delivering the recall in a segmented day format (before school, on the way to school, midmorning etc.) has been shown to enhance recall in children[37]. Most Danish children have between 3-5 eating events during the day[20]. Eating is concentrated around conventional hours: breakfast, lunch and dinner. Former research has shown that among the Nordic countries eating rhythm are most uniform in Denmark[80]. Therefore it would also make sense to use a meal-based approach with Danish children.

If time is asked about, it has to be in a very simple way. The same is probably true for the questions about who prepared the meal and where it was eaten.

Step 4. Searching and registering the food eaten

The evaluation of a simple computer program developed to assess dietary behaviour previous day in school children (7-15 year) (SNAP), showed that 1/3 of the children wanted more options than the 21 food groups included[37]. In an American study evaluating dietary assessment using PDA's through focus groups, the subjects explained that they did not always know the food grouping for a food and that they needed an open search feature. Other issues that distracted from the data entry process were the unfamiliar food names used in the database and programme bugs[26]. According to research conducted by Baranowski et al (2010) children have experienced difficulty in finding specific foods in a hierarchal organized food categorization system, which reflect dietician's in-depth understanding of foods and nutrients. Children reported food categories different from those specified by food and nutrition practitioners[38]. In the study by Baranowski et al (2010), the quickest categorization of foods was obtained with child generated categories in a three category-subcategory structure compared to using an "Apple iTunes"-like cover flow[38].

Beltran et al (2008) found that a food category search system that places food items in mostly taxonomic-professional and scrip/scheme (e.g. meal) categories, with some redundant placement of food items in multiple categories, should facilitate the rapid and accurate findings of food items that a 8-13 year old child ate the previous day[40,41]. In these categorization studies it was expected to find an age group in the age-interval 8-13 years, below which the children could not perform the categorization task but no such age cut-off was detected. However, the category labelling was affected by age in the study of Sepulveda, where the children used more complex "taxonomic-professional" names with increasing age[39]. The studies by Baranowski et al. found that depending on the context the children placed the same food in different groups. A special challenge for children is to categorize mixed foods e.g. lasagne, pizza which include several food ingredients. In a study investigating the categorization of mixed foods by 8-13 years it was found that the children often used "taxonomic-professional" labels or "specific-food item" label suggesting there is no cultural consensus at what meals mixed foods are eaten[42]. Another challenge for a category search facility is that children learn food names from their families rather than learning consistent names in school[39].

In focus groups with Danish children the children also conducted a card sort with photos and names of 63 foods and dishes and similar results as in the above study was illustrated. The children in the focus groups used 3 main strategies for categorizing foods: 1. "taxonomic-professional" often used for bread, meat, fish, fruits, vegetables, beverages and confectionary. 2. Script-scheme (especially used for breakfast) often used for oatmeal, yoghurt, cornflakes, mysli, fruit juice, jam, raisins, white bread. And 3. "Complementary" often used for cereal + milk, burger + french-fries, french-fries + Coca-Cola, pasta + ketchup. In these focus groups the hardest for the children to categorize was the mixed dishes as burger, bolognaise, pizza, lasagne, sausage breads[62].

Consequences for a software system

It is clear from the literature that there is no one single solution to a search facility using categorization other than the use of “taxonomic-professional” labelling should only occur on a food group if the name most likely is the name used about that food/food group (as vegetables) in the family. Furthermore, the same food/dish should appear in several relevant categories.

In surveys with children it is important to avoid words that need explanation and word that needs an explanation should be exchanged with the explanation(49). This can have consequences for the database and a category search facility where it will be essential not to use the professional generic label as e.g. “poultry” but “chicken, turkey, duck and similar”.

Step 5. Portion size estimation

Estimating the amount of food consumed is a complex cognitive task, even for adults. It requires that children are able to recognize and describe quantities in terms of proportions or whole units of household measures and that they can think abstractly about food while viewing generic food models of different volumes or other tools such as food photographs. Training in portion size estimation (for 45 min) is shown to improve the accuracy in both adult and children for some foods (solid foods estimated by dimensions and cups and liquids estimated by volume), but errors for several foods remained(14). It was found that the magnitude of errors in children’s quantitative estimates of food portions was large when using manipulative props (modelling clay, small plastic beads etc.), 2-dimensional food models, food photographs, or descriptions of food portions as small, medium or large(24). An English study found that the accuracy of portion size estimation was better with an interactive portion size assessment system (IPSAS) compared to food photographs and food models(44). Because children may never see the amount of food consumed it was decided that the IPSAS could facilitate the estimation of the amount served and the amount of food leftover. Among newer tools for dietary assessment are reference books with life-size photographs of portion sizes, which have been credited as being both easy and accurate(7).

An English study underlines the importance of the use of age appropriate food portions(81). Other studies assessing diet of children have used e.g. the four lowest weight photographs for each food from an adult food atlas. Results from these studies show that performance is poor using adult food photographs to estimate the children’s amount of food on a plate. Accuracy of children’s estimates of portion size using age-appropriate photographs was not significantly different from that of adults(82). In another British study they investigated the effect of timing on the ability of children (4-14 years) to estimate food portion size. They found that children were as accurate in their estimates of portion size 24 h after consuming the food as when the food was in front of them(83). In a Norweigan study they investigated 9-19 year old childrens ability to estimate portion sizes of pre-weighed food by viewing photographs of 4 different portion sizes. They found that 60% of the comparisons were made correctly and that for most food items, no significant differences existed between 9-10, 13-15 and 16-19-year-old’s abilities to choose the correct photograph(84). However, as in most studies, validating the use of photographs to estimate portion sizes, this validation were also conducted under highly controlled conditions. Participants neither served themselves, nor ate the food, and most of the food and portion sizes presented were the same as on the photographs. Furthermore, the food in question was the only food on the plate. This sceneraio would never happen in real life.

