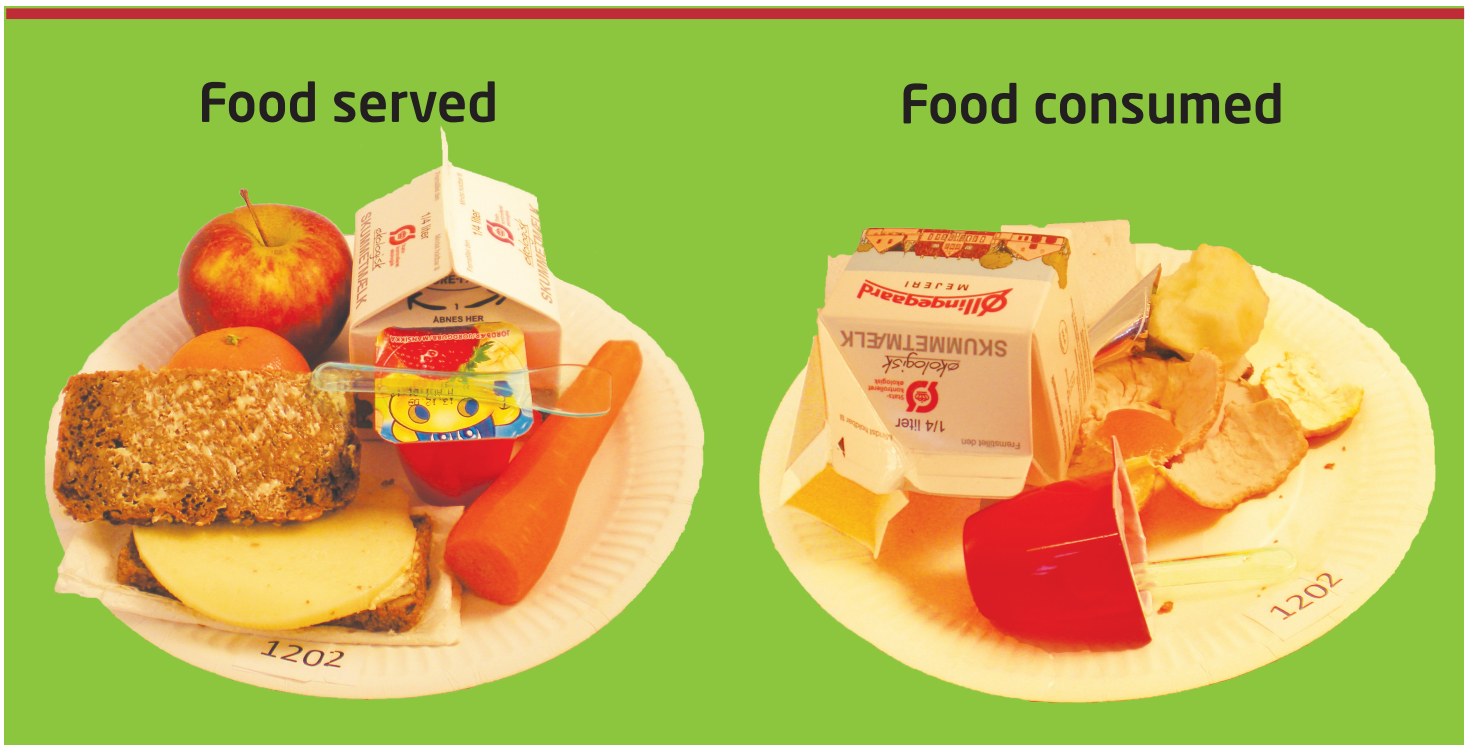


Accuracy of 11-year-olds self-reported school lunch consumption



Nina Lyng
PhD Thesis
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Accuracy of 11-year-olds' selfreported consumption of school lunch

Ph.D. thesis by Nina Lyng

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Preface and acknowledgements

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Nina Lyng,
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Abbreviations

DI	=	Digital Images
DI _(served)	=	Food served as determined by the digital images
DI _(consumed)	=	Food consumed as determined by the digital images
LRQ	=	Lunch Recall Questionnaire
OE-Q	=	Open-Ended Questionnaire
PC-Q	=	Pre-Coded Questionnaire
INT	=	Interviews
DANSDA	=	Danish National Survey about Dietary Intake and Physical Activity
PCA	=	Principal Component Analysis

List of papers

The thesis is based on the work presented in the following three papers:

Paper I Lyng N, Fagt S, Davidsen M, Hoppe C, Holstein B, Tetens I.
Accuracy of self-reported school lunch consumption by 11-year-old Danish children
Submitted, August 2012

Paper II Lyng N, Hoppe C, Fagt S, Davidsen M, Tetens I.
Characteristics of intrusions in the reporting of packed lunch consumption by 11-year-old children: A cross-sectional dietary recall validation study from Copenhagen, Denmark.
Submitted, August 2012

Paper III Lyng N, Hoppe C, Fagt S, Davidsen M, Tetens I.
Accuracy of 11-year-olds reporting of packed lunch and school meal consumption
Submitted, November 2012

The papers are referred to in the text as Papers I-III and complete versions are included as appendices.

Summary

Background

This thesis is embedded in the emerging scientific discipline of public health nutrition and explores the methodological aspect of measuring children's ability to report their school lunch consumption accurately. Children's dietary intake does not concur with nutritional recommendations or food-based dietary guidelines which constitutes a public health concern for several reasons. In Denmark children's food consumption during school hours constitutes more than a third of children's daily energy intake. Assessment of school lunch consumption among children in their natural settings holds a range of methodological challenges when a population-based approach is applied.

Children's lunch on week-days is predominantly prepared by others and consequently children cannot be expected to provide detailed self-reported information beyond the food level. Parents, care-givers and kitchen staff may have accurate knowledge of what children are **served** but children are often asked what they have **consumed**. When self-reported methods are applied the remaining research questions relate to how accurately children's actual consumption is **reported**. The majority of existing food level validation studies among children has addressed accuracy in relation to school meals. However, in several countries including Denmark packed lunch is the prevalent lunch format and the lack of packed lunch reporting accuracy studies needs to be addressed to increase the knowledge about school hour reporting accuracy in general.

Objectives

The aim of the present thesis was to assess food level reporting accuracy in Danish 11-year-old children's self-reported school lunch consumption, and the aim was operationalized in following objectives.

- 1- To identify food items clustering by lunch format (Preliminary analyses)
- 2- To assess reporting accuracy in relation to gender and self-reported methods (Paper I)
- 3- To address aspects of reporting inaccuracy from intrusions by food group, against different objective measures, and classification of intrusions in stretches and confabulations (Paper II)
- 4- To assess how reporting accuracy differ by the lunch format consumed (Paper III)

Material and methods

The study was conducted as a cross-sectional dietary reporting study. The population consisted of 11-year-old children from three public schools in Copenhagen. The study was conducted on two consecutive days and assessed reporting accuracy of packed lunch and school meals. Digital pre- and post-meal images constituted the objective reference against which accuracy of self-reported consumption was assessed. Self-reports were obtained by a non-quantitative food level Lunch Recall Questionnaire (LRQ) which consisted of an open-ended random ordered report (OE-Q) and a pre-coded food-group prompted report (PC-Q). Individual multi-pass recall interviews were conducted and anthropometrics were measured objectively.

Food items reported and obtained from the images were characterized according to pre-defined food groups. Self-reported food items were categorized as *matches* (food items reported and verified by the images), *omissions* (food items not reported but verified by the images) and *intrusions* (food items reported but not verified by the images). Intrusions were further categorized as *stretches* which expressed food items served on the plate, not consumed as determined by the images but reported consumed by the child and *confabulations* which expressed food items that were neither served nor consumed according to the images but reported consumed. Accuracy were expressed as match rates

(% correctly reported food items), omission rates (% food items omitted), and intrusions rates (% phantom food items reported).

Two sample t-tests were conducted to assess differences in background variables gender and BMI and differences in mean accuracy and inaccuracy rates were tested with paired t-test statistics. In the assessment of which objective measure reflected self-reports better a one-sided match t-test was applied.

Results

No significant difference was found in anthropometric characteristics by gender. Girls *consumed* a more varied packed lunch i.e. girls consumed a higher number of food items compared with boys. Further, girls *reported* more food items than boys with all self-reported methods although the difference in mean number reported was only significant in the open-ended part of the questionnaire (OE-Q) ($p=0.005$). Proportions of correctly reported food items consumed expressed as match rates ranged between 65 and 90%. Intrusion rates ranged between 12 and 36%.

40% of the children had at least one intrusion in self-reports obtained with OE-Q and the corresponding proportion was 77% with the PC-Q. Stratification by food groups showed that bread and fruits including nuts were most accurately reported. Intrusions and particularly omissions from fat spreads were high in OE-Q self-reports. Intrusions from snacks were substantial with the PC-Q reports. The majority of intrusions were confabulations (84% in OE-Q and 73% in PC-Q self-reports). Correspondingly stretches constituted 16% of the intrusions in OE-Q self-reports and 27% of the intrusions in PC-Q self-reports.

Omission rates and intrusions rates were significantly higher for school meals compared with packed lunch consumption. Packed lunch consumption contributed to a higher diversity i.e. variation across food groups compared with school meal consumption.

Conclusions and perspectives

Accuracy among 11-year-old' self-reported school lunch consumption differed by gender, self-reported method and lunch format. Gender differences were identified in relation to consumption, reporting and accuracy of self-reports. Accuracy of self-reported packed lunch obtained by interviews was higher compared with both the open-ended (OE-Q) and the pre-coded (PC-Q) parts of the Lunch Recall Questionnaire. Food level reporting accuracy was higher for packed lunch compared with school meals, and actual consumption of packed lunch was more diverse than school meals even though diversity in food served did not differ significantly.

In the context of the public health nutrition research population-based methods to measure dietary intake are crucial and the need for a high level of details may be less prominent compared with nutrition research. In order to ensure construct validity of moderated recalls or records selection of food items needs further investigation - and may differ depending on the objective and research outcome of the particular study.

An emergent but still undefined research question regards of what constitutes an acceptable level of accuracy at the food level, in relation to portion size estimations and consequently at nutrient level.

Sammenfatning (Danish summary)

Hvor nøjagtigt rapporterer elever fra 5. klasse deres indtag af madpakker og skolemad

Baggrund

Elever indtager mere end en tredjedel af deres daglige energi i skoletiden, hvoraf frokosten udgør det største bidrag. I Danmark spiser eleverne oftest medbragte madpakker, men samtidig fremhæves skolemad som en strukturel indsats, der kan fremme sunde vaner. Hovedparten af de eksisterende valideringsstudier af svarnøjagtigheden i elevers frokostindtag er gennemført i USA baseret på 24h recall, hvor svarnøjagtighed er valideret ved hjælp af direkte observation, mens resten af dagens indtag er baseret på selvrapportering. Analytisk kan svarnøjagtighed opdeles i **matches**, dvs. fødevarer, der ifølge en objektive metode er korrekt rapporteret; **omissions** beskriver fødevarer, der udeladt/glemt i rapportering, men ifølge den objektive metode er konsumeret og **intrusions** eller fantomfødevarer er rapporteret konsumeret men ifølge en objektiv metode slet ikke er serveret (*konfabulation*) eller serveret og ikke spist (*stretch*).

Både 24h recall og direkte observation er tidskrævende og omkostningstunge at gennemføre, så der er behov for at videreudvikle eksisterende metoder til store populationer. Resultater fra USA kan ikke overføres direkte til en dansk kontekst, og der kun sparsom viden om, hvor nøjagtigt elever rapporterer indtag af madpakker. Afhandlingen bygger på en grundlæggende præmis om, at elever har den mest nøjagtige viden om, hvad de har spist, og det er derfor en forskningsmæssig opgave at udvikle valide metoder, der er tilpasset til deres kognitive forudsætninger.

Formål

Formålet med nærværende afhandling er at vurdere svarnøjagtigheden selvrapporteret indtag af madpakker og skolemad på fødevareniveau blandt elever i 5. klasse. Formålet er operationaliseret til fire specifikke delformål:

1. At identificere fødevarer, der korrelerer med madpakke- og skolemadsformatet (Baggrundsanalyser).
2. At sammenligne svarnøjagtighed i selvrapporteret indtag af madpakker fordelt på køn og dataindsamlingsmetode (Artikel I).
3. At behandle aspekter af svar unøjagtigheder, der vedrører rapportering af fantomfødevarer herunder fejlrapportering fordelt på fødevaregruppe (Artikel II).
4. At sammenligne svarnøjagtighed i selvrapporteret skolefrokost fordelt på frokostformat (Artikel III).

Materiale og metoder

Nærværende studie blev gennemført som et selvrapporteret tværsnitsstudie. Populationen bestod af elever i 5. klasse fra 3 københavnske folkeskoler. Studiet strakte sig to dage, hvoraf eleverne spiste og rapporterede, hvad de spiste af madpakken den første dag. Næste dag fik eleverne serveret et valgfrit måltid skolemad, som de ligeledes rapporterede.

Information om faktisk indtag blev indsamlet ved hjælp af et todelt spørgeskema. Den ene del bestod af et åbent spørgsmål, hvor eleverne med deres egne ord skulle beskrive, hvad de havde spist (OE-Q) og den anden del indeholdt en række prækodede spørgsmål (PC-Q). Herefter blev eleverne interviewet om deres faktiske indtag. Svarnøjagtigheden blev beregnet ved at sammenholde elevernes rapporterede indtag med en objektiv reference indsamlet ved hjælp af digitale billeder. Højde og vægt blev målt objektivt

Rapporterede fødevarer blev kategoriseret i seks fødevaregrupper, der var baseret på empirisk viden om, hvad danske børn i den pågældende aldersgruppe spiste til frokost på hverdage. Sværnøjagtigheden blev bestemt i to trin. Først blev alle fødevarer klassificeret som matches, omissions og intrusions herunder konfabulationer og stretches. På baggrund heraf blev procentandelen af nøjagtige og unøjagtige rapporterede fødevarer og fødevaregrupper beregnet.

Resultater

Der var ingen signifikante forskelle i BMI mellem eleverne. Til gengæld viste studiet kønsforskelle i svaradfærd og sværnøjagtighed. Drengene rapporterede signifikant færre fødevarer (3.3) end pigerne (4.2) med OE-Q ($p=0.005$). Pigenes rapporterede deres indtag mere nøjagtigt end drengene alle metoder om end forskellen kun var signifikant for interviewmetoden. Begge køn rapporterede signifikant færre fødevarer med OE-Q sammenlignet med den objektive reference ($p<0.001$), mens PC-Q og interviewene ikke adskilte sig signifikant fra antallet af konsumerede fødevarer baseret på den objektive reference. 40% af børnene rapporterede én eller flere intrusioner (fantomfødevarer) i rapporteringer indsamlet med OE-Q og 77% med PC-Q. Beregning af intrusions rater fordelt på fødevaregrupper viste, at især fedtstof på brød og snacks var unøjagtige i rapporteringen af konsumeret madpakke. Af de identificerede intrusioner udgjorde 84% og 73% med henholdsvis OE-Q og PC-Q konfabulationer.

Både omissioner og intrusioner var signifikant højere for den konsumerede skolemad sammenlignet med rapporteringen af madpakker på fødevaregruppeniveau. Der var ikke signifikant forskel på antallet af fødevaregrupper, der blev serveret, men elevernes faktiske indtag viste en signifikant om end lille forskel i fødevaregruppe diversitet. Det gennemsnitlige indtag af fødevaregrupper var 3.8 for madpakkerne og 3.5 for skolemad. Match raten for madpakker var 89% og 50% for skolemad med PC-Q. OE-Q registreringer for skolemaden var 67% og ikke signifikant forskellig fra madpakkerne. Intrusions raten var lavere for OE-Q rapporteringer sammenlignet med PC-Q og varierede mellem 10-20%.

Forskningsmæssigt har studiet implikationer for den videre metode udvikling, såvel køn og metoder ser ud til at påvirke sværnøjagtigheden. Skriftlige åbne rapporteringer (OE-Q) er mindre udførligt forstået som antallet af fødevarer, der rapporteres. Den fundne forskel i sværnøjagtighed blandt drenge og piger bør undersøges i andre populationer med henblik på at bestemme om køn bidrager til en systematisk bias. Der ligger en stor metodisk udfordring i at måle fedtstof og snacks, der udgør et lille bidrag til frokosten på gruppeniveau, men som har betydning for kostkvaliteten på individ niveau. Endelig er der behov for at studere intrusioner og især konfabulationer for at bestemme i hvor høj grad de er udtryk for børnenes fantasi.

Konklusion og perspektivering

Der var forskelle mellem drenge og pigers svaradfærd og sværnøjagtighed, og betydningen af kønsforskelle bør tænkes ind i fremtidige studier af indtag i skolen. Nøjagtigheden af de enkelte dataindsamlingsmetoder afhænger af frokostformatet og af de enkelte fødevarer og fødevaregrupper, der knytter sig til formatet. Selvrapporteret indtag af fødevaregrupper kan være egnet til at beskrive og evaluere forskellen i faktisk indtag mellem madpakker og skolemad. De anvendte og analyserammen kan med fordel anvendes til at vurdere andre måltider uden for skolen og blandt andre målgrupper. Der kan være et sundhedsfremmende potentiale i at formulere retningslinjer for indholdet i madpakker gennem en strukturel indsats.

[Tekst-Slet ikke efterfølgende linje da den inderholder et sektionsskifte]

1. Background

1.1 The public health nutrition context

This thesis is embedded in the emergent scientific discipline of public health nutrition (1) and explores the methodological aspect of measuring children's ability to report their school lunch consumption accurately.

Danish children's dietary intake does not concur with the dietary recommendations (2, 3) which constitutes a major public health concern for several reasons. Dietary habits are established through childhood and adolescence and dietary habits have been shown to persist into adulthood by a tracking mechanism in terms of both frequency (4, 5) and quantity (6, 7). Physiologically, dietary intake in adolescence relates to growth and maturation (8) and from an epidemiological perspective chronic diseases e.g. cardiovascular diseases (CVD), cancer, type II diabetes and obesity have been identified as the most important diet-related public health issues (9, 10).

The scientific evidence of the importance of nutrients in relation to health and disease is well established and although the nutrient level and food level are strongly associated from a nutritional perspective measurements of what children eat cannot be reduced to a matter of nutrients (11). As a relatively new phenomenon the Nordic Nutrition Recommendations (12) have been extended to encompass food based dietary guidelines (FBDG) which concerns the food level and where a reduction of the intake of certain food items and an increase of the intake of others are recommended (13). Further, FBDG have existed in Denmark for many years as a separate entity (13)

In Denmark children consume approximately one third of their daily energy intake during school hours and lunch contributes with 20-25% (14). As a means of ensuring that food offered in the school setting contribute to a healthy diet the FBDG have been operationalized to recommendations regarding healthy meals in schools (14). The guidelines only apply for school meal provision and have existed in Denmark since 2005, however they are not mandatory. In several countries including Denmark the prevalent lunch format is packed lunch (15-18) which typically consists of open sandwiches on rye bread with cold cuts and supplementary fruit and vegetables (17).

Measuring school lunch consumption accurately is important as a means of evaluating the nutritional effects of school meals to assess the degree to which FBDG are met in the meals served. Several studies have shown that the packed lunches and school meals differ in nutritional content and that school meals to a higher degree comply with FBDG in several countries including Denmark (19-23). Despite the differences in nutritional content packed lunches are more prevalent in Denmark (17), Australia (20) and UK (22).

1.2 Methodological challenges

In the area of public health nutrition an important methodological challenge is to bridge expertise from collecting individual consumption data to population-based approaches that are applicable in natural settings. Measuring what children consume in the school setting is challenging and a range of individual and study design factors may contribute to reporting bias. Measuring food level consumption is difficult and estimations are always subjected to a degree of inaccuracy (24, 25).

1.2.1 Measurement of food consumption during school hours

Measurement of food consumption during school hours poses additional methodological challenges because food consumption occurs relatively unsupervised either in the classroom or in the school canteen. It has been argued that parents and other caretakers can only provide information about their specific context, i.e. parents can assist in provision of information about food consumption in the home setting but not in the school setting (26) Parents or school meal providers may have exact knowledge of what children are served but since they are absent during the meal occasion they cannot be expected to provide accurate reports on children's behalf (27) In dietary surveys including the Danish National Survey of Dietary Habits and Physical Activity (DANSDA) parents are often encouraged to assist children aged 10-12 in the completion of the diary but the age and degree of parental assistance are not clearly specified in the completed food diary (2). Consequently, it is not possible to determine the relations between different individual characteristics and reporting accuracy (28).

1.2.2 Bias from food level misreporting

Reporting bias may occur as a consequence of either incorrect description of single food items or as an incorrect portion-size estimation of the consumed amount. Conceptually, reporting of food consumption can be divided in a qualitative part that concerns the food level and a quantitative part that concerns quantification and portions size estimation (29). The division and investigation of the parts separately may be beneficial because the quantitative element of portion size estimations requires mathematical skills which is not required for the qualitative element of food level reporting (30). A study conducted by Baxter and her colleagues demonstrated that when fourth grade students recalled school meal consumption at the food level accurately then a subsequent quantification was fairly accurate (31). So it may be beneficial to focus on improving the qualitative food level reporting accuracy as a means of improving quantification.

Several studies have addressed children's ability to estimate portion-sizes and found that self-reported size estimates resulted in substantial quantification errors at the individual level. It has been argued that individuals do not pay attention to the portion size while eating and even if they do so, remembering and estimating the amounts are difficult (32). The ability to quantify amounts improved as a function of age in a sample of English 6-14 year olds included in a portion size validation study by

Foster et al. (33). The validation study in the experimental setting also showed that children provided more accurate recalls for amounts served compared with amounts consumed (33). If children's age is used as a proxy of their cognitive development the findings correspond to the development of mathematical skills as mentioned by Hernández et al. (30).

Familiarity with the food, preparation method and morphology have been identified as factors that influence bias from incorrect reporting of both the qualitative and quantitative description of reported foods (32, 34, 35). Different self-reported methodologies (36) e.g. 24h recall (31, 37); diet history questionnaire (38); food records (39, 40) have shown that bias from under-reporting is extensive in child populations. Over-reporting is less prevalent among children but has been shown in relation to inaccurate portion size estimations (33, 38, 41).

1.3 Measurement of reporting accuracy

Accuracy is an integrated dimension of validity and expresses the proportion of true results as determined by a golden standard (42). In validation studies of self-reported consumption accuracy expresses the proportions of correctly reported food items validated against an objective reference method (43). Additionally, an exploration of incorrectly reported food items has highlighted typical reporting errors related to both under- and over-reporting. Obtaining accurate information about actual consumption is a prerequisite for obtaining valid information on food intake and thus on nutrient intake and for the determination of diet-health associations.

Commonly applied terminology of accuracy in relation to dietary intake is *matches*, *omissions/exclusions*, and *intrusions/phantom foods*. In this terminology *matches* are food items reported consumed and verified according to the objective reference. *Omissions/exclusions* are food items that have not been reported consumed but verified by the reference and *intrusions/phantom foods* are food items that are reported but cannot be verified by the reference (39, 44-47). The concept of intrusions has been further operationalized to encompass *stretches* that are intrusions of food items served on the plate but not consumed according to the objective reference (48). *Confabulations* are intrusions of food items not served on the plate nor consumed according to the reference (48). Conceptually stretches and confabulations are means of describing the origins of the intrusions.

Accuracy of children's self-reported school lunch consumption has primarily been assessed in relation to school meals in USA. Self-reported intakes have been collected with 24h dietary recall of which only school breakfast and school meals have been validated by direct observation (31, 43, 49) whereas questionnaires have been applied in fewer studies (27, 47). Several factors have been shown to influence accuracy of children's recalls including individual characteristics like age (15), gender (16, 17), familiarity with the lunch formats (18), and morphology of the foods served (19). In addition, design factors e.g. prompting method (20, 21) and retention interval (22) have been shown to influence self-reported recalls of consumption.

Direct observations have often been chosen as validation methods in relation to school meals (24) but the observation method is difficult to apply with packed lunch because portions are not necessarily standard servings (25) and because the packed lunches may be kept in containers which puts a high strain on the observers (26). Recently, the application of methods that rely on digital images has shown its value as an objective means of measuring lunch consumption among school children objectively (27, 28).

1.2.3 Individual characteristics associated with reporting bias

Several individual characteristics have been shown to explain differences in dietary reporting accuracy. Age can serve as a proxy of cognitive development and existing literature concur that children above the age of 9 are able to report their own consumption as the primary respondent and thus be an informant of their own dietary intake (24, 50, 51). However, in several studies children aged 9 years (52) or older have been encouraged to participate with a parent (17, 51) which seems reasonable given that accuracy and consistency of breakfast and school meals recalls were low when obtained with 24h recall among fourth graders (31). In a cross-sectional (53) and longitudinal study of 10-15-year-old healthy girls (40) accuracy of self-reported intake decreases as a function of age from middle childhood (10-years-olds) where accuracy of EI was 88% to adolescence (15-year-olds) where accuracy was reduced to 67% ($p=0.001$).

Gender has been shown to have an impact on food level reporting accuracy (45, 54) and on portion-size estimation (55). Males tended to omit more food items compared with females in both adult (25, 54) and children (55). Berg showed that boys had a higher drop-out rate compared with girls which is prone to introduce a selection bias in dietary surveys of school-aged children (47). Further, a gender difference in interest in food related topics may also be related to both actual consumption and reporting bias among children (56, 57). BMI has not been shown to have a major effect on food level reporting accuracy among children but inaccuracies in portion size estimations have been shown among American fourth grade students (28, 55). Further, social desirability and reporting bias has been documented in several studies in children (25, 58, 59).

1.2.4 Design factors associated with reporting bias

Reporting bias may be influenced by design factors. In dietary recall validation studies of school meal consumption retention period i.e. the period from consumption to time of reporting has been demonstrated to influence accuracy of reporting among American fourth grade students (60-62). Further, recalls of single breakfast or lunch occasions has been shown to be recalled more accurately compared with 24h recalls (63). Prompting by context and activity has been emphasized as a means to improve the validity of intake data by improving memory (41, 64). Finally, the item length of

questionnaire and number of response categories may influence the validity of self-reported dietary intake in children (65).

1.4 Current challenges in assessing reporting accuracy of school lunch

One of the ongoing methodological challenges is how actual consumption can be measured and validated in natural settings. The existing knowledge of food level reporting accuracy is primarily based on studies conducted in USA where the work has been informed primarily by cognitive psychological theories about memory (66, 67).

In USA and to a smaller extent UK school meal programs are federally assisted and based on eligibility for free and reduced price meals, and in USA more than half of all participants in the national school meal program received a fully or partly reimbursed meal (68). The generalizability of these findings in a Danish context can be questioned because the actual participation rates are significantly smaller and the majority of Danish school meal programs are based on day-to-day purchases without consideration of parental income. Thus research protocols cannot be adapted without adjustments for several reasons.

Firstly, since packed lunch is the prevalent lunch format in Denmark dietary intake methods must be able to measure both packed lunch *and* school meals. Information about school lunch consumption has been collected at the structural level in studies of the food offered (69, 70), nutritional quality of food school meals offered (23) or data from DANSDA (17, 71). However, little is known about reporting accuracy in children's self-reported consumption of packed lunch. In addition, a comparison of reporting accuracy by lunch formats has not to our knowledge been conducted yet.

Secondly, direct observations of packed lunch are manageable yet more time consuming compared with school meal observations (72, 73). Packed lunches do not necessarily comply with standard servings and especially food items in small containers can make the observation difficult without imposing a degree of reactivity (73). Individual level methods to assess dietary intake have successfully been applied in small scale studies (60) or in validation studies (74).

Thirdly, the current challenge is to explore and advance methods to assess food consumption during school hours with inclusion of children as primary respondents of consumption. Since children's lunch on school days are prepared by parents or school meal providers children cannot be expected to report consumption beyond the food level.

Fourthly, development of methods to assess self-reported consumption applicable at population level is crucial in public health nutrition science. With the assumption that children should serve as primary

respondents the level of details required in e.g. records or recalls may not be feasible. Instead identification of which food indicators are both measurable and of nutritional relevance needs to be addressed.

To sum up the study of packed lunch consumption is of public health relevance because of the meal's contribution to children's daily energy intake. Methodologically, the study of packed lunch poses other challenges than the study of school meal consumption and the children are primary respondents and informants of consumption the level of details must be adjusted to meet the cognitive abilities of the study population. Finally to enter into the scientific discipline of public health nutrition the methods should be applicable in larger samples of children in their natural settings.

2. Aim and objectives

The aim of the PhD thesis was to explore reporting accuracy and related inaccuracy measures in relation to 11-year-olds' self-reported school lunch consumption.

The objectives were:

1. To identify food item clustering by lunch formats that reflected Danish 11-year-olds' school lunch consumption (Preliminary analyses)
2. To investigate reporting accuracy in packed lunch consumption relation to gender and self-reported methods (Paper I)
3. To determine reporting inaccuracy including omissions and intrusion in self-reported packed lunch consumption.(Paper II)
4. To compare reporting accuracy by the lunch format consumed (Paper III)

The thesis is based on three papers (I-III)

Paper I

Lyng, N; Fagt, S; Davidsen, M; Hoppe, C., Holstein, BE; Tetens, I. *"Accuracy of self-reported school lunch consumption by 11-year-old Danish children"*.

Paper submitted, August 2012

Paper II

Lyng, N; Hoppe, C; Fagt, S; Davidsen, M; BE, Tetens, I. *"Characteristics of intrusions in the reporting of packed lunch consumption by 11-year-old children: A cross-sectional dietary recall validation study from Copenhagen, Denmark"*.

Paper submitted, August 2012

Paper III

Lyng, N; Hoppe, C; Fagt, S; Davidsen, M; Tetens, I *"Accuracy of 11-year-olds reporting accuracy of packed lunch and school meal consumption"*.

Paper submitted, November 2012

3. Material and methods

This thesis is based on preliminary analyses of food items clustering by lunch formats and an empirical study. The analysis strategy was informed by the setting, the age group of the population and current methodological challenges. Recruitment of schools for a dietary reporting study can be challenging because of children's dietary intake is not part of the schools' core curriculum and many actors wish to conduct studies in the school setting. Thus the study design had to be feasible in a busy everyday life and not interfere minimally with the daily routines – and still contribute with analyses of public health and nutritional relevance.

The level of reporting was restricted to food items with focus on the frequency of consumption because children rarely prepare their own school lunch. Despite the close relation between food level reporting accuracy and portion size estimations from a nutritional perspective, we only focused on consumption and non-consumption of the food items. The recognition that complete recalls were not feasible in this study informed my decision to explore existing empirical data to identify how the measured food items were correlated and clustered in interpretable lunch formats as a means of ensuring that the developed method was developed on a sound empirical foundation. Further, the methods had to apply to both packed lunch and school meals.

Figure 1 shows how objectives were investigated with a description of the included data set, applied methods and outcomes.