In an American study they assessed the accuracy of portion-size estimates and participant preferences using various presentations of digital images among adults. The results from this study showed that images of household measures (such as photographs of tablespoons and teaspoons) yielded more accurate results than arial photographs for foods like spreads. Furthermore, the preference results clearly indicated that the images of varying size should be presented simultaneously rather than sequentially and that subjects disliked the extra steps (clicks) needed to view the alternatives in a sequential presentation. Photograph size did not affect accuracy, although most participants preferred larger over smaller photographs. In contrast, eight vs. four photos in a photo series tended to be slightly more accurate, despite the preference for four photos[85]. In the IPSAS it was chosen to illustrate 7 photos in a photo series based on the estimation from child psychologists (Personal communication).

In the YANA-C 9 or more photographs were available of the selected foods for adolescents[86]. This was a problem in a simultaneous presentation, because the photos became relatively small and much smaller than the minimum size 7.5 x 10 cm suggested by Nelson et al.(1994)[87]. In the Danish National Survey of Dietary Habits and Physical Activity (4-75 years) 6 photographs is available depicting increasing portion size of the selected foods. 6 were chosen based on the recommendations from Nelson & Haraldsdottir (1998) that an uneven number may tempt the subjects to choose the central image[88]. Among children it is better to use fewer and clearer answer alternatives than for adults[49].

Consequences for a software system

The above review of the pertinent research point in the direction that using photos for estimating portion size. An uneven number of photos could be chosen, if the children should be provided with a “neutral” answer possibility. If the purpose of the system is to be able to place all children according to their portion size, an even number of photos should be chosen (that force the children to place themselves lower or higher than the middle – this is however also more difficult for the children).

Using fewer photographs e.g. 4 instead of 6 as used in the Danish National Survey of Dietary Habits and Physical Activity, would make the task easier for children. This also makes sense since the age span (8-10 years) is much smaller in the OPUS study compared to the National Survey (4-75 years). The portion sizes behind the photos used in the Danish National Survey of Dietary Habits and Physical Activity were collected separately and in this data collection portion sizes for children were oversampled, making it possible to use age appropriate portion sizes. The photos should present very clear differences in portion size and be presented simultaneously, to make the task quicker and easier. 4 photos instead of more also make it possible to present larger photographs on the screen.

Training

Children are not used to perform the tasks included in a dietary assessment. They are not used to think about food like adults who have to plan, time, buy and prepare. Therefore, training in some of the tasks, like estimating portion sizes, remembering etc. may improve the reporting.

Furthermore, the reporting may be improved if the children beforehand get confidentiality with the web-based system[89]. Therefore the children should be encouraged to try the system at least once and preferable several times before the real registration starts.

Summary of the considerations that need to be made to tailor the web-based instrument to the study population

The above review suggests that a web-based dietary assessment software system to assess the dietary intake among 8-10 year old children should include motivation factors, and try to motivate the children by the soft-wares functionality, content, aesthetics and setting. The setting of the OPUS intervention and delivery of the dietary assessment software system to the children and parents e.g. by a professional interviewer, is essential for the motivation, trust and finally the response rate. Accurate assessment of dietary intake in children is a challenge, because children are not used to perform the tasks remembering which foods they had for which meals. Furthermore, they do not have a common understanding for naming of all eating events (especially not snacks eaten in the afternoon), naming of foods and their belonging to food categories. Their skills may depend on how often they are involved in cooking, shopping and talking about food at home. Furthermore, their spelling and reading competences are not yet fully developed. This leads to the conclusion that 8-10 year old children need support from their parents to complete a dietary assessment. To enhance completeness of reporting appropriate cues and prompts could help memory retrieval. It can also be considered that the children keep notes of what she or he has been eaten and these used as memory prompts. During the intervention it will be essential that the schools/caterers provide the children with a menu plan, so both the children and parents have a chance to find and report the eaten dishes in the dietary assessment software system.
It would be preferable if the system had an audio function, so the questions and probes could be read out to the children and their parents as well.

To avoid misreporting and intrusions it will be important that the reporting is done on the same day e.g. in the evening for the same day, and that the system "reward" this behaviour. See Table 6 for an overview of the reporting method.

A meal based approach would be sensible, since eating in the Danish food culture is still concentrated around breakfast, lunch and dinner. The challenge will be to give the appropriate prompts for the reporting of snacks – especially during the afternoon.

There is no single solution to the most obvious and easy way for children and parents to search and find and report the eaten food items in a software system. A combination of search facilities should be available. A hierarchically search facility should be careful with the naming and the use of taxonomic-professional names (e.g. poultry, fats) especially if these names are not likely to be used by the child and their families about daily eating.

For portion size estimation photos depicting increasing portion size can be used. However, the task of portion size estimation should not be too complicated. This can be obtained by using fewer photos e.g. 4 instead of 6 or 8 and presenting a clear difference in portions and using a simultaneously presentation. However, an even number of portions will be used, forcing children to place themselves in the low or high end. Not having a “neutral” answer possibility will be more difficult for the children.
The children and parents should be encouraged to try and “play around” with the system before the registration starts.

Table 6: Reporting method for the web-based dietary assessment, suitable for the OPUS intervention trial.