Objectives	Material	Methods	Outcomes
3.1 Identify food item clustering by lunch formats	Data from DANSDA 2000-2004 (N=311). Guidelines for healthy meals in schools and Kindergartens	Explorative PCA.	Food items correlated to different lunch formats
3.2 Assess accuracy of self-reported consumption of packed lunch in relation to gender and self-reported method	11-year-old children from three public schools in Copenhagen (N=114)	1. Objective method: Digital images (DI) 2. Self-reported methods: Lunch Recall Questionnaire - Open-Ended (OE-Q) - Pre-Coded (PC-Q) Interviews (INT)	Match rates, omission rates, intrusion rate Stratification by - gender - self-reported method
3.3 Characterize intrusions in self-reported packed lunch consumption	11-year-old children from three public schools in Copenhagen (N=114)	1. Objective method: Digital images (DI) 2. Self-reported methods: Lunch Recall Questionnaire - Open-Ended (OE-Q) - Pre-Coded (PC-Q)	Intrusion rates and classification in stretches and confabulations Stratification by - food group - objective measure
3.4 Compare how reporting accuracy and inaccuracy is influenced by lunch formats i.e. school meals and packed lunch	11-year-old children from three public schools in Copenhagen (N=127)	1. Objective method: Digital images (DI) 2. Self-reported methods: Lunch Recall Questionnaire - Open-Ended (OE-Q) - Pre-Coded (PC-Q)	Omission rates and intrusion rates Stratification by - lunch formats

Figure1. Objectives, material, methods, and outcomes

3.1 Clustering of food items by lunch formats

The purpose of the preliminary analyses was to identify statistically and nutritionally relevant to substantiate the choice of food items to include in the LRQ. Since the indicator selection did not provide information about how the single food items were clustered and a subsequent explorative principal component analysis was conducted.

The material consisted of data from DANSDA (2). Data consisted of a sample of 1488 week day lunch meals from 311 children aged 10-12-year-olds who were enrolled in DANSDA 2000-2004 including

background information about gender and age. The empirical data was complemented with the theoretically based guidelines for healthy meals in schools and kindergartens (14).

The approach to identify which food indicators described the largest variance in selected diet quality indicators has been described previously by Sepp et al. (75) and the approach has been applied as a means of simplifying the process of collecting dietary intake information from representative samples of the general population (76). Initially, correlations between the selected food items and the diet quality indicators were determined. Spearman's rho was chosen because diet intake variables usually are skewed and the non-parametric correlation coefficient takes this fact into account.

The explorative PCA approach to identify clustering in data based on correlations is based on the assumption that in a multivariate data set there exist some underlying dimensions and structures that define latent variables (77, 78). I only pursued the two main dimensions in data corresponding to Loadings PC1 and Loadings PC2 in Figure 4a and Figure 4b and consequently interpretations were based on these dimensions. The numbers in the parentheses describe the proportion of variance that the particular dimension explains. The dimensions are numbered according to explained variance, and the dimension that explains the largest variance is assigned number 1, the second largest variance explained is assigned number 2 and so forth. Food items with high values influenced the model more than lower values in the proximity of 0.0. Food items that were positioned orthogonally were inversely correlated with each other.

Figure 4a shows that a certain degree of food item clustering did occur. The green circle included rye bread, cold cuts e.g. ham and fat spreads which was identified as a packed lunch format, The red circle identified a fast food format and finally the blue circle corresponded to a hot meal format. Figure 4a indicated that children with a high intake of packed lunch had a correspondingly low intake of fast food for lunch on school days. Perpendicular to an imaginary line between the packed lunch format and fast food format were food items not correlated with either packed lunch or fast food positioned. It appeared that intakes of fruit, water and snacks were not correlated with either packed lunch or fast food, and that these food items were positively correlated with the hot meal format.

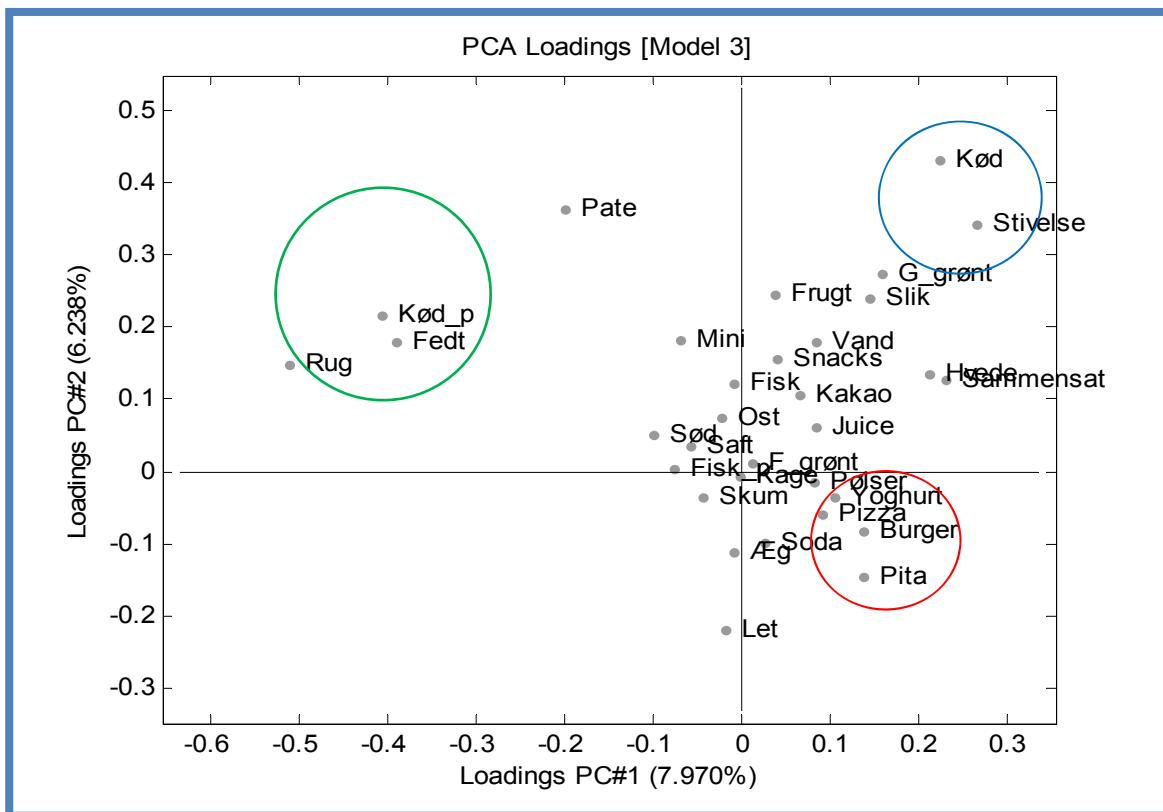


Figure 2a. Clustering of food items. Preliminary model.

Figure 4a shows that the first dimension (PC #1) explained 8% of the variation, whereas the second dimension explained PC # 2 explained 6%. However, it was difficult to separate the remaining food items from each other and different model improvement step was conducted.

In the model improvement step single food items were aggregated based on the initial clustering and labeled according to the identified lunch format. The final model revealed a healthy - less healthy dimension in data (Figure 4b). A healthy - less healthy was identified in the second dimension but it was not possible to identify an interpretable latent variable in the first dimension.

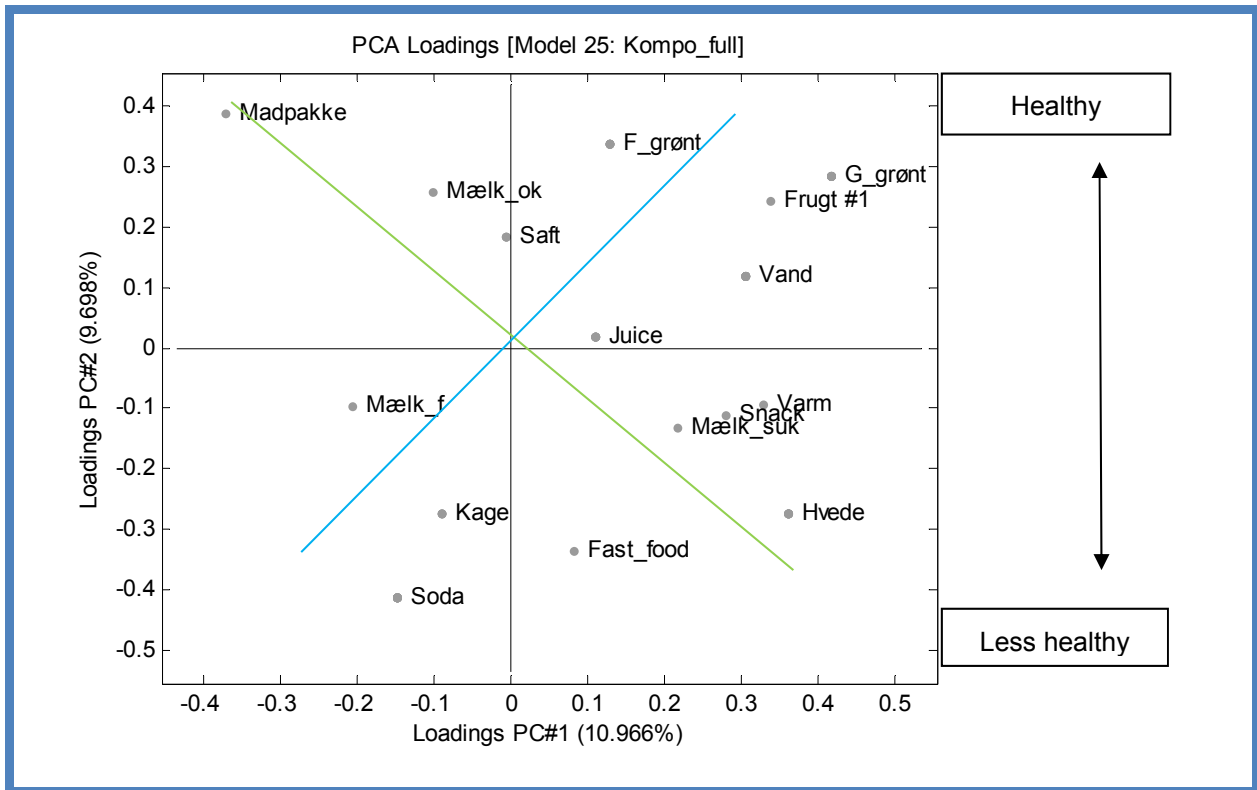


Figure 2b. Clustering of food items . Final model.

The identified dimension in data showed that healthy food items were positioned in the upper half of the figure and unhealthy food items in the lower part of the figure.

Packed lunches were often accompanied by an intake of low fat milk and to some extent fruit syrup, which was reflected in the plot. The beverages that were closest correlated to hot meals were sugar sweetened dairy products e.g. hot chocolate/cocoa and to some extent juice. All these food items might reflect food items that could be purchased in canteens at the schools. Another finding was that the snacking products like fruit and vegetables vs. cake and snacks were only slightly correlated with either lunch format. This could be realized if a line was drawn from madpakke through 0.0 (green line). A corresponding line was positioned orthogonal to the green line through 0.0 which indicated no correlation (blue line). The position of fruit and vegetables in the loading plot indicated that these food groups were only slightly correlated with either lunch format. Based on the plots we decided to pursue the more prevalent lunch formats i.e. packed lunch and school meals in the LRQ.

The final model improved the explained variance in both dimensions and improved interpretability of data. The explained variance in the first dimension increased from 8% to 11% in the final model and along the second dimension explained variance was improved from 6% to 10%. The indicators and clustering was in accordance with existing knowledge about frequently consumed food items which led to the decision of including six food groups:

Bread, cold cuts, fat spreads, vegetables, fruits & nuts, and snacks. Beverages were excluded in the final selection of food groups for two reasons: Firstly, opaque drinking bottles or containers hindered identification of content and obstructed a subsequent assessment of reporting accuracy. Secondly, beverages are not included in the school meal programs in Denmark and milk can be purchased separately.

3.2 Recall accuracy

3.2.1 Design

This study was designed as a cross-sectional dietary recall validation study. Data were collected on two consecutive days. On the first day the accuracy of self-reported consumption of packed lunch was assessed and on the second day the accuracy of self-reported consumption of school meals was assessed. Self-reported consumption was collected with a Lunch Recall Questionnaire (LRQ) which consisted of an open-ended part (OE-Q) and a pre-coded part (PC-Q). An individual face-to-face interview (INT) was conducted after completion of the questionnaire. Self-reports were validated against a set of digital images comprising a pre-meal image and a post-meal image.

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and was approved by the Danish Data Protection Agency. According to the Danish National Committee on Health Research Ethics studies with no intervention and with no invasive treatment do not require ethical approval. Hence, the present study, in which dietary intake was recorded, falls outside the category of research projects that requires approval from the Ethical Committee.

3.2.2 Setting and participants

The School meal program EAT (79) was served at 48 public schools in Copenhagen and was implemented as a structural intervention en bloc to students in the participating schools. EAT was based on a manifest that comprised 10 guiding principles regarding organizational, nutritional and culinary content. As examples of the 10 principals 75% of the foods should be organic and menus should reflect the seasons and use local food. EAT was ambitious in their attempt to develop menus that reflected children's different food and taste preferences (79). Menus were available several weeks in advance and all food was prepared outside the school premises. Consequently, food had to be ordered and paid for at least two days in advance to ensure that the meal was available on a particular day. The five schools with the highest participation rate were identified with assistance from The Children and Youth Administration in the City Council of Copenhagen. Of the five schools invited three schools accepted the invitation. All children (N=205) in 5th grade were invited to participate (mean age (SE) = 11.1 (0.39); BMI=18.2 (0.02)).

In this study double consent was sought. Parents and children were informed in writing prior to initiation of the study. Parents were asked to opt out by completing the written consent form enclosed in the information letter, only if they did not wish their child to participate in the study. After thorough information and instruction in the classroom each child was asked to give their consent before participating. All parents and children were informed that they could withdraw from the study at any time without providing any reason.

3.2.3 Data collection flow

I collected data in collaboration with two graduate students and a pre-graduate student. The tasks were assigned as follows: One was responsible for instruction of the children in the classroom and answering any questions from the children, one helped to hand over the plates and questionnaire according to the students' identification number and two were responsible for taking the digital images. Each student was assigned a four digit identification number that was consistent with the plate on which the food was served, the questionnaire as well as in the subsequent interviews. After the children had eaten their lunch post-meal images were taken. In some classes children used their break to complete the data collection in agreement with the teachers. The data collection flow is shown in figure 2.

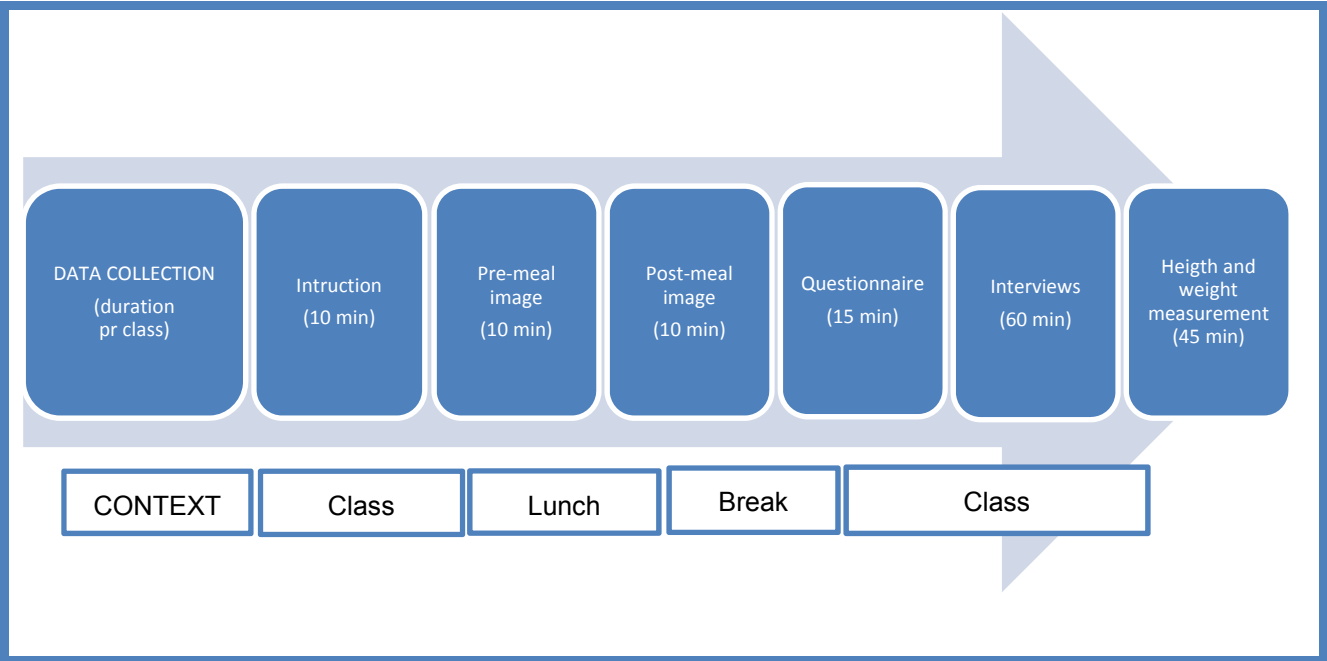


Figure 3. Data collection flow diagram

Completion time for the entire data collection was estimated to 1½ hours with instruction and preparation for approximately 15 minutes in the lesson before lunch break and questionnaire completion and interviews during the lesson after break.

3.2.4 Digital images

Digital images were chosen as the objective method to obtain information about food served and food consumed. The lunch meal was photographed twice per eating occasion i.e. in a pre- and a post-meal image using a standardized protocol as described by Sabinsky et al (23). Nikon Coolpix S210 with electronic VR stabilization and Motion Detection were used and the images were taken in Cubelite Kit from Lastolite. The plate was placed on a squared 1x1cm table cloth on which a fork and knife served as fiducial markers i.e. size indicators which also provided additional depth information (80).

In the pre-meal image the children were instructed to unpack their lunch and place the food on the plate. If necessary, they were provided with a fork to lift cold-cuts from their sandwiches to get a visual impression of fat spreads. When the child told that they were finished they brought the plate to the camera and had a post-meal image taken. Potential left-over food was captured in the post-meal image and if children had consumed everything an image of an empty plate was displayed. Food served was assessed directly whereas food consumed was determined by estimating and subtracting possible leftover foods at the post-meal image from what was captured in the pre-meal image.

3.2.5 Self-administered Lunch Recall Questionnaire (LRQ)

A non-quantitative self-administered Lunch Recall Questionnaire was developed for the purpose of the study. The questionnaire contained the following two self-reported measures: an open-ended part of the questionnaire (OE-Q) where students were instructed to write down everything they had consumed for lunch and a pre-coded part of the questionnaire (PC-Q) in which self-reports were prompted by pre-coded food groups. Self-reports were restricted to the food level. Food based indicators were selected according to the results and findings in Objective 3.1. The order of questions concerning food intake was structured according to the food diary used in DANSDA (2) and knowledge of what children consume for lunch on school days (71). The questionnaire contained self-reported background information about gender and age and frequency questions were included to assess habitual lunch and pre-lunch consumption pattern. The response categories applied in the frequency questions have been validated in a comparable study population of Danish 5th grade students as part of the Pro Children intervention (Krølner, personal communication).

The questionnaire was tested in a feasibility study among 61 eleven year-old children from a public school in county of Copenhagen. As a result of the feasibility study an additional question about pre-lunch activities to differentiate whether pre-lunch consumption reflected usual intake or special

occasions e.g. participating in home economics or birthday celebrations. Lines reserved for open-ended responses were added as some of the children's handwriting was too large to fit the first edition of the questionnaire. The LRQ was administered in the class room and students completed them individually immediately after consumption or after the adjacent lunch break. Completion time ranged from 5-15 minutes mainly due to variation in time spent on reporting their food intake.

3.2.6 Face-to-face personal interviews

After the students completed the questionnaires, he or she was interviewed individually by interviewers trained for the purpose. Interviews (INT) followed a multi pass protocol as described by Baxter et al. (81). Initially the students were asked to report everything they had eaten and drunk for lunch in a random order, followed by a non-directive prompted self-report and finally self-reports were prompted by food group. Afterwards the interviewer and student went through the completed questionnaire and the student was asked to repeat his or her answers and read aloud the answers to the open-ended questions. The purpose was to elaborate on the students understanding of the questions and response behavior in general. The student was not allowed to change their response in the questionnaire if a discrepancy became apparent during the interview. Interviews were conducted in a quiet location at the school. Four trained interviewers conducted the interviews and duration ranged from 4-8 minutes. All interviews were recorded (Olympus WS-450S digital voice recorder). All interviews were listened thoroughly and self-reported food level consumption was transcribed afterwards.

3.2.7 Anthropometrics

Anthropometrics were measured on the second day because children were then familiar with the data collection procedures and consequently less time was needed to instruct the children. Height and weight were measured with light clothes and without shoes after completion of the questionnaire and interview in a private location at the school by a member of the research team. Height was measured with a portable stadiometer to nearest cm (Soehnle 5003.01.001) and weight was measured in kilograms with one decimal (OBH Nordica, personal scale) following DTU Food, Division of Nutrition's standard protocol (Fagt, 2012 personal communication).

3.2.8 Analytical framework

Accuracy measures were determined in four steps. Initially all food items obtained by the objective reference (DI) and self-reported methods (OE-Q, PC-Q and INT) were coded according to six pre-determined food groups: Bread, cold cuts, fat spreads, vegetables, fruits & nuts, and snacks. Within each food group food items were further coded at food item level with a total of 18 single food items.

Secondly, a simple binary classification table was applied to assess the accuracy of self-reported school lunch consumption (Table 1). A true positive result i.e. a food item that was both determined by the digital image and reported by the child was classified as a match. A true negative result occurred if a food item was determined by the digital image but not reported by the child and was classified as an omission. A false positive result was classified as an intrusion because the food item was reported by the child but not determined by the digital image and as such it could also be characterized as a phantom item (67). Finally, a false negative result was not relevant in this study because only food items that occurred at the digital images or were reported by the child could be assessed.

Table 1. Classification of self-reported food items as matches, omissions and intrusions

Self-reported consumption	Consumption as determined by the digital images	
	True	False
Positive	Match	Intrusion
Negative	Omission	Irrelevant (not measurable)

As an illustration of how the method was applied the accuracy of a fictive meal is displayed in Figure 3. The meal consisted of four food items i.e. an apple, a milk, and rye bread with butter which had been determined by the reference method. In terms of assessing recall accuracy three food items i.e. apple, rye bread, and milk were correctly reported in the self-report and thus classified as matches between the objective and self-reported method. Figure 3 shows that two types of misreporting occurred. As an example butter was omitted from the self-report and instead a snack bar was reported consumed. According to the objective reference the snack bar did not exist for this particular meal in which case the snack was classified as an intrusion or phantom food item.

In addition to be accurate with a high proportion of matches it is warranted that the method is not inaccurate either. Figure 3 shows that two sources of inaccurate reports contributed to the misreporting. Omissions contribute to food level under-reporting whereas intrusions contribute to food level over-reporting and consequently both sources were pursued analytically.

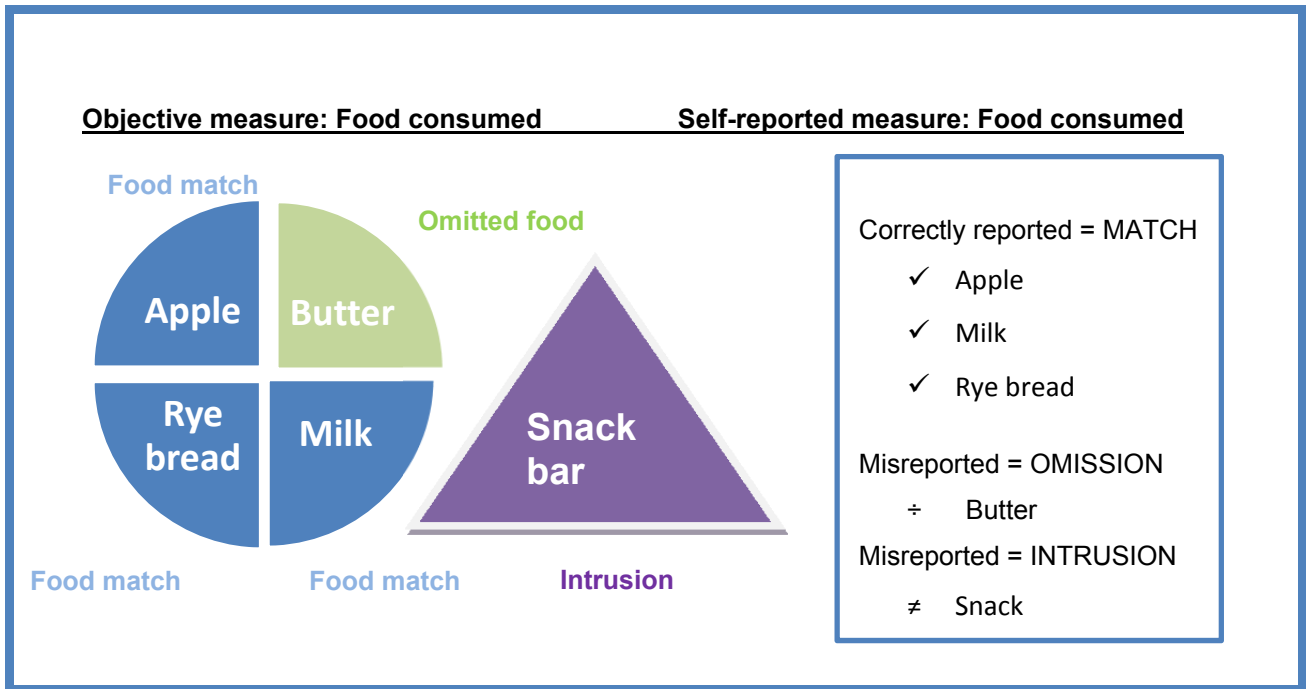


Figure 4. Objective and self-reported measures of an exemplary meal



Thirdly, accuracy and inaccuracy measures were calculated by adapting the general equation for self-reported food level accuracy as shown in Table 2 based on the sum of matches, sum of omissions and sum of intrusions (72).

Table 2. Calculation of accuracy and inaccuracy measures

Accuracy measures	Equations
Match rate (accuracy)	_____
Omission rate (inaccuracy)	_____
Intrusion rate (inaccuracy)	_____
Match rate for exemplary meal	_____

Fourthly, inclusion of objective measures (by images) of both food served and food consumed facilitated a further classification of intrusions in stretches and confabulations. In order to do this the binary classification table was extended to include food served and food consumed as objective measures against which self-reported consumption was validated. The classification matrix is shown in Table 3.

Table 3. Classification matrix of food items served, consumed, and reported. (Modified after Baxter et al., 2008 (67); Baxter, 1997(72))

Food items		Classification of accuracy		
				
Served* (1)	Consumed† (2)	Reported‡ (3)	Food served§ (1) - (3)	Food consumed (2) - (3)
+	+	+	Match	Match
+	-	+	Match	Stretch#
-	-	+	Confabulation ^α	Confabulation ^α

* Food items served as determined by the pre-meal image.

† Food items consumed based on the difference between pre-meal and post-meal images.

‡ Food items reported consumed in the self-reported recall.

§Classification of accuracy between food items served and reported.

|| Classification of accuracy between food items consumed and reported.

#Stretch = food item served, not consumed but reported consumed (intrusion).

αConfabulation = food item not served and not consumed but reported consumed (intrusion).

Table 3 shows that *stretches* are reports of uneaten food items served on the plate, not consumed as determined by the images but reported consumed by the child. *Confabulations* are neither served nor consumed according to the images but reported consumed (55, 67).

3.2.9 Application of the analytical framework

The following images are chosen to illustrate food served in packed lunch and school meals.

Responses in from the Open-Ended part of the questionnaire (OE-Q) are included without editing as children reported their consumption. The coding process and analytical output shows how data was handled.



Pre-meal image	Food served	Food reported Q-OE
	Bread, rye Fat spreads Chicken filet Cod roe Cucumber Bell pepper Carrot Raisins	"mælk rugbrød med kylling rugbrød med torskerogn peberfrugt gulerod agurk" [milk, rye bread with chicken, cod roe, bell pepper, carrot, cucumber]
Post-meal image	Food consumed	Food item classification
	Food items = 8 Food groups = 5	Bread: match Cold cut: match (chicken), intrusion (cod roe) Fat spreads: omission Vegetables : match (pepper, cucumber, carrot) Fruit: match (raisin)
Analytical output	Comments	
OE-Q Matches food items = 6 Matches food groups = 4 Omissions food items = 1 Omissions food groups = 1 Intrusions food items = 1 Intrusions food groups = 1	These pictures are chosen because it shows that the child reports food served in the packed lunch and not what was actually consumed which leads to the intrusion from cod roe (stretch). The images are also illustrative of the high omission rate from fat spreads which children frequently omitted in reports obtained by OE-Q.	

Figure 5a. Packed lunch 1 served, consumed, reported and classified

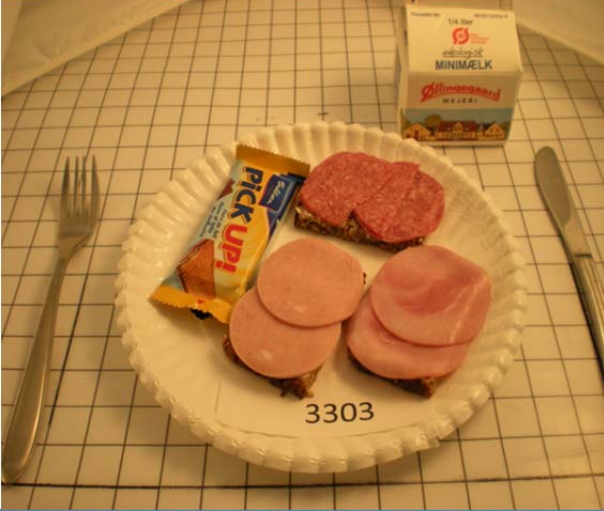

Pre-meal image	Food served	Food reported OE-Q
	<p>Rye bread Fat spreads Salami Ham Mortadella Pick-up chocolate bar</p>	<p>"3 madder med spegepølse, skinke, røget pølse og en pick-up" [3 open sandwiches with salami, ham, mortadella and a pick up]</p>
Post-meal image	Food consumed	Food item classification
	<p>Food items = 8 Food groups = 5</p>	<p>Bread: omission* Cold cut: match (salami, ham, mortadella) Fat spreads: omission</p>
Analytical output	Comments	
<p>OE-Q Matches food items = 3 Matches food groups = 1 Omissions food items = 1 Omissions food groups = 1 Intrusions food items = 1 Intrusions food groups = 1</p>	<p>A more simple packed lunch with low dietary diversity i.e. only bread, fat spreads and cold cuts. Fat spreads was omitted, and the intruded snack bar was a stretch. Omission from bread illustrates that when children only reported 'open sandwiches' it was on rye bread.</p>	

Figure 5b. Packed lunch 2 served, consumed, reported and classified



Pre-meal image	Food served	Food reported OE-Q
	<p>Rye bread Pasta Homemade remoulade Dressing on pasta Fish cake Chicken Carrot Raisins Chocolate pieces</p>	<p>"en fiskefrikadelle en kylling en gulerod" [a fish cake, chicken and a carrot</p>
Post-meal image	Food consumed	Food item classification
	<p>DI_(consumed) Food items = 3 Food groups = 2</p>	<p>Cold cuts: match (fish cake, chicken) Vegetables: match (carrot) Fruit: omission (raisins) Snacks: omission (chocolate)</p>
Analytical output	Comments	
<p>OE-Q Matches food items = 3 Matches food groups = 2 Omissions food items = 2 Omissions food groups = 2 Intrusions food items = 0 Intrusions food groups = 0</p>	<p>This meal was prepared to resemble a packed lunch format. Actual consumption only constituted the protein constituents i.e. chicken and fish cake. The high proportion of plate waste was not uncommon with the school meals that resembled the packed lunch format. The raisin and chocolate was omitted.</p>	

Figure 5c. School meal 1 served, consumed, reported and classified



Pre-meal image	Food served	Food reported OE-Q
	Pasta Meat sauce Carrot Raisins Walnuts Parmesan cheese Basil leaves	"pasta m. kødsovs gulerødder salat rosiner mælk" [pasta with meat sauce, carrots salad, raisins and milk]
Post-meal image	Food consumed	Food item classification
	$DI_{(consumed)}$ Food items = 2 Food groups = 2	Starch: match (pasta) Protein: match (meat sauce) Vegetables: intrusion (carrots) Fruits: intrusion (raisins)
Analytical output	Comments	
OE-Q Matches food items = 2 Matches food groups = 2 Omissions food items = 0 Omissions food groups = 0 Intrusions food items = 2 Intrusions food groups = 2	This hot option of pasta with meat sauce and vegetables on the side was very popular. All of the pasta and most of the meat sauce was consumed whereas the carrot salad has not been consumed. Again the child reported food items served rather than food items consumed and illustrates intrusions (stretches	

Figure 5d. School meal 2 served, consumed, reported and classified

3.2.10 Statistics

This study was concerned with assessing validity of children's self-reports and since children's self-reports were collected individually we made the assumption that their ability to report consumption was neither affected by the class-level nor the school level. Characteristics of the study population were stratified by gender and presented as means with standard error (SE). Two sample t-test statistics for difference between genders were conducted for the background variables age, height, weight and BMI.