			Time of the day						
Day	Target period	Recording time	Before breakfast	Breakfast	Mid-morning snack	Lunch	Afternoon snack	Dinner	Evening Snack
1	Prior day	Evening							
2	Prior day	Evening							
3	Prior day	Evening							
4	Prior day	Evening							
5	Prior day	Evening							
6	Prior day	Evening							
7	Prior day	Evening							

Validating a web-based dietary assessment software system

Often relative validation standards are used to validate dietary assessment methods e.g. records are used to validate recalls and the other way around. This is often the only feasible option and adds to the understanding of how a method works in a particular research setting. Information from relative validation studies can be used to calibrate/adjust the method and in the intrepetation of the results from the overall study. However, it can also be problematic to 'validate' one dietary assessment method against another due to the risk of correlated errors between the methods. Furthermore, the reference periods will differ. Direct observation of meals is often considered a "gold standard" for evaluating the validity of other dietary assessment tools, because eating is an observable behaviour. Direct observation of dietary intake is typically conducted during structured school or group activities such as school lunches since it is almost impossible to perform during a whole day and for longer periods. Despite its intuitive appeal, direct observation is not a "perfect" measure of dietary intake, and factors such as variations in food type and portion size and observer variability may affect accuracy(29). The ideal way to validate a dietary assessment tool may be to use a mix of methods e.g. compare to an objective measure of intake together with observation or an relative validation standard. An objective measure of intake, is independent of intake i.e. quantitative recovery biomarkers such as doubly labelled water or 24 h urine collections; but doubly labelled water are very expensive(90) and doesn't give information about food group intake, and reasonable 24 h urine collections would be almost impossible to collect in children 8-10 years.

Energy expenditure

The gold standard to validate energy intakes is to compare them to measures of energy expenditure made by doubly labelled water, but as mentioned they are very expensive. Energy expenditure can also be estimated by the use of indirect calorimetry or standard equations to measure resting metabolic rate, and then physical activity level estimated using a measure of physical activity as an accelerometer or a position and movement monitor e.g. ActiReg (ActiReg; PreMed AS, Oslo, Norway) or other devises.

In a Danish study by Rothausen et al. (2010. Unpublished results) ActiReg® monitors were used as an objective measure of energy expenditure (EE) to validate a) Two non-consecutive 24 h recalls and b) a 7-day precoded food record in 7-8 (n=67) and 12-13 (n=64) year-old children, respectively. The ActiReg® monitors were carried on the same 7 days as the food records were completed. The two 24 h recalls were separated by a period of 4 weeks. Recordings in the food record were started on one of the following days after the second recall was completed. The results showed that for the 7-8 year old children, energy intake (EI) was slightly overestimated with the 24 h recalls (3%) and slightly underestimated with the food record (7%) when compared with EE. For the 12-13 year-old children, EI was underestimated with both dietary assessment methods; 10% with the 24 h recalls and 20% with the food record, respectively. However, the intake data collected by the 24 h recall were healthier than the intake data collected by the food record. Probably because of more social desirable answers given to the interviewer in the recalls. It is also possible that the participants changed their dietary habits for the recall, because they knew in advance when the interview would take place – and it is easier to change habits for just one day compared to 7 days as with the food record.

Accelerometers have also successfully been used in numerous field-based studies in children of various ages and location with the aim to measure pattern of Physical Activity(91). However, accelerometers have several weaknesses when the accelerometer counts are translated to Physical Activity Energy Expenditure (PAEE):

1. The accelerometer measures vertical accelerations and underestimates the intensity of specific types of physical activity that does not involve a minimal vertical displacement of the body such as cycling, weight lifting, walking in a hilly terrain, skating etc[92].
2. Currently, the accuracy of different equations in prediction of PAEE from accelerometers is unclear. Predicted values of PAEE vary substantially between equations and interpretations of levels of PAEE in children based on these equations should be made with caution[93].

Newer devises combine accelerometer counts and heart rate to estimate PAEE, which solve some of the problems related to activities such as cycling. But it remains to be shown that this approach actually results in improved daily physical activity assessment in large field based studies[91].

Examples of use of biomarkers to validate dietary intake
Circulating concentrations of nutrients in blood such as plasma ascorbic acid can be used to evaluate the performance of a dietary assessment method but they may be influenced by behaviours such as smoking or use of supplements therefore they do not reflect absolute dietary intake. They can therefore only be used to interpret the lower limit of the true validity of the dietary assessment[94] and correlation values rarely exceed r=0.4.

Validation of dietary intake data with biomarkers has demonstrated substantial differences in the extent of measurement error from those derived by comparison with other methods of dietary assessment[90]. Below some relevant plasma measures for the New Nordic Diet and the OPUS school-intervention study is described in short.

Alkylresorcinols
The most validated biomarker for wholegrain intake is Alkylresorcinoles (AR) phenolic lipids present exclusively in the outer parts of wheat and rye grains. AR correlates with the intake of wholegrain wheat and rye[95,96]. The analysis is however expensive and need to be based on fasting blood samples. Furthermore, AR does not exist in oats which is a major weakness in relation to measure whole grain in a Danish population because oats are one of the two main contributors to whole grain intake in the Danish population[97]. A possible future marker for oats is ”aventhramides” however they are not yet validated on humans.

A Danish team has worked on a biomarker for wholegrain intake in pigs “betain”, however it is not specific to wholegrain because it is also contained in e.g. broccoli, spinach and shellfish [98].
Until date there is no validated unambiguous biomarker for whole grain intake.

Carotenoids
Plasma concentrations of carotenoids have been shown to reflect dietary intake of fruits and vegetables[99] despite individual variability in absorption, availability and metabolism[100,101]. It is recommended that a range of carotenoids measured as a single biomarker is unlikely to be meaningful because of the diverse phytochemical composition of plant foods[102]. Validation studies of dietary assessment tools with carotenoids have yielded a wide range of correlation.

A dose-response relationship between carotenoid intake and appearance in plasma has been shown[103], making carotenoids a reasonable biomarker of intake. The most commonly measured carotenoids in studies to date include the provitamin A compounds: α-carotene, β-carotene, cryptoxanthin and also lycopene and lutein. Validation studies using carotenoids as biomarkers have largely been carried out in adults[104,105], with relatively few studies undertaken in children. Previously published studies in children have found body weight to be a cofounder of plasma carotenoid concentration levels with obese children reported to have lower levels of α and β-carotene compared to normal weight children[106].

Polyphenols
A recent review has focused on the identification and validation of individual polyphenols, or their metabolites, that may represent useful biomarkers of the intake of polyphenols in humans[(107)].
The likely active compounds of fruits and vegetables and pulses are a group of phytochemicals, known as polyphenols. Their major class is flavanoids. A Danish study suggests that 24 h urine excretion of flavanoids may be used effectively as biomarkers for fruit and vegetable intake[(108)]. However, 24 h urine samples is not realistic in large scale epidemiological studies. This is due to problems in organizing the collection of 24 h urine samples from a large study population and there will be problems with completion when the target group is 8-10 year old children. The usefulness of fasting plasma concentrations of selected flavanoids as markers of ordinary dietary intake has been investigated by Radtke et al, (2002) and Cao et al, (2009). Mean intake estimates (7-d period) of quercetin, kaempferol, isorhamnetin, naringenin, apigenin, luteolin and hesperetin were estimated using literature data on the flavanoid content of foods. In addition fasting plasma samples were taken in the end of the record period for flavanoid determination. For all flavanoids, there were significant correlations between 7-d intake results and fasting plasma concentrations[(109,110)].

However, for many of the flavanoids, which possess short plasma half-lives, measurement of plasma concentrations will provide information of the acute intake. The output in urine may be a better approach. But plasma flavanoids may be usable biomarkers in combination with carotenoids in the OPUS intervention study. Combining different biomarkers may provide a more solid estimation of total fruit and vegetable intake because of the diverse phytochemical composition of plant foods.

Fatty acid intake
In individuals in energy balance, adipose tissue is an ideal objective measure of long-term intakes of exogenous fatty acids. It is not possible to relate to a quantitative intake at a definite time point so it is a ranking or concentration marker[(111)]. An understanding of fatty acid metabolism, exogenous factors and the contributions of various body pools is important when interpreting these biomarkers[(112)].

Summary of validation

To date some biomarkers for the validation of dietary assessment methods have been developed but the area is limited by the lack of biomarkers to reflect wider aspects of diet. Doubly labelled water, urinary nitrogen is recognised as routine methods in validation studies. Circulating concentrations provide a less robust, validation method.

However, since the ”paradigm” for the ”New Nordic Diet” is ”More energy from plant foods and less from animal foods” the combination of carotenoids and flavanoids may provide a useful biomarker for fruit and vegetable intake. The combination of these biomarkers with a measure for total energy expenditure measured with a physical activity monitor and observation of the children’s school lunch may provide a solid validation of the dietary assessment tool.

Final conclusions

Based on a review of the scientific literature and considerations of other pertinent aspects in relation to the research question and other available data it is concluded that the most suitable method for assessing dietary intake among 8-10 year old children in the OPUS project is a Web-based Dietary Assessment Software system for Children (Web-DASC). This method will be developed to be used at the end of the day to recall the children's diet for that particular day. Ideally, the children will record the diet for 7 consecutive days before, under and after the intervention study with support from their parents, Reference List

1. Ebbeling CB, Pawlak DB & Ludwig DS (2002) Childhood obesity: public-health crisis, common sense cure. *Lancet* ; **360**(9331):473-482.

2. Lobstein T & Frelut ML (2003) Prevalence of overweight among children in Europe. *Obes Rev* ; **4**(4):195-200.

3. Matthiessen J, Velsing GM, Fagt S, Biltoft-Jensen A, Stockmarr A, Andersen JS & Trolle E (2008) Prevalence and trends in overweight and obesity among children and adolescents in Denmark. *Scand J Public Health* ; **36**(2):153-160.

4. Freedman DS, Khan LK, Serdula MK, Dietz WH, Srinivasan SR & Berenson GS (2004) Inter-relationships among childhood BMI, childhood height, and adult obesity: the Bogalusa Heart Study. *Int J Obes Relat Metab Disord* ; **28**(1):10-16.

5. Magarey AM, Daniels LA, Boulton TJ & Cockington RA (2003) Predicting obesity in early adulthood from childhood and parental obesity. *Int J Obes Relat Metab Disord* ; **27**(4):505-513.

6. Meyer C, Mithril C & Blauert E (2010) Grundlag for Ny Nordisk Hverdagsmad. [The foundation for and definition of a New Nordic Diet]. In Danish. Copenhagen: Københavns Universitet, Institut for Human Ernæring [University of Copenhagen. [Department of Human Nutrition].

7. McPherson DRS, Hoelscher DM, Eastham CA, Koers EM (2008) Lessons Learned over 35 years: Dietary assessment methods for school-age children. In: Berdanier CD, Dwyer J, Feldman EB, editors. Handbook of nutrition and foods. CRC PRESS INC, 543-576.

8. Subar AF, Thompson FE, Potischman N et al. (2007) Formative research of a quick list for an automated self-administered 24-hour dietary recall. *J Am Diet Assoc* ; **107**(6):1002-1007.

9. Nordic Council of Ministers (2004) *Nordic Nutrition Recommendations 2004. Integrating nutrition and physical activity*. Fourth ed. Copenhagen: Nordic Council of Ministers.

10. Gibson RS (2005) *Principles of Nutritional Assessment*. Second ed. Oxford: Oxford University Press.

11. Black AE, Cole TJ, Wiles SJ & White F (1983) Daily variation in food intake of infants from 2 to 18 months. *Hum Nutr Appl Nutr* ; **37**(6):448-458.

12. Nelson M, Black AE, Morris JA & Cole TJ (1989) Between- and within-subject variation in nutrient intake from infancy to old age: estimating the number of days required to rank dietary intakes with desired precision. *Am J Clin Nutr* ; **50**(1):155-167.