Descriptive analyses of the number of food items consumed obtained by the objective reference and the self-reported measures were stratified by gender (Paper I) and by lunch format (Paper III). Differences were tested with paired t-tests. Differences in accuracy measures (Papers I-III) between methods were tested with paired t-tests. Matched one-sided t-tests were conducted to compare the difference in mean intrusion rate between food served (Classification 1-3) and food consumed (Classification 2-3) (Paper II). Comparison of proportions of stretches and confabulations were tested with matched t-tests (Paper II). Statistical analyses were conducted with SAS Enterprise Guide 4.3, (SAS Institute Inc., North Carolina, USA).

4. Results

This section contains a summary of the main findings from the three papers included in the thesis. Additional selected descriptive analyses are included as a complement to the papers. The reader is referred to Appendices 1-3 for further details from the individual papers.

4.1 Reporting accuracy, gender and self-reported method (Paper I)

The objective of Paper I was to assess food level reporting accuracy of packed lunch among Danish 11-year-old children in relation to gender and dietary assessment method.

Girls were served a significantly more varied packed lunch compared with boys. The analyses showed that gender specific differences were expressed in relation to variation in consumption level, response behavior and the level of accuracy in recalls. Girls *consumed* a more varied packed lunch compared with boys i.e. girls consumed a higher number of food items than boys (5.4 vs. 4.6 $p=0.05$). Further, girls *reported* more food items than boys with all self-reported methods although the difference in mean number reported only was significant in the open-ended part of the questionnaire (OE-Q) where girls on average reported 4.2 food items compared with boys who reported 3.3 food items ($p=0.005$). Finally, the gender difference was significant for the interview method in which girls provided more accurate recalls compared with boys. Girls' self-reported consumption included higher match rates and lower intrusion rates. This trend was seen with all three self-reported methods although the difference was only significant for recalls obtained with the interview method.

The proportion of correctly reported food items consumed expressed as match rates ranged between 65 and 90% and the corresponding omission rates were 35% and 10%. The lowest match rate was found for boys when consumption was assessed with the open-ended part of the questionnaire (65%) and girls' recalls obtained with interviews provided the highest match rate (90%). The study also included a measure of incorrectly reported food items and intrusion rates ranged between 12 and 36%. Boys made up more than one third of the food items that they reported to have consumed with the pre-coded part of the questionnaire and contrastingly girls' open-ended questionnaire recalls contained 12% incorrectly reported food items (Table 5).

Table 5. Match rates, omission rates and intrusion rates for self-reported consumption of packed lunch obtained by OE-Q, PC-Q, INT against DI by genders. N=114.

Self-reported method	Accuracy and inaccuracy rates (%)					
	Girls (n=65)			Boys (n=49)		
	Match	Omission	Intrusion	Match	Omission	Intrusion
OE-Q	71 ^a	29 ^a	12 ^a	65 ^a	35 ^a	13 ^a
PC-Q	74 ^a	26 ^a	27 ^b	72 ^a	28 ^a	36 ^b
INT	90 ^{*b}	10 ^b	15 ^{†a}	84 ^{*b}	16 ^b	23 ^{†c}

* Significant difference between genders (p=0.04).

† Significant difference between genders (p=0.05).

Different superscript letters a-c in each column show significant different rates (p< 0.01) when comparing self-reported methods. Paired t-tests.

Self-reports obtained with the open-ended part of the questionnaire (OE-Q) contained fewer food significantly fewer food items than the objective reference and fewer food items than the pre-coded part of the questionnaire (PC-Q) and the interviews (INT). The mean number of food items obtained with PC-Q and INT did not differ significantly from the digital images.

4.2 Characteristics of intrusions (Paper II)

The methodological challenge of food level misreporting was addressed in Paper II. The objectives of the present study were 1) to assess intrusion rates in self-reported consumption of packed lunch in relation to objective measurements of food served and food consumed and 2) to categorize intrusions by food group. 40% of the children had at least one intrusion in self-reports obtained with OE-Q and the corresponding proportion was 77% with the PC-Q.

Our expectation that children recalled *food served* more accurate than *food consumed* was only accepted for self-reports obtained with PC-Q. Intrusion rates calculated against objective measures of Food served and Food consumed did not differ significantly for self-reports obtained with the open-ended part of the questionnaire (OE-Q) (p=0.21). Intrusion rates for self-reports obtained with the pre-coded part of the questionnaire (PC-Q) was lower i.e. less inaccurate when food served were used as reference measure compared with food consumed.

Figure 6a and Figure 6b show match rates, omission rates and intrusion rates by the open-ended part of the questionnaire (OE-Q) and the pre-coded part of the questionnaire (PC-Q). The bars in the charts represent the distribution of accuracy measures within each food group. For each food group

matches, omissions and intrusions were calculated for the specific food items included in the food group. Match rates and omission rates sum up 100%.

Intrusion rates express another aspect and can only be calculated if a food item is observed on the digital image or has been reported by the child. Consumption varied across the food groups which was reflected in numbers included for calculation of the accuracy rates. For instance if a child did not report bread, because it was not consumed, then the child's report was excluded from the analyses of bread. However, the child's report could be included in calculation of another food group specific intrusion rate if the child reported consumption of an item that was not consumed according to the images.

To illustrate how the absolute number of food group specific intrusion influenced the calculated intrusion rate fat spreads is chosen. In Figure 6a match rate and omission rate was calculated on the basis of 59 children's whereas the calculation of intrusion rate was based on 9 children's reports. In Figure 6b the corresponding match rate and intrusion rate was based on 50 children's report and intrusion rate was based on 59 children's reports.

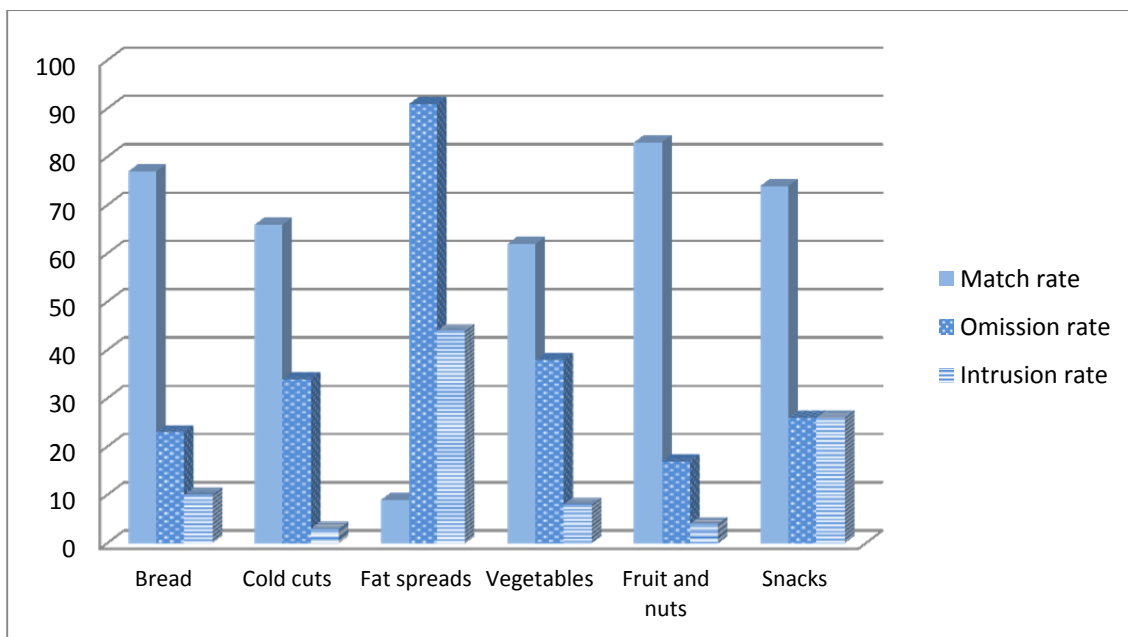


Figure 6a. Accuracy of self-reported packed lunch consumption obtained with Open-Ended Questionnaire (OE-Q)

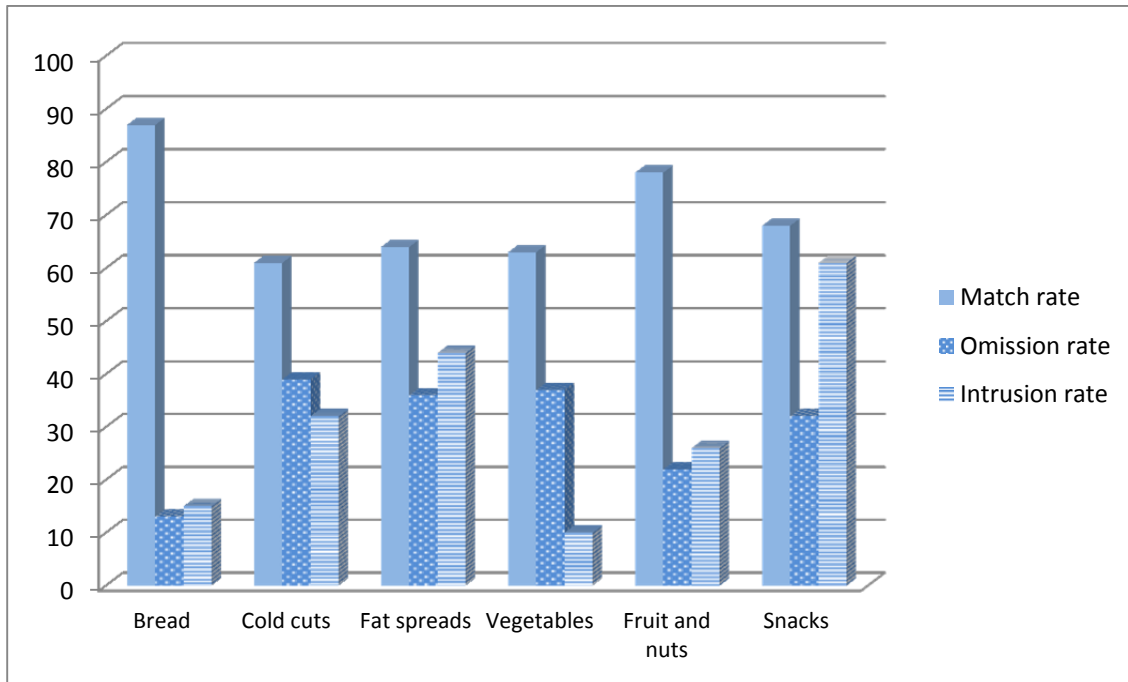


Figure 6b. Accuracy of self-reported packed lunch consumption obtained with Pre-Coded Questionnaire (PC-Q)

Stratification by food groups showed that bread and fruits including nuts were most accurately reported (Figure 5a-b). Intrusions and particularly omissions from fat spreads were high in OE-Q self-reports. The other food group that contributed to intrusions was snacks which were substantial with PC-Q where intrusion rate was calculated on the basis of 36 children's reports.

The classification table showed that intrusions could be classified as *stretches* and *confabulations*. Stretches i.e. food items that were served on the plate, but not consumed according to DI, yet reported consumed by the child, only constituted 16% of the intrusions in OE-Q self-reports and 27% of the intrusions in PC-Q self-reports. Stretches were illustrated in section 3.2.9 Application of the analytic framework. Confabulations were not captured on the digital images and characterized food items that not served and consequently not consumed but reported consumed constituted the majority of 84% and 73% respectively.

4.3 Recall accuracy in relation to lunch formats (Paper III)

Paper III assessed three measures of accuracy and inaccuracy of self-reported consumption obtained with the LRQ in relation to lunch formats. The objectives of the study were to: A) compare 11-year-old children's ability to recall packed lunch and school meals accurately and to B) explore the omission rates and intrusion rates in relation to the two school lunch formats. The analytical outcome was more aggregated compared with Paper I-II and diversity i.e. the number of food groups consumed was assessed contrary to variety expressed as the number of single food items consumed in the first papers (82, 83).

Table 6 shows the relation between number of food groups served $DI_{(served)}$, number of food groups consumed $DI_{(consumed)}$ and the number of food groups reported consumed with OE-Q and PC-Q by lunch formats. Descriptive analyses of the number of food groups consumed obtained by the objective reference (DI) showed that the mean number of food groups served did not differ significantly between lunch formats. Surprisingly, actual consumption did and packed lunch consumption was significantly more diverse compared with school meal consumption ($p=0.001$).

Table 6. Average number of food groups served ($DI_{(served)}$), consumed ($DI_{(consumed)}$) as determined by digital images and self-reported recall methods: Open-Ended part of questionnaire (OE-Q), Pre-Coded part of questionnaire (PC-Q) in 11-year-old children by lunch format (N=127).

Method	Packed lunch		School meals		P-value [†]
	Mean [*]	SE	Mean [*]	SE	
$DI_{(served)}$	3.9 ^a	0.10	3.7 ^a	0.09	0.09
$DI_{(consumed)}$	3.8 ^a	0.11	3.5 ^a	0.10	0.001
OE-Q	3.0 ^b	0.12	2.5 ^b	0.12	0.009
PC-Q	4.0 ^a	0.13	2.3 ^b	0.13	< 0.0001

[†] Paired t-test for differences between lunch format

$DI_{(served)}$ showed that school meals and packed lunches contained a similar number of food groups. $DI_{(consumed)}$ revealed that this difference was not reflected in the actual consumption where variety in food groups consumed was significantly higher in the packed lunch format. Further, Table XX shows that OE-Q self-reports of packed lunch and school lunch included reports of significantly fewer food groups compared with $DI_{(consumed)}$. PC-Q only differed from $DI_{(consumed)}$ in school meal recalls.

Match rates for PC-Q self-reports of packed lunch consumption (88.5%) were significantly more accurate than PC-Q self-report of school meal consumption (50.4%). There was a tendency that OE-Q self-reports of packed lunch were more accurate than OE-Q recalls of school meals although the difference was not significant ($p=0.06$). Omission rates, which corresponded to (1-match rate) were higher for school meal reports but differed only with PC-Q ($p<0.0001$). Intrusion rates did not differ by lunch formats and ranged from 8-9% for OE-Q to 15-20% for PC-Q self-reports. Intrusion rates for self-reports obtained with OE-Q was significantly lower than PC-Q self-reports in both lunch formats.

5. Discussion

This section includes a discussion of some of the topics that were not addressed in the papers or that would merit further exploration and discussion. The thesis was positioned in the relatively new scientific field of public health nutrition and as such it explored a small fragment of the mosaic that constitutes the methodological challenges of obtaining accurate self-reported consumption data from children in their natural settings.