13. de Castro JM (1991) Weekly rhythms of spontaneous nutrient intake and meal pattern of humans. *Physiol Behav* ; **50**(4):729-738.

14. Livingstone MB & Robson PJ (2000) Measurement of dietary intake in children. *Proc Nutr Soc* ; **59**(2):279-293.

15. Nusser SM, Carriquiry AL & Fuller WA (1996) A semi-parametric transformation approach to estimating usual daily intake distributions. *Journal of American Statistical Association* ; **91**:1440-1449.

16. Meidtner K, Harttig U, Haubrock J & Knüppel SBH (2009) Mutiple Source Method (MSM) for estimating usual dietary intake from 24h-recall data. Potsdam: German Institute of Human Nutrition.

17. National Research Council (NCR) (1986) Nutrient Adequacy: Assessment using Food Composition Surveys. Washington DC: National Acadamy Press.

18. Subar AF, Dodd KW, Guenther PM, Kipnis V, Midthune D, McDowell M, Tooze JA, Freedman LS & Krebs-Smith SM (2006) The food propensity questionnaire: concept, development, and validation for use as a covariate in a model to estimate usual food intake. *J Am Diet Assoc* ; **106**(10):1556-1563.

19. Biltoft-Jensen A, Matthiessen J, Groth MV, Hartkopp H, Rasmussen LB, Fagt S. (2009). Influence of recording length on reporting status. 7th International Conference on Diet and Activity Methods.Diet and Physical Activity Assessment: From the Individual to the Environment. 1-324. Washington DC, National Cancer Institute.

20. Fagt S, Christensen T, Groth MV, Biltoft-Jensen A, Matthiessen J & Trolle E (2007) Børn og unges måltidsvaner 2000-2004 [Meal habits of children and adolescent 2000-2004]. København: Fødevareinstituttet [National Food Institute].

21. Gille M, Biltoft-Jensen A, Hartkopp HB, Christensen T, Fagt S & Trolle E (2010) Brug af kosttilskud blandt unge danskere - og sammenhæng med næringsstofindtag, kostkvalitet og livsstilsfaktorer [Use of dietary supplements among young Danes]. København: Fødevareinstituttet [National Food Institute].

22. Groth MV, Fagt S, Stockmarr A, Matthiessen J & Biltoft-Jensen A (2009) Dimensions of socioeconomic position related to body mass index and obesity among Danish women and men. *Scand J Public Health* ; **37**(4):418-426.

23. Biltoft-Jensen A, Groth MV, Matthiessen J, Wachmann H, Christensen T & Fagt S (2009) Diet quality: associations with health messages included in the Danish Dietary Guidelines 2005, personal attitudes and social factors. *Public Health Nutr* ; **12**(8):1165-1173.

24. National Cancer Institute (2007) National Children's Study Dietary Assessment Literature Review. Rockville MD: National Institutes of Health, Applied Research Program and Westat.

25. Tassy A (2009) Befolkningens brug af internet - 2009 [The Danish populations use of internet - 2009]. Copenhagen: Danmarks Statistik [Statistisk Denmark].

26. Boushey CJ, Kerr DA, Wright J, Lutes KD, Ebert DS & Delp EJ (2009) Use of technology in children's dietary assessment. *Eur J Clin Nutr* ; **63 Suppl 1**:S50-S57.

27. Vereecken CA, Covents M, Haynie D & Maes L (2009) Feasibility of the Young Children's Nutrition Assessment on the Web. *J Am Diet Assoc* ; **109**(11):1896-1902.

28. Livingstone MB, Robson PJ & Wallace JM (2004) Issues in dietary intake assessment of children and adolescents. *Br J Nutr* ; **92 Suppl 2**:S213-S222.

29. Sherwood N (2008) Diet assessment in children and adolescents. In: Elissa J, Steele RG, editors. Handbook of childhood and adolescent obesity. Springer, 73-89.

30. Ngo J, Engelen A, Molag M, Roesle J, Garcia-Segovia P & Serra-Majem L (2009) A review of the use of information and communication technologies for dietary assessment. *Br J Nutr* ; **101 Suppl 2**:S102-S112.

31. Thompson FE, Subar AF, Loria CM, Reedy JL & Baranowski T (2010) Need for technological innovation in dietary assessment. *J Am Diet Assoc* ; **110**(1):48-51.

32. Probst YC & Tapsell LC (2005) Overview of computerized dietary assessment programs for research and practice in nutrition education. *J Nutr Educ Behav* ; **37**(1):20-26.

33. Probst YC (2007) A self-administered dietary assessment website for use in primary health care: usability testing and evaluation. *Primary Health Care Research & Development* ; **8**:271-280.

34. Boeckner LS, Pullen CH, Walker SN, Abbott GW & Block T (2002) Use and reliability of the World Wide Web version of the Block Health Habits and History Questionnaire with older rural women. *J Nutr Educ Behav* ; **34 Suppl 1**:S20-S24.

35. Balter KA, Balter O, Fondell E & Lagerros YT (2005) Web-based and mailed questionnaires: a comparison of response rates and compliance. *Epidemiology* ; **16**(4):577-579.

36. Lu C, Pearson M, Renker S, Myerburg S & Farino C (2006) A novel system for collecting longitudinal self-reported dietary consumption information: the internet data logger (iDL). *J Expo Sci Environ Epidemiol* ; **16**(5):427-433.

37. Moore HJ, Ells LJ, McLure SA, Crooks S, Cumbor D, Summerbell CD & Batterham AM (2008) The development and evaluation of a novel computer program to assess previous-day dietary and physical activity behaviours in school children: the Synchronised Nutrition and Activity Program (SNAP). *Br J Nutr* ; **99**(6):1266-1274.

38. Baranowski T, Beltran A, Martin S et al. (2010) Test of the accuracy and speed of categorizing foods into child vs professional categories using two methods of browsing with children. *J Am Diet Assoc* ; **110**(1):91-94.

39. Sepulveda KK, Beltran A, Watson K, Baranowski T, Baranowski J, Islam N & Missaghian M (2009) Fruit and vegetables are similarly categorised by 8-13-year-old children. *Public Health Nutr* ; **12**(2):175-187.

40. Beltran A, Knight SK, Watson K, Baranowski T, Baranowski J, Islam N & Missaghian M (2008) Grains are similarly categorized by 8- to 13-year-old children. *J Am Diet Assoc* ; **108**(11):1921-1926.

41. Beltran A, Knight SK, Watson K, Baranowski T, Baranowski J, Islam N & Missaghian M (2008) Diverse food items are similarly categorized by 8- to 13-year-old children. *J Nutr Educ Behav* ; **40**(3):149-159.

42. Beltran A, Knight SK, Watson K, Baranowski T, Baranowski J, Islam N & Missaghian M (2008) Mixed foods are similarly categorized by 8-13 year old children. *Appetite* ; **50**(2-3):316-324.

43. Baranowski T, Islam N, Baranowski J, Cullen KW, Myres D, Marsh T & de MC (2002) The food intake recording software system is valid among fourth-grade children. *J Am Diet Assoc* ; **102**(3):380-385.

44. Foster E, Matthews JN, Lloyd J et al. (2008) Children's estimates of food portion size: the development and evaluation of three portion size assessment tools for use with children. *Br J Nutr* ; **99**(1):175-184.

45. Zhu F, Mariappan A, Boushey CJ, Kerr D, Lutes KD & et al (2008) Technology-assisted dietary assessment. *Proceedings of the IS&/SPIE Conference on Computational Imaging VI* ; **6814**:1-10.

46. Beasley J, Riley WT & Jean-Mary J (2005) Accuracy of a PDA-based dietary assessment program. *Nutrition* ; **21**(6):672-677.

47. Wang DH, Kogashiwa M & Kira S (2006) Development of a new instrument for evaluating individuals' dietary intakes. *J Am Diet Assoc* ; **106**(10):1588-1593.

48. Weiss R, Stumbo PJ & Divakaran A (2010) Automatic food documentation and volume computation using digital imaging and electronic transmission. *J Am Diet Assoc* ; **110**(1):42-44.

49. Haraldsen G, Dale T (2002) Hvordan spørre barn og ungdom [How to ask children and youth]. In: Andersen D, Ottosen MH, editors. Børn som respondenter. Om børns medvirken i survey [Children as respondents. About childrens coorporation in surveys]. København: Det nationale forskningscenter for velfærd [The Danish National Center for Social Research], 119-150.

50. Andersen D, Kjærulff A (2003) *Hvad kan børn svare på [What can children respond to]*. København: Det nationale forskningscenter for velfærd [The Danish National Center for Social Research].

51. Larsen HB (2002) Spørgsformuleringer til børn - set fra et udviklingspsykologisk perspektiv [Formulation of questions to children - from a developmental psychology perspective]. In: Andersen D, Ottosen MH, editors. Børn som respondenter. Om børns medvirken i survey [Children as respondents. About childrens coorporation in surveys]. København: Det nationale forskningscenter for velfærd [The Danish National Center for Social Research], 99-118.

52. Rasmussen VC, Fischer LH (2008) *Målgruppeanalyse [Target group analysis]*. København: Nyt Teknisk Forlag.

53. Kiezebrink K, Crombie IK, Irvine L, Swanson V, Power K, Wrieden WL & Slane PW (2009) Strategies for achieving a high response rate in a home interview survey. *BMC Med Res Methodol* ; **9**:46.

54. Yu J & Cooper H (1983) A quantitative review of research design effects on response rates to questionnaires. *Journal of Marketing Research* ; **20**(1):36-44.

55. Baxter SD (2009) Cognitive processes in children's dietary recalls: insight from methodological studies. *Eur J Clin Nutr* ; **63 Suppl 1**:S19-S32.

56. Baranowski T, Sprague D, Baranowski JH & Harrison JA (1991) Accuracy of maternal dietary recall for preschool children. *J Am Diet Assoc* ; **91**(6):669-674.

57. Measuring children's health behaviours, comparing answers from 10-11 years old children and their parents. 7th International Conference on Diet and Activity Methods; Washington, DC: National Cancer Institute, 2009.

58. Reinaerts E, de NJ & de Vries NK (2007) Parental versus child reporting of fruit and vegetable consumption. *Int J Behav Nutr Phys Act* ; **4**:33.

59. Baxter SD, Thompson WO, Litaker MS, Guinn CH, Frye FH, Baglio ML & Shaffer NM (2003) Accuracy of fourth-graders' dietary recalls of school breakfast and school lunch validated with observations: in-person versus telephone interviews. *J Nutr Educ Behav* ; **35**(3):124-134.

60. Baxter SD, Thompson WO, Litaker MS, Frye FH & Guinn CH (2002) Low accuracy and low consistency of fourth-graders' school breakfast and school lunch recalls. *J Am Diet Assoc* ; **102**(3):386-395.

61. Eck LH, Klesges RC & Hanson CL (1989) Recall of a child's intake from one meal: are parents accurate? *J Am Diet Assoc* ; **89**(6):784-789.

62. Biltoft-Jensen A (2009) Kostregistrering i børnehøjde [Dietary Assessment with Children's Eyes] (Report in Danish. 76 pp). København [Copenhagen]: Fødevareintsituttet [National Food Institute].

63. Baxter SD, Thompson WO, Davis HC & Johnson MH (1997) Impact of gender, ethnicity, meal component, and time interval between eating and reporting on accuracy of fourth-graders' self-reports of school lunch. *J Am Diet Assoc* ; **97**(11):1293-1298.