The thesis contributed to the scarce yet growing body of studies concerned with accuracy of self-reported food consumption during school hours. The study included the two dominant lunch formats among 11-year-old children because lunch was the major contributor to school hour food consumption. The main objective was to assess the accuracy of children's self-reports at the food level and not on amounts consumed. The methodological aspects of portion size estimations is closely intertwined to food level reporting accuracy as a pre-requisite of obtaining valid nutrient level analyses. However, obtaining accurate portion size estimations hold a range of other challenges and it has been argued that restricting analyses to either food level or portion size estimations eliminate the translational error from food to nutrient conversion (30).

The three papers progressed from a broad assessment of children's recall accuracy with different self-reported methods in Paper I. The results clearly showed that in addition to obtain a high match rate it was warranted to reduce misreporting from omissions and intrusions, and the problem of intrusions was pursued in Paper II. After an investigation of accuracy in relation to packed lunch which is dominant in Denmark, Paper III addressed the issue of accuracy in self-reports of both packed lunch and school meals.

5.1 Main findings

5.1.1 Food served, food consumed and food reported

The study of packed lunch showed a gender difference and girls consumed a more varied packed lunch which consisted of more food items, which may reflect a difference in food preferences between genders that can be accommodated in packed lunches prepared by parents but not in school meals where children choose from a pre-determined menu. Future studies should assess the degree to which packed lunch reflect gender differences when it is prepared and served. Boys reported significantly fewer food items in OE-Q which indicated a gender specific difference in response behavior i.e. that girls' compliance with open ended written reports were higher. Girls' reporting accuracy was higher for all three self-reported measures although only significant for interviews. In studies where the degree of parents' assistance is not clearly defined e.g. in DANSDA the potential

gender differences are masked. Our finding was facilitated by the design where consumption solely relied on self-reports. Analyses at the food group level (Paper III) showed that the mean number of food groups served did not differ significantly, however a small but significant difference was identified in relation to actual consumption where dietary diversion was higher for packed lunch compared with school meals in terms of mean number of food groups consumed.

5.1.2 Reporting accuracy and characteristics of the self-reported method

In addition to obtaining high match rates both intrusions and omissions should be minimized for research purposes because food level reporting inaccuracy impedes validity of data. Intrusions contribute to food level over-reporting and omissions contribute to food level under-reporting in studies where it is not feasible to include an objective reference to validate self-reported consumption (72). Self-reports obtained with interviews were more accurate compared with both OE-Q and PC-Q in packed lunch self-reports, however since the challenge regards the development of population based methods we pursued methodological aspects of the LRQ.

Analysis of intrusions by food groups showed that fat spreads were reported with highest inaccuracy. In OE-Q children omitted it from their written reports, and in PC-Q the food group prompting resulted in high intrusion rates. Intrusions from snacks were high and the fact that the majority of intrusions were classified as confabulations may be an account of the children's wishful thinking or indicate pre-meal snack consumption in which case it would not appear from the pre-meal image. By focusing on school day consumption we would expect that intrusion rates would diminish and the potential error from misclassification of eating occasion would be eliminated too.

Reporting accuracy differed by data collection method. Interviews posed the least strain on the participants insofar that the child could focus on the recall process without considering how single food items were categorized in food groups. In addition non-directive and food group specific prompts were provided during the multiple passes in the interview. Interviews provided the most accurate self-reports in terms of the highest match rate, lowest omission rate and lowest intrusion rate.

The open-ended part of the questionnaire (OE-Q) resembled the interviews in the sense that they did not have to categorize single food items. OE-Q held the extra cognitive strain compared with interviews because it preempted that children read and understood the questions in addition to writing down the reports. Numbers of food items reported in OE-Q was significantly lower than the objective reference in both lunch formats and a significant difference between genders was observed for packed lunch self-reports. The latter finding was in agreement with another study with Danish 5th grade students in which boys wrote fewer items when they were asked to describe in short what they consumed for lunch (Krølner, personal communication). Unfortunately, with fewer food items reported with OE-Q compared with the objective reference self-reports were subjected to food-level under-reporting.

The pre-coded part of the questionnaire was prompted by food group. However, especially in relation to school meal reports inaccuracy rates were high. Prompting increased the match rates for fat spreads but unfortunately it also increased intrusion rates. It has been argued that prompting by food group may induce intrusions by confusion of specific and generic memory i.e. instead of reporting consumption of the actual meal habitual intake is reported instead (66, 84). This problem has been accentuated for recalls with a high retention period. However, in this study data was collected immediately after consumption and thus close to real time which potentially eliminates reporting errors associated with memory (30, 85). Questionnaire items of consumption from seven food groups were constructed but beverages were excluded from the analyses. In self-reported packed lunches the operationalization of the diverse cold cut category may have been too complex and exceeded the number of categories that the children could cope with.

5.2 Comparison with existing research

5.2.1 Reporting accuracy, gender and self-reported method (Paper I)

Institute of Medicine recommended that sex should always be taken into consideration in health research. The term gender has been applied consistently throughout the thesis in recognition of the meaning that exceeds the biological difference between boys and girls. This study showed gender differences in reporting accuracy but the differences were also expressed in relation to response behavior and actual consumption of packed lunch. Potential differential recall bias from gender is important to address in all self-reported methods both diet and other health related topics e.g. self-reported weight status (57, 86).

In a review conducted among children and adolescents Forrestal finds that only two out of 12 studies that assessed gender differences found significant differences with females being more likely to under-report Energy Intake (36). However the review does not consider whether misreporting stems from food level or portion size estimations. The higher odds of boys dropping out of surveys (47) may very well apply to this study. We only included children with complete data entries in Paper I and the characteristics of the population showed a higher proportion of girls than boys in the analytical sample. Our study identified differences in relation to packed lunch consumption which was facilitated by the application of self-reported methods.

The choice of self-reported methods enabled an identification of the gender specific consumption expressed as the difference in number of food items consumed. The question of gender differences in availability does not apply to school meals served because children can select meals from the same menu – regardless of the fact that selection of meals may differ between boys and girls. Gender differences have not been shown in food level recall accuracy of school meals (31) but in the subsequent portion size estimation of fourth graders (55). Gender difference in mean number of food

items consumed for lunch as determined by the digital images is similar to the findings of an American dietary validation study of school meal consumption among fourth grade students. Guinn and colleagues find that girls consumed more food items for lunch (mean (SD) 5.1 (1.33)) compared with boys (4.55 (1.82)) ($p=0.054$) (55). They did not observe difference by gender in the mean number reported (3.55) which is similar to self-reports obtained with OE-Q but lower than the self-reports obtained with PC-Q (55). Gender specific differences in consumption have been shown previously in relation to energy intake (20), but Baxter et al. argued that nutrient level analyses do not necessarily reveal differences in consumption at the food level and inaccurate recalls at the food level may provide accurate nutrient level analyses (31).

Gender has been shown to be an important determinant of fruit and vegetable intake (87) and perceived accessibility has been accentuated as a mediator (56). The explanation may be caused by a gender specific difference in availability if parents of girls provide a higher variety of food items in girls' packed lunch than parents of boys. In such case future health promoting activities should address the importance of ensuring variety to parents and other caregivers that are responsible for preparation of packed lunches.

5.2.2 Reporting inaccuracy at the food level (Paper II)

Intrusion rates expressed food items that were reported consumed by the child but could not be verified by the objective reference measure. As such food items could be characterized as food items that the children conceived from their imagination. However, even though this may be true, it is still necessary to study this phenomenon further to get a more thorough understanding of children's self-reports.

Intrusion rates were particularly high for snacks and fat spreads (Figure 1a and Figure 1b). Earlier studies of which strategies are used in recalls showed that visualization, behavior chaining and liking are commonly used children (88) and (89). In addition, portion size estimation studies have suggested that children recalled food served more accurately compared with food consumed (74). Hence, we expected that if children used visualization to recall the food level, then intrusion rates for calculated with food served as objective reference would be lower than intrusion rates calculated against Food consumed (Table 3). Surprisingly, this was only significant for recalls obtained with PC-Q.

Behavior chaining may explain the high extent of intrusions from fat spreads. In this case children would draw from their generic rather than specific knowledge about how their foods would usually appear (66). Figure 4a showed that rye bread was closely associated with cold cuts and fat spreads due to the close spatial clustering in the loading plot. The finding is similar to other Danish studies among children (17, 71). Alternatively, it has been shown that different food groups are assigned different (symbolic) values and that they cannot be expected to get the same amount of attention in recalls (88). Pre-lunch consumption may explain the high intrusion rates from snacks. Special liking of

particular food items may have influenced the order with which children consumed the items in the packed lunch. In addition parents tend to put a treat in the packed lunch as a symbolic marker of affection and connectedness (18, 90).

5.2.3 Intrusions, stretches and confabulations (Paper II)

This study showed intrusions were predominantly confabulations which is problematic insofar that confabulations contribute to food level over-reporting in non-validation studies. A recent review of Energy Intake misreporting among children and adolescents showed that approximately half of children in the included studies were categorized as acceptable reporters. The review also showed that although under-reporting was more prevalent over-reporting did occur (36).

Confabulations do not appear from the objective reference which makes it difficult to correct in natural settings. Contrary to confabulations it is possible to identify stretches as they are captured by the validation method. We were not able to distinguish between internal and external confabulations in our assessment of packed lunch consumption. The conceptual distinction has been applied by Baxter and her group where they have used access to food production records to identify the origin of the intrusions (67). Guinn et al found that intrusions in school lunch recalls were likely to be internal confabulations in terms of food offered but not served (55).

Expanding the window of consumption from lunch to school hour food consumption would probably reduce some of the intrusions identified in relation to packed lunch. The lunch pack is available throughout the school day and it has been shown in an ethnographic field study with Danish children aged 3-16 that the content of their lunch pack was divided into several eating occasions (90).

5.2.3 Reporting accuracy and lunch formats (Paper III)

Comparisons of reporting accuracy in relation to lunch formats are not very prevalent in literature. Warren conducted a study among 5-7 year children and found in line with our findings, that packed lunches were reported more accurately compared with school meals (34). Even though the study was conducted in a context where packed lunches were more common and thereby comparable the age difference in our study and Warren's rendered a strict comparison improbable. A dietary recall validation of school meal reporting by meal component showed that 4th grade students omitted 54% of all food items they were observed consuming for both breakfast and lunch and overall intrusion rate was 41% (81).

Plate waste can impede the nutritional effect of school lunch and has been shown to be closely related to children's acceptance of food offered and served and differed across food groups and preparation method among 6th grade students in USA (35). School meal programs that enabled children to serve themselves e.g. in Japan showed that amount of food served and consumed differed by gender among 10-11-year-old 5th grade students and the ration between food served and food consumed was

significantly higher for boys (0.88) compared with girls (0.84) (38). In accordance with the findings of Murakami a Swedish study found that preferences for specific food combinations affected children's consumption and plate waste and Ahlström argued for as much flexibility in food offered to comply with children's different preferences (91).

Despite the high prevalence of packed lunch consumption and documented nutritional differences in the content of packed lunches and school meals (16, 21, 68, 92) packed lunches are not covered by guidelines or standards. However, it has been advocated by the UK School Trust Fund (16). The lack of standards for packed lunches may increase the nutritional gap between food offered on school days (21) which may impact children's health status and thus constitute a public health nutrition concern.

5.3 Methodological considerations

5.3.1 Selection bias

In this study the analytic sample was lower than potential sample because only children from whom we had obtained digital images, self-reported consumption and anthropometric data were included. We cannot disregard the fact that the children that were present at the day of the data collection but did not complete data collection may have differed from those that were included in the analytic sample. The differences may have emerged at different stages of the data collection e.g. in relation to consumption pattern where those who did not consume anything were excluded. Participants vs. non-participants have been shown to differ in several aspects e.g. completion rate in surveys (47). The differences may also be a consequence of different response behaviors or in the ability to report consumption accurately.

Completion of interviews may have contributed to selection bias. Only 59 children were identical in the analytical samples of Paper I-II and Paper III. Inclusion in the data set for Paper I-II were that the child had a complete set of digital images, that the child had completed both OE-Q and PC-Q, had participated in the interview and had anthropometrics measured (N=114). The inclusion criterion in Paper III was that complete set of digital images, OE-Q and PC-Q for both packed lunch *and* school meals in addition to anthropometrics (N=127). The BMI distribution of the study population did not reflect the general populations of children in that age-group and the vast majority of children's BMI were within the range of normal weight based on age- and gender specific cut-offs (93, 94) . Consequently, analysis of BMI and reporting accuracy was not pursued further.

5.3.2 Information bias

Three sources of information bias may have influenced validity of the results. If the process by which indicators were selected did not reflect variation in diet quality then we would have introduced a source of non-differential bias if the proposed response categories did not reflect how children categorized food items (88). The cold cut category in PC-Q was heterogeneous which may have introduced misclassification bias if the construction of the item was too complex and exceeded what

the children could cognitively be expected to master (88). This may explain part of the relatively high intrusion rate and omission rate from cold-cuts.

The data for identifying food items clustering by lunch formats were based on data collected from 2000-2004 and since then school meals have become more prevalent. Further, the Guidelines for healthy school meals were not published until 2005. If lunch consumption patterns have changed then there would be a risk that the data set could be outdated. However, the food item clustering by lunch formats identified with the PCA concurred with existing findings from more recent samples of the survey (17, 71). The model improvement steps in the explorative PCA may also have introduced misclassification bias (5, 95) as well as the single meal approach.

Another source of information bias may have appeared as a consequence of the categorization of food items from the digital images and the self-reported food items according to pre-defined food groups. By applying a standard protocol for the use of digital images we attempted to avoid introduction of misclassification in the objective reference. However, the high proportion of intrusions from snack and fat spreads may be a result of an improper use of the method i.e. that the digital images did not capture fat spreads on the open sandwiches. The initial data handling was conducted by a bachelor student who did her internship in Division of Nutrition and subsequent all results were reviewed at least once. Misclassification from coding procedures may occurred and influenced the findings.

The equations to determine accuracy measures were sensitive to the relative numbers of matches, omissions and intrusions influencing the magnitude of the rates. Intrusion rates for both snacks and fat spreads relatively were high in Paper II but the absolute numbers of intrusions from these food items were relatively low compared to intrusions from e.g. cold cuts. Intrusions from cold cuts would not have had this impact on the overall intrusion rate if the target period was different e.g. 24h because then the total number of food items consumed would have been larger. Even if beverages were included this would have changes the rates. The low number of food groups in Paper III may have diminished variation in consumption data.

5.4 Strengths and limitations

205 children were invited to participate in the study but only 114 children were included in the analysis of packed lunch reporting accuracy and 127 was included in the comparison of reporting accuracy of lunch formats. Previously, it has been shown that participants differ from non-participants in several aspects including gender, consumption pattern, response behavior and the generalizability of our results may be impeded as a consequence of the proportion of non-participants.

The population was relatively small and thus not powered to assess the role of BMI as a determinant of reporting accuracy. Baxter and colleagues did not find an association between BMI and food level

reporting (31) and in a more recent study by the same group Guinn et al. found that BMI was associated with portion size estimations and the children in high BMI groups tended to under-report the amounts consumed (55). The association between accuracy and BMI group has been identified in child populations in relation to portion size estimations (31, 55, 58, 96).

By analyzing reporting of items without considering amounts consumed provided insights about what contributes to inaccurate reports which then can inform what improvements should be made (55, 81). Further, when food items are omitted or intruded amounts will be inaccurate and contribute to inaccurate energy and nutrient level analyses. The analytical framework in this study has been used to assess school meals but our study showed that it can also be applied to assess accuracy of packed lunch consumption. The studies conducted by Baxter and her group who have contributed immensely to the knowledge about recall accuracy in relation to school meal consumption avoid assessing packed lunches with reference to the same study by Simons-Morton (73) who found that observation of packed lunch was feasible although impractical and time consuming.

Another strength of this study was the focus on self-reports which is the only way to obtain insights about reporting accuracy among children. The inclusion of several self-reported methods was useful to illustrate that depending on the purpose and specific study population different self-reported methods are feasible. In Denmark where packed lunches are more common the open-ended part of the questionnaire provided more accurate reports compared with the pre-coded part and was then illustrative of the point that until school meals can be prompted more specifically then open-ended methods may be a viable method in studies where an objective reference method is available.