64. Baxter SD, Smith AF, Litaker MS, Baglio ML, Guinn CH & Shaffer NM (2004) Children's Social Desirability and Dietary Reports. *J Nutr Educ Behav* ; **36**(2):84-89.

65. Guinn CH, Baxter SD, Hardin JW, Royer JA & Smith AF (2008) Intrusions in children's dietary recalls: the roles of BMI, sex, race, interview protocol, and social desirability. *Obesity (Silver Spring)* ; **16**(9):2169-2174.

66. Baxter SD, Hardin JW, Smith AF, Royer JA & Guinn CH (2008) Children's Dietary Recalls from Three Validation Studies: Types of Intrusion Vary with Retention Interval. *Appl Cogn Psychol* ; **22**(8):1038-1061.

67. Baxter SD, Thompson WO & Davis HC (2000) Prompting methods affect the accuracy of children's school lunch recalls. *J Am Diet Assoc* ; **100**(8):911-918.

68. Domel SB, Thompson WO, Baranowski T & Smith AF (1994) How children remember what they have eaten. *J Am Diet Assoc* ; **94**(11):1267-1272.

69. Baxter SD, Thompson WO, Davis HC & Johnson MH (1997) "How do you remember you ate...?": a Delphi technique study to identify retrieval categories from fourth-grade children. *J Am Diet Assoc* ; **97**(1):31-36.

70. Vereecken CA, Covents M, Matthys C & Maes L (2005) Young adolescents' nutrition assessment on computer (YANA-C). *Eur J Clin Nutr* ; **59**(5):658-667.

71. Vereecken CA, Covents M, Sichert-Hellert W et al. (2008) Development and evaluation of a self-administered computerized 24-h dietary recall method for adolescents in Europe. *Int J Obes (Lond)* ; **32 Suppl 5**:S26-S34.

72. Small L, Sidora-Arcoleo K, Vaughan L, Creed-Capsel J, Chung KY & Stevens C (2009) Validity and reliability of photographic diet diaries for assessing dietary intake among young children. *ICAN: Infant,Child, & Adolescent Nutrition* ; **1**(27):27-36.

73. Martin CK, Newton RL, Jr., Anton SD, Allen HR, Alfonso A, Han H, Stewart T, Sothern M & Williamson DA (2007) Measurement of children's food intake with digital photography and the effects of second servings upon food intake. *Eat Behav* ; **8**(2):148-156.

74. Thompson FE, Subar AF (2008) Dietary assessment methodology. In: Coulson A, Boushey C, editors. Nutrition in the prevention and treatment of disease. Burlington: Elsevier Academic Press, 3-22.

75. Lindquist CH, Cummings T & Goran MI (2000) Use of tape-recorded food records in assessing children's dietary intake. *Obes Res* ; **8**(1):2-11.

76. Baxter SD, Smith AF, Guinn CH, Thompson WO, Litaker MS, Baglio ML, Shaffer NM & Frye FH (2003) Interview format influences the accuracy of children's dietary recalls validated with observations. *Nutr Res* ; **23**(11):1537-1546.

77. Baxter SD, Smith AF, Litaker MS, Guinn CH, Shaffer NM, Baglio ML & Frye FH (2004) Recency affects reporting accuracy of children's dietary recalls. *Ann Epidemiol* ; **14**(6):385-390.

78. Baxter SD, Hardin JW, Guinn CH, Royer JA, Mackelprang AJ & Smith AF (2009) Fourth-grade children's dietary recall accuracy is influenced by retention interval (target period and interview time). *J Am Diet Assoc* ; **109**(5):846-856.

79. Zoellner J, Anderson J & Gould SM (2005) Comparative validation of a bilingual interactive multimedia dietary assessment tool. *J Am Diet Assoc* ; **105**(8):1206-1214.

80. Gronow J & Jããskelãinen A (2002) Eating Patterns. A day in the lives of Nordic people. Norway, Lyksaker: The National Institute for Consumer Research.

81. Foster E, Matthews JN, Nelson M, Harris JM, Mathers JC & Adamson AJ (2006) Accuracy of estimates of food portion size using food photographs--the importance of using age-appropriate tools. *Public Health Nutr* ; **9**(4):509-514.

82. Foster E, Adamson AJ, Anderson AS, Barton KL, Wrieden WL. (2009). Estimation of portion size in children's dietary assessment: lessons learnt. European Journal of Clinical Nutrition 63[Suppl. 1], S45-S49.

83. Foster E, O'Keeffe M, Matthews JN, Mathers JC, Nelson M, Barton KL, Wrieden WL & Adamson AJ (2008) Children's estimates of food portion size: the effect of timing of dietary interview on the accuracy of children's portion size estimates. *Br J Nutr* ; **99**(1):185-190.

84. Lillegaard IT, Overby NC & Andersen LF (2005) Can children and adolescents use photographs of food to estimate portion sizes? *Eur J Clin Nutr* ; **59**(4):611-617.

85. Subar AF, Crafts J, Zimmerman TP et al. (2010) Assessment of the accuracy of portion size reports using computer-based food photographs aids in the development of an automated self-administered 24-hour recall. *J Am Diet Assoc* ; **110**(1):55-64.

86. Vereecken C, Dohogne S, Covents M & Maes L (2010) How accurate are adolescents in portion-size estimation using the computer tool Young Adolescents' Nutrition Assessment on Computer (YANA-C)? *Br J Nutr* ;1-7.

87. Nelson M, Atkinson M & Darbyshire S (1994) Food photography: The perception of food portion size from photographs. *Br J Nutr* ; **72**:649-663.

88. Nelson M & Haraldsdottir J (1998) Food photographs: practical guidelines II. Development and use of photographic atlases for assessing food portion size. *Public Health Nutr* ; **1**(4):231-237.