Digital images have been applied in natural settings to assess school lunch consumption and evaluate nutritional content of food served and consumed (23, 85, 97). This study showed that the method was a feasible validation method that provided objective measures against which self-reports were assessed.

5.5. Implications for research

In relation to packed lunch further exploration is needed to address the conceptual distinction between school lunch and food consumption during school hours. Contrary to school meals the packed lunch is accessible throughout the school day and pre-lunch consumption in morning recess is common.

Previous studies suggested that both food item variety and food group diversity were simple measures and feasible as an indicator of micronutrient adequacy (82, 83). Interestingly, our study showed that even though school meals included more food groups compared with packed lunch, the higher diversity was not reflected in actual consumption. However, the generalizability of the result would

merit further studies in larger samples as a contribution to the ongoing debate about the nutritional effects of school meal provision as a health promoting structural intervention.

This thesis has identified important determinants for high reporting accuracy among 11-year-old. As demonstrated the applied methods hold pros and cons and the choice of which method to use prospectively depends on the purpose of the study. Inclusion of digital images as an objective reference provided a method that can be applied in natural settings and that is applicable in large samples. The digital images facilitate a researcher-driven portion size estimation post data collection (85). The combination of digital images as objective reference method and self-reports facilitates an analytical approach in which children's reports can be restricted to the food level and subsequent quantification enables analyses of energy and nutrient distribution in different meals.

Intrusion rates expressed food items that was reported consumed by the child but could not be verified by the objective reference measure. As such food items could be characterized as food items that the children conceived from their imagination. However, even though this may be true, it is still necessary to study the phenomenon to get a more thorough understanding of children's self-reports. The categorization of intrusions into stretches and confabulations can inform future methodological studies

An emergent but still undefined research question regards the absence of discussions of what constitutes an acceptable food level reporting (72) and portion size estimation accuracy (30). In the absence of well-defined criteria the validity of this and similar studies are difficult to assess. The problem exceeds this particular study and needs further exploration and debate.

5.6 Implications for practice

A few perspectives regarding practice are worth mentioning. This study showed that even though school meals and packed lunch did not differ in terms of food groups served children's consumption of packed lunch was significantly higher compared with school meal consumption. The health promoting benefits of school meals that comply with nutritional recommendations can be questioned if children's consumption turns out to be less diverse compared with packed lunch consumption. School meal provision increases the availability of healthy meals at the structural level but other factors e.g. queuing to purchase meals, inconvenient ordering system or competitive vendors e.g. in the community may confine children's perceived availability and consequently diminish participation rate in school meal programs (98).

Further, children's acceptability of different lunch formats should be assessed to understand how the school meals could be adjusted to the temporal structures that children's eating practices is embedded in. Complete meals e.g. spaghetti bolognaises cannot be divided in several eating occasions and consequently children may leave more plate waste and thereby reduce the nutritional effect of the

meal compared with packed lunch that can easily be divided in several eating occasions. Finally, hot options may not coincide with children's priority of their time and the fact that non-eating activities may take precedence over food and eating activities (98) may reduce children's acceptance.

The question of affordability should be addressed in future studies in the Danish context. In USA, England and Scotland children are found eligible to receive a free meal because of low parental income (98, 99) as a means of reducing social inequalities in health. This is not the case in Denmark where the majority of school meal programs are based on parents' financing. The Danish model for organizing school meal interventions and research on the impact of the price level is needed to assess the potential economic barrier. If school meals are too costly to be accessible to all students and if children for one reason or another do not consume the complete meal as intended then the effort to serve healthy meals that comply with food based dietary guidelines may not be the most appropriate means of promoting healthy eating during school hours

6. Conclusions and perspectives

6.1 Conclusions

Paper I. Gender differences were expressed in relation to reporting accuracy and related behaviors i.e. response behavior and variety of actual consumption. Girls' self-reports were more accurate with all self-reported methods although the difference was only significant for the interview method. Another gender difference was identified in the number of food items reported in the Open-Ended part of the questionnaire (OE-Q). Both boys and girls reported consumption of significantly fewer items compared with the objective measure and boys reported significantly fewer food items than girls. Of the three self-reported methods applied, data obtained by interviews provided the most accurate reports. Intrusion rates for the Pre-Coded part of the questionnaire (PC-Q) were high indicating that prompting by food group may have influenced children's reports negatively. Trade-off between the pros and cons should be taken into consideration in the evaluation of which self-reported method are more accurate.

Paper II. The hypothesis that children's food level reports reflected food served more than food consumed was only accepted for self-reports obtained with the Pre-Coded part of the Questionnaire (PC-Q). If the hypothesis was true, then the majority of intrusions would have been stretches and not confabulations as the findings indicated. Intrusion rates varied across different food groups and that each food group may represent unique challenges in terms of reporting them accurately. Particular attention must be paid to reduce inaccurate reporting of fat spreads and snacks. These food groups are important indicators of diet quality although their relative contribution at group level is small.

Paper III. Food level reporting accuracy was higher for packed lunch compared with school meals with higher match rates, lower omission rates and lower intrusion rates. Actual consumption of packed lunch was more diverse and consumption consisted of more food groups compared with school meals even though diversity in food served did not differ significantly between the lunch formats. The low food group reporting accuracy in reports obtained with the Pre-Coded part of the Questionnaire (PC-Q) indicated that school meals were more difficult to report compared with the Open-Ended part of the questionnaire (OE-Q) which allowed children to report school meals in their own words and leave categorization of consumption in food groups to the researchers.

6.2 Perspectives

School lunch provision is subjected to nutritional standards in UK (21) and in USA (68) but these standards do not apply for packed lunches provided by parents or other care-givers. In the UK Government strategy document to tackle obesity rates from 2008 states that all schools must have a policy on packed lunches (16). An extension of school food policies to include guidelines for packed lunches may be a viable solution in Denmark as a structural means of promoting healthy eating habits

in the school setting. Further, school meal programs are costly to establish and to sustain. The cost-benefits of maintaining school meals as a structural health promoting interventions should be considered given the existing organization in Denmark. Participation rate rely on parents' financing rather than objective parameters e.g. income eligibility which is the foundation of USA or UK school meal programs. Instead, the acceptance of other less expensive structural interventions e.g. breakfast programs or organized efforts to improve the diversity and variety in packed lunches among school children should be considered.

The National School Lunch Program in USA (68) operates with a menu planning tool in which meals should include four components: milk, bread/starchy component, meat/alternative protein component and two servings of fruit or vegetables. In UK a cluster randomized trial to improve the content of packed lunches also focus on starch, protein, dairy, vegetables and fruit. This way of conceptualizing is in accordance with an information activity by The Danish Food and Veterinary Administration called "Give the packed lunch a hand" (my translation) (100) that includes instructions on how to prepare a packed lunch that comply with FBDG. A packed lunch should comprise five elements: vegetables, bread – preferably rye or whole grain, cold cut, fish and fruit. Further research should address if the concept of dietary diversity are feasible indicators of packed lunch and school meal consumption. T

From a methodological perspective efforts to bridge the gap between compliance with dietary assessment methods and accuracy of collected consumption data are of utmost importance. Simplifying the methods by relying on scientifically sound alternative analytic approaches to e.g. indicator selection and pattern analysis may help pave the road to development of new methods without compromising the nutritional relevance. Further, simplification of methods is an integral element of transforming methods applicable at the individual and small scale studies into large population-based methods and the need for a high level of details may be less prominent compared with nutrition research.

The analytical frame work to assess reporting accuracy can be used in other context were dietary intake is assessed e.g. in other age groups and settings or as a means of evaluating intervention studies. The prospective of integrating the digital images and the questionnaire in one device could bring the use beyond the school setting e.g. if tablets or smart phones provide the platform. Tablets are becoming more widely distributed in the educational system and in the general population. The digital dietary device could also provide contextual information through the use of the GPS, the digital camera and bar code scanning (101). Further, a portable device could also comply with adolescents irregular eating pattern where in between snacking occasion replaces regular meals (5, 17, 102, 103)

7. References

1. Lawrence M, Dr. Public health nutrition : From principles to practice. Worsley T, editor. Maidenhead: Open University Press; 2007.
2. Pedersen AN, Fagt S, Groth MV, Christensen T, Biloft-Jensen A, Matthiessen J, et al. Danskernes kostvaner 2003-2008: Hovedresultater. [Dietary habits in Denmark 2003-2008. main results]. 1. ed. Pedersen AN, (editor). Copenhagen, Denmark: National Food Institute, Technical University of Denmark; 2010.
3. Fagt S, Fødevareinstituttet. Danskernes kostvaner 1995-2006: Status og udvikling med fokus på frugt og grønt samt sukker. [Dietary habits 1995-2006: Status and development with focus on fruit and vegetables and sugar] 1. ed. DTU Fødevareinstituttet; 2008.
4. Lien N, Lytle LA, Klepp KI. Stability in consumption of fruit, vegetables, and sugary foods in a cohort from age 14 to age 21. *Prev Med.* 2001 09;33(3):217-26.
5. Cutler GJ, Flood A, Hannan P, Neumark-Sztainer D. Major patterns of dietary intake in adolescents and their stability over time. *J Nutr.* 2009 02;139(2):323-8.
6. Lake AA, Mathers JC, Rugg-Gunn AJ, Adamson AJ. Longitudinal change in food habits between adolescence (11-12 years) and adulthood (32-33 years): The ASH30 study. *J Public Health (Oxf).* 2006 03;28(1):10-6.
7. Patterson E, Warnberg J, Kearney J, Sjostrom M. The tracking of dietary intakes of children and adolescents in Sweden over six years: The European youth heart study. *Int J Behav Nutr Phys Act.* 2009;6:91.
8. Brug J, Klepp KI. Children and adolescents. In: Worsley T, editor. *Public health nutrition : from principles to practice.* Maidenhead: Open University Press; 2007. p. 126.
9. WHO. Obesity: Preventing and managing the global epidemic: Report of a WHO consultation on obesity. Geneva: World Health Organisation; 2000.
10. WHO. Diet, nutrition and the prevention of chronic diseases. report of a joint WHO/FAO expert consultation. Geneva: World Health Organization; 2003. Report No.: WHO Technical Report Series 916.
11. Waijers PM, Feskens EJ, Ocke MC. A critical review of predefined diet quality scores. *Br J Nutr.* 2007 02;97(2):219-31.
12. Nordic Council of Ministers. Nordic Nutrition Recommendations 2004. Copenhagen: Nord 2004:13; 2004.

13. Astrup AV, Andersen NL, Stender S, Trolle E. The Danish Dietary Recommendations 2005. *Ugeskr Laeg.* 2005;167(21):2296-9.
14. Biloft-Jensen A, Ygil KY, Christensen LM, Christensen SM, Christensen T. Forslag til retningslinjer for sund kost i skoler og institutioner. [Guidelines for healthy meals in schools and kindergartens]. Copenhagen, Denmark: National Food Institute, Technical University of Denmark; 2005. Report No.: 14.
15. Bell AC, Swinburn BA. What are the key food groups to target for preventing obesity and improving nutrition in schools? *Eur J Clin Nutr.* 2004 02;58(2):258-63.
16. Evans CE, Greenwood DC, Thomas JD, Cade JE. A cross-sectional survey of children's packed lunches in the UK: Food- and nutrient-based results. *J Epidemiol Community Health.* 2010 11;64(0143-005; 11):977-83.
17. Fagt S, Christensen T, Groth MV, Biloft-Jensen A, Matthiessen J, Trolle E. Børn og unges måltidsvaner 2000-2004. [Children and adolescents' dietary habits 2000-2004]. Copenhagen, Denmark: National Food Institute, Technical University of Denmark; 2007.
18. Bathgate K, Begley A. 'It's very hard to find what to put in the kid's lunch': What perth parents think about food for school lunch boxes. *Nutr Diet.* 2011;68(1):21-6.
19. Rogers IS, Ness AR, Hebditch K, Jones LR, Emmett PM. Quality of food eaten in english primary schools: School dinners vs packed lunches. *Eur J Clin Nutr.* 2007 07;61(7):856-64.
20. Sanigorski AM, Bell AC, Kremer PJ, Swinburn BA. Lunchbox contents of australian school children: Room for improvement. *Eur J Clin Nutr.* 2005 11;59(11):1310-6.
21. Rees GA, Richards CJ, Gregory J. Food and nutrient intakes of primary school children: A comparison of school meals and packed lunches. *J Hum Nutr Diet.* 2008 10;21(1365-277; 5):420-7.
22. Evans CE, Cleghorn CL, Greenwood DC, Cade JE. A comparison of british school meals and packed lunches from 1990 to 2007: Meta-analysis by lunch type. *Br J Nutr.* 2010 08;104(4):474-87.
23. Sabinsky M, Toft U, Andersen K, Mikkelsen B, Tetens I. Ernæringsmæssig evaluering af skolemads betydning for eleveres kostindtag til frokost. [Nutritional evaluation of the impact of school lunches on the dietary quality of school children's lunch]. Ballerup: Aalborg Universitet; 2010.
24. McPherson RS, Hoelscher DM, Alexander M, Scanlon KS, Serdula MK. Dietary assessment methods among school-aged children: Validity and reliability. *Prev Med.* 2000;31:11-33.
25. Macdiarmid J, Blundell J. Assessing dietary intake: Who, what and why of under-reporting. *Nutr Res Rev.* 1998 12;11(2):231-53.

26. Scott J. Children as respondents - the challenge of quantitative methods. In: James A, Christensen P, editors. *Conducting research with children*. 1st ed. Brighton: Falmer Press; 2000.
27. Paxton A, Baxter SD, Fleming P, Ammerman A. Validation of the school lunch recall questionnaire to capture school lunch intake of third- to fifth-grade students. *J Am Diet Assoc*. 2011;111(3):419-24.
28. Baxter SD, Smith AF, Litaker MS, Guinn CH, Nichols MD, Miller PH, et al. Body mass index, sex, interview protocol, and children's accuracy for reporting kilocalories observed eaten at school meals. *J Am Diet Assoc*. 2006;106(10):1656-62.
29. Eck LH, Klesges RC, Hanson CL. Recall of a child's intake from one meal: Are parents accurate? -*Journal of the American Dietetic Association*. 1989;89(6):784.
30. Hernández T, Wilder L, Kuehn D, Rubotzky K, Moser-Veillon P, Godwin S, et al. Portion size estimation and expectation of accuracy. *J Food Compos Anal*. 2006;19(SUPPL.):S14-21.
31. Baxter SD, Thompson WO, Davis HC, Johnson MH. 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*. 1997 11;97(11):1293-8.
32. Subar AF, Crafts J, Zimmerman TP, Wilson M, Mittl B, Islam NG, et al. 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*. 2010 01;110(1):55-64.
33. Foster E, O'Keeffe M, Matthews JN, Mathers JC, Nelson M, Barton KL, et al. 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*. 2008 01;99(1):185-90.
34. Warren JM, Henry CJ, Livingstone MB, Lightowler HJ, Bradshaw SM, Perwaiz S. How well do children aged 5-7 years recall food eaten at school lunch? *Public Health Nutr*. 2003 02;6(1):41-7.
35. Marlette MA, Templeton SB, Panemangalore M. Food type, food preparation, and competitive food purchases impact school lunch plate waste by sixth-grade students. *J Am Diet Assoc*. 2005 11;105(11):1779-82.
36. Forrestal SG. Energy intake misreporting among children and adolescents: A literature review. *Matern Child Nutr*. 2011 04;7(2):112-27.
37. Ventura AK, Loken E, Mitchell DC, Smiciklas-Wright H, Birch LL. Understanding reporting bias in the dietary recall data of 11-year-old girls. *Obesity (Silver Spring)*. 2006 06;14(6):1073-84.

38. Murakami K, Miyake Y, Sasaki S, Tanaka K, Arakawa M. Characteristics of under- and over-reporters of energy intake among Japanese children and adolescents: The Ryukyus child health study. *Nutrition*. 2011 11/22.
39. Weber JL, Lytle L, Gittelsohn J, Cunningham-Sabo L, Heller K, Anliker JA, et al. Validity of self-reported dietary intake at school meals by American Indian children: The pathways study. *J Am Diet Assoc*. 2004 05;104(5):746-52.
40. Bandini LG, Must A, Cyr H, Anderson SE, Spadano JL, Dietz WH. Longitudinal changes in the accuracy of reported energy intake in girls 10-15 y of age. *Am J Clin Nutr*. 2003;78(3):480-4.
41. Biloft-Jensen A, Trolle E, Christensen T, Islam N, Andersen LF, Egenfeldt-Nielsen S, et al. WebDASC: A web-based dietary assessment software for 8-11-year-old Danish children. *J Hum Nutr Diet*. 2012.
42. Merriam-webster's collegiate® dictionary, eleventh edition [Internet].; 2012. Available from: <http://www.merriam-webster.com/dictionary/accuracy>.
43. Baxter SD, Guinn CH, Royer JA, Hardin JW, Mackelprang AJ, Smith AF. Accuracy of children's school-breakfast reports and school-lunch reports (in 24-h dietary recalls) differs by retention interval. *Eur J Clin Nutr*. 2009;63(12):1394-403.
44. Moore GF, Tapper K, Moore L, Murphy S. Cognitive, behavioral, and social factors are associated with bias in dietary questionnaire self-reports by schoolchildren aged 9 to 11 years. *J Am Diet Assoc*. 2008 11;108(11):1865-73.
45. Novotny JA, Rumpler WV, Riddick H, Hebert JR, Rhodes D, Judd JT, et al. Personality characteristics as predictors of underreporting of energy intake on 24-hour dietary recall interviews. *J Am Diet Assoc*. 2003 09;103(9):1146-51.
46. Baxter SD. Cognitive processes in children's dietary recalls: Insight from methodological studies. *Eur J Clin Nutr*. 2009 02;63 Suppl 1:S19-32.
47. Berg C, Jonsson I, Conner MT, Lissner L. Sources of bias in a dietary survey of children. *Eur J Clin Nutr*. 1998 09;52(9):663-7.
48. Baxter SD, Hardin JW, Royer JA, Smith AF, Guinn CH. Sources of intrusions in children's dietary recalls from a validation study of order prompts. *J Health Psychol*. 2008;13(8):1157-62.
49. Baxter SD, Guinn CH, Hardin JW, Royer JA, Wilson DK. Methodological research concerning the accuracy of children's dietary recalls. *Appetite and Nutritional Assessment*. 2009.
50. Frank GC. Taking a bite out of eating behavior: Food records and food recalls of children. *J Sch Health*. 1991 05;61(5):198-200.

51. Goodwin RA, Brule D, Junkins EA, Dubois S, Beer-Borst S. Development of a food and activity record and a portion-size model booklet for use by 6- to 17-year olds: A review of focus-group testing. *J Am Diet Assoc.* 2001 08;101(8):926-8.
52. Lillegaard IT, Overby NC, Andersen LF. Can children and adolescents use photographs of food to estimate portion sizes? *Eur J Clin Nutr.* 2005 04;59(4):611-7.
53. Rothausen BW, Matthiessen J, Groth MV, Brockhoff PB, Andersen LF, Trolle E. Comparison of estimated energy intake from 2 x 24-hour recalls and a seven-day food record with objective measurements of energy expenditure in children. *Food Nutri Res.* 2012;56.
54. Novotny JA, Rumpler WV, Judd JT, Riddick PH, Rhodes D, McDowell M, et al. Diet interviews of subject pairs: How different persons recall eating the same foods. *J Am Diet Assoc.* 2001 10;101(10):1189-93.
55. Guinn CH, Baxter SD, Hardin JW, Royer JA, Smith AF. Intrusions in children's dietary recalls: The roles of BMI, sex, race, interview protocol, and social desirability. *Obesity.* 2008;16(9):2169-74.
56. Bere E, Brug J, Klepp K-. Why do boys eat less fruit and vegetables than girls? *Public Health Nutr.* 2008;11(3):321-5.
57. Wardle J, Haase AM, Steptoe A, Nillapun M, Jonwutiwes K, Bellisle F. Gender differences in food choice: The contribution of health beliefs and dieting. *Annals of Behavioral Medicine.* 2004;27(2):107-16.
58. Guinn CH, Baxter SD, Royer JA, Hardin JW, Mackelprang AJ, Smith AF. Fourth-grade children's dietary recall accuracy for energy intake at school meals differs by social desirability and body mass index percentile in a study concerning retention interval. *J Health Psychol.* 2010 05;15(4):505-14.
59. Klesges RC, Eck LH, Ray JW. Who underreports dietary intake in a dietary recall? evidence from the second national health and nutrition examination survey. *J Consult Clin Psychol.* 1995 06;63(0022-006; 0022-006; 3):438-44.
60. Baxter SD, Hardin JW, Royer JA, Guinn CH, Smith AF. Children's recalls from five dietary-reporting validation studies. intrusions in correctly reported and misreported options in school breakfast reports. *Appetite.* 2008;51(3):489-500.
61. Baxter SD, Smith AF, Litaker MS, Guinn CH, Shaffer NM, Baglio ML, et al. Recency affects reporting accuracy of children's dietary recalls. *Ann Epidemiol.* 2004;14(6):385-90.
62. Baxter SD, Guinn CH, Royer JA, Hardin JW, MacKelprang AJ, Smith AF. Accuracy of children's school-breakfast reports and school-lunch reports (in 24-h dietary recalls) differs by retention interval. *Eur J Clin Nutr.* 2009;63(12):1394-403.

63. Baxter SD, Thompson WO. Accuracy by meal component of fourth-graders' school lunch recalls is less when obtained during a 24-hour recall than as a single meal. *Nutr Res.* 2002;22(6):679-84.
64. Wallen V, Cunningham-Sabo L, Auld G, Romaniello C. Validation of a group-administered pictorial dietary recall with 9- to 11-year-old children. *J Nutr Educ Behav.* 2011;43(1):50-4.
65. Borgers N. Children as respondents in survey research: Cognitive development and response quality 1. *BMS.Bulletin de méthodologie sociologique.* 2000;66(1):60.
66. Smith AF, Jobe JB, Mingay DJ. Retrieval from memory of dietary information. *Applied Cognitive Psychology.* 1991;5:269-96.
67. Baxter SD, Hardin JW, Royer JA, Guinn CH, Smith AF. Insight into the origins of intrusions (reports of uneaten food items) in children's dietary recalls, based on data from a validation study of reporting accuracy over multiple recalls and school foodservice production records. *J Am Diet Assoc.* 2008;108(8):1305-14.
68. Gordon AR, Cohen R, Crepinsek MK, Fox MK, Hall J, Zeidman E. The third school nutrition dietary assessment study: Background and study design. *J Am Diet Assoc.* 2009 02;109(2):S20-3.
69. Christensen LM, Hansen KS, Sabinsky M. Kvalitet af skolefrokost - undersøgelse af skoleeleversfrokostmåltider [Quality of school lunch - assessment of school children's lunches]. 2009.
70. Christensen LM, Hansen KS. Kvalitet af skolefrokost – mad og drikkevareudbud i danske grundskoler [Quality of school lunch - food and beverages offered in Danish public schools]. 2007.
71. Hoppe C, Biloft-Jensen AP, Trolle E, Tetens I. Beskrivelse af 8- til 10-årige og 12- til 14-årige børns kost – med fokus på indtag i skole og fritidsordning. [Description of 8-10-year-old and 12-14-year-old children's nutrition - with focus on intake in schools and after-school facilities]. 2009.
72. Domel SB. Self-reports of diet: How children remember what they have eaten. *Am J Clin Nutr.* 1997;65(4 SUPPL.):1148S-52.
73. Simons-Morton BG, Forthofer R, Huang IW, Baranowski T, Reed DB, Fleishman R. Reliability of direct observation of schoolchildren's consumption of bag lunches. *J Am Diet Assoc.* 1992;92(2):219-21.
74. Foster E, Adamson AJ, Anderson AS, Barton KL, Wrieden WL. Estimation of portion size in children's dietary assessment: Lessons learnt. *Eur J Clin Nutr.* 2009 02;63 Suppl 1:S45-9.

75. Sepp H, Ekelund U, Becker W. Questions on diet and physical activity among adults in sweden. basis for the selection of questions in population based surveys. [Enkätfrågor om kost och fysisk aktivitet bland vuxna. underlag till urval av frågor i befolkningsinriktade enkäter]. The National Food Administration. 2004.
76. Fagt S, Anderssen SA, Becker W, Borodulin K, Fogelholm M, Groth MV, et al. Nordic monitoring on diet, physical activity and overweight. part 1: Description of a common nordic method for collecting representative data. Søborg: National Food Institute, Technical University of Denmark; 2009.
77. Hearty AP, Gibney MJ. Dietary patterns in irish adolescents: A comparison of cluster and principal component analyses. *Public Health Nutr.* 2011 10/13:1-10.
78. Rothausen BW, Matthiessen J, Andersen LF, Brockhoff PB, Tetens I. Dietary patterns on weekdays and weekend days in 4-14-year-old danish children. *Br J Nutr.* 2012:1-10.
79. EAT [Internet].; 2012. Available from:
<http://www.kk.dk/sitecore/content/Subsites/EAT/SubsiteFrontpage.aspx>.
80. Boushey CJ, Kerr DA, Wright J, Lutes KD, Ebert DS, Delp EJ. Use of technology in children's dietary assessment. *Eur J Clin Nutr.* 2009 02;63 Suppl 1:S50-7.
81. Baxter SD, Thompson WO, Litaker MS, Frye FH, Guinn CH. Low accuracy and low consistency of fourth-graders' school breakfast and school lunch recalls. *J Am Diet Assoc.* 2002 03;102(3):386-95.
82. Steyn NP, Nel JH, Nantel G, Kennedy G, Labadarios D. Food variety and dietary diversity scores in children: Are they good indicators of dietary adequacy? *Public Health Nutr.* 2006 08;9(5):644-50.
83. Murphy SP, Foote JA, Wilkens LR, Basiotis PP, Carlson A, White KK, et al. Simple measures of dietary variety are associated with improved dietary quality. *J Am Diet Assoc.* 2006 03;106(3):425-9.
84. Smith AF, Baxter SD, Hardin JW, Royer JA, Guinn CH. Some intrusions in dietary reports by fourth-grade children are based on specific memories: Data from a validation study of the effect of interview modality. *Nutr Res.* 2008;28(9):600-8.
85. Martin CK, Han H, Coulon SM, Allen HR, Champagne CM, Anton SD. A novel method to remotely measure food intake of free-living individuals in real time: The remote food photography method. *Br J Nutr.* 2009 02;101(3):446-5.
86. Elgar FJ, Roberts C, Tudor-Smith C, Moore L. Validity of self-reported height and weight and predictors of bias in adolescents. *J Adolesc Health.* 2005 11;37(1054-139; 5):371-5.
87. Rasmussen M, Krølner R, Klepp K, Lytle L, Brug J, Bere E, et al. Determinants of fruit and vegetable consumption among children and adolescents: A review of the literature. part I:

Quantitative studies. *International Journal of Behavioral Nutrition and Physical Activity*. 2006;3(1).

88. Baranowski T, Baxter SD. A cognitive model of children's reporting of food intake. *Am J Clin Nutr* 1994;59(1):S212-7.

89. Chambers IV E, Godwin SL, Vecchio FA. Cognitive strategies for reporting portion sizes using dietary recall procedures. *J Am Diet Assoc*. 2000;100(8):891-7.

90. Christensen PH. Børn, mad og daglige rutiner. [Children, food and daily routines]. *Barn*. 2003;2-3:119-35.

91. Ahlström R, Baird JC, Jonsson I. School children's preferences for food combinations. *Food Qual Preference*. 1990;2(3):155-6.

92. Conway TL, Sallis JF, Pelletier RL, Powers HS, Marshall SJ, ZIVE MM, et al. What do middle school children bring in their bag lunches? *Prev Med*. 2002;34(4):422-7.

93. Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward WA, et al. Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. derivation of cut-off limits to identify under-recording. *Eur J Clin Nutr*. 1991 12;45(12):569-81.

94. Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cut offs to define thinness in children and adolescents: International survey. *BMJ*. 2007 07/28;335(0959-535; 7612):194.

95. Smith AD, Emmett PM, Newby PK, Northstone K. A comparison of dietary patterns derived by cluster and principal components analysis in a UK cohort of children. *Eur J Clin Nutr*. 2011 10;65(10):1102-9.

96. Baxter SD, Smith AF, Nichols MD, Guinn CH, Hardin JW. Children's dietary reporting accuracy over multiple 24-hour recalls varies by body mass index category. *Nutr Res*. 2006;26(6):241-8.

97. Martin CK, Thomson JL, LeBlanc MM, Stewart TM, Newton RL, Jr., Han H, et al. Children in school cafeterias select foods containing more saturated fat and energy than the institute of medicine recommendations. *J Nutr*. 2010 09;140(9):1653-60.

98. Wills W, Backett-Milburn K, Gregory S, Lawton J. The influence of the secondary school setting on the food practices of young teenagers from disadvantaged backgrounds in Scotland. *Health Education Research*. 2004;20(4):458.

99. Clark MA, Fox MK. Nutritional quality of the diets of US public school children and the role of the school meal programs. *J Am Diet Assoc*. 2009 02;109(2):S44-56.

100. Gi' madpakken en hånd [give the packed lunch a hand] [Internet]. Available from: <http://www.foedevarestyrelsen.dk/Publikationer/Alle%20publikationer/2010208.pdf>.

101. Larsen JE, Jensen K. In: Mobile context toolbox : An extensible context framework for S60 mobile phones. 4th european conference on smart sensing and context (EuroSSC 2009); Springer Berlin / Heidelberg; 2009. p. 193-206.

102. Currie C, Gabhainn SN, Godeau E, Roberts C, Smith R, Currie D, et al. Inequalities in young peoples health. WHO; 2008.

103. Øverby N, Stea TH, Vik FN, Klepp K-, Bere E. Changes in meal pattern among norwegian children from 2001 to 2008. Public Health Nutr. 2011;14(9):1549-54.

8. Appendices (Paper I-III)

Paper I

Recall accuracy in 11-year-old children's self-reported consumption of school lunch

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Keywords: School lunch, self-reported intake, recall accuracy

Running head: Is self-reported intake influenced by gender and assessment method?

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Background: Packed lunch is the dominant lunch format in many countries including Denmark. School lunch is consumed unsupervised and self-reported recalls are appropriate in the school setting, however little is known about accuracy of recalls in relation to packed lunch.

Objective: To assess the qualitative recall accuracy of self-reported consumption of packed lunch among Danish 11-year-old children in relation to gender and dietary assessment method.

Design: A cross-sectional dietary recall study of packed lunch consumption. Digital images (DI) served as objective reference method to determine food items consumed. Recalls were collected with a Lunch Recall Questionnaire (LRQ) comprising an open-ended recall (OE-Q) and a pre-coded food group prompted recall (PC-Q). Individual interviews (INT) were conducted successively. Number of food items was identified and accuracy calculated as match rates (% identified by DI and reported correctly) and intrusion rates (% not identified by DI but reported) was determined.

Setting and subjects: Three Danish public schools from Copenhagen. 114 Danish 11-year-old children, mean (SE) age = 11.1 (0.03) and BMI = 18.2 (0.26).

Results: The reference (DI) showed that girls consumed a higher number of food items than boys (mean (SE) 5.4 (0.25) vs. 4.6 (0.29) items ($p=0.05$)). Number of food items recalled differed between genders with OE-Q recalls ($p=0.005$) only. Girls' interview recalls were more accurate than boys' with higher match rates ($p=0.04$) and