89. Andersen D, Højlund O (2007) *Interview med 11-årige børn [Interviews with 11 year old children]*. København: Det nationale forskningscenter for velfærd [The Danish National Center for Social Research].

90. Bingham SA (2002) Biomarkers in nutritional epidemiology. *Public Health Nutr* ; **5**(6A):821-827.

91. Dencker M & Andersen LB (2008) Health-related aspects of objectively measured daily physical activity in children. *Clin Physiol Funct Imaging* ; **28**(3):133-144.

92. Nilsson A, Anderssen SA, Andersen LB, Froberg K, Riddoch C, Sardinha LB & Ekelund U (2009) Between- and within-day variability in physical activity and inactivity in 9- and 15-year-old European children. *Scand J Med Sci Sports* ; **19**(1):10-18.

93. Nilsson A, Brage S, Riddoch C, Anderssen SA, Sardinha LB, Wedderkopp N, Andersen LB & Ekelund U (2008) Comparison of equations for predicting energy expenditure from accelerometer counts in children. *Scand J Med Sci Sports* ; **18**(5):643-650.

94. McKeown NM, Day NE, Welch AA, Runswick SA, Luben RN, Mulligan AA, McTaggart A & Bingham SA (2001) Use of biological markers to validate self-reported dietary intake in a random sample of the European Prospective Investigation into Cancer United Kingdom Norfolk cohort. *Am J Clin Nutr* ; **74**(2):188-196.

95. Landberg R. Alkylresorcinols as biomarkers of whole grain wheat and rye. Uppsala: Doctorial thesis. Swedish University of Agricultural Sciences, 2009.

96. Ross AB. Alkylresorcinols in Cereal Grains. Occurrence, absorption, and possible use as biomarksrs of whole grain wheat and rye intake. Uppsala: Doctorial thesis. Swedish University of Agricultural Sciences, 2003.

97. Biltoft-Jensen A, Ygil KH, Kørup K & Christensen T (2008) Intake of wholegrain in the Danish population. In: Wholegrain. Definition and scientific background for recommendations of wholegrain intake in Denmark. Copenhagen: National Food Institute, Technical University of Denmark.

98. Bertram HC, Malmendal A, Nielsen NC, Straadt IK, Larsen T, Knudsen KE & Laerke HN (2009) NMR-based metabonomics reveals that plasma betaine increases upon intake of high-fiber rye buns in hypercholesterolemic pigs. *Mol Nutr Food Res* ; **53**(8):1055-1062.

99. van Het Hof KH, West CE, Weststrate JA & Hautvast JG (2000) Dietary factors that affect the bioavailability of carotenoids. *J Nutr* ; **130**(3):503-506.

100. Block G, Norkus E, Hudes M, Mandel S & Helzlsouer K (2001) Which plasma antioxidants are most related to fruit and vegetable consumption? *Am J Epidemiol* ; **154**(12):1113-1118.

101. Brevik A, Andersen LF, Karlsen A, Trygg KU, Blomhoff R & Drevon CA (2004) Six carotenoids in plasma used to assess recommended intake of fruits and vegetables in a controlled feeding study. *Eur J Clin Nutr* ; **58**(8):1166-1173.

102. Campbell DR, Gross MD, Martini MC, Grandits GA, Slavin JL & Potter JD (1994) Plasma carotenoids as biomarkers of vegetable and fruit intake. *Cancer Epidemiol Biomarkers Prev* ; **3**(6):493-500.

103. Rock CL, Swendseid ME, Jacob RA & McKee RW (1992) Plasma carotenoid levels in human subjects fed a low carotenoid diet. *J Nutr* ; **122**(1):96-100.

104. Andersen LF, Veierod MB, Johansson L, Sakhi A, Solvoll K & Drevon CA (2005) Evaluation of three dietary assessment methods and serum biomarkers as measures of fruit and vegetable intake, using the method of triads. *Br J Nutr* ; **93**(4):519-527.

105. McNaughton SA, Marks GC, Gaffney P, Williams G & Green A (2005) Validation of a food-frequency questionnaire assessment of carotenoid and vitamin E intake using weighed food records and plasma biomarkers: the method of triads model. *Eur J Clin Nutr* ; **59**(2):211-218.

106. Decsi T, Molnar D & Koletzko B (1997) Reduced plasma concentrations of alpha-tocopherol and beta-carotene in obese boys. *J Pediatr* ; **130**(4):653-655.

107. Spencer JP, bd El Mohsen MM, Minihane AM & Mathers JC (2008) Biomarkers of the intake of dietary polyphenols: strengths, limitations and application in nutrition research. *Br J Nutr* ; **99**(1):12-22.

108. Krogholm KS, Haraldsdottir J, Knuthsen P & Rasmussen SE (2004) Urinary total flavonoid excretion but not 4-pyridoxic acid or potassium can be used as a biomarker for the intake of fruits and vegetables. *J Nutr* ; **134**(2):445-451.

109. Radtke J, Linseisen J & Wolfram G (2002) Fasting plasma concentrations of selected flavonoids as markers of their ordinary dietary intake. *Eur J Nutr* ; **41**(5):203-209.

110. Cao J, Zhang Y, Chen W & Zhao X (2010) The relationship between fasting plasma concentrations of selected flavonoids and their ordinary dietary intake. *Br J Nutr* ; **103**(2):249-255.

111. Arab L & Akbar J (2002) Biomarkers and the measurement of fatty acids. *Public Health Nutr* ; **5**(6A):865-871.

112. Arab L (2003) Biomarkers of fat and fatty acid intake. *J Nutr* ; **133 Suppl 3**:925S-932S.

National Food Institute
Technical University of Denmark
Mørkhøj Bygade 19
DK - 2860 Søborg

Tel. 35 88 70 00
Fax 35 88 70 01

www.food.dtu.dk

ISBN: 978-87-92158-78-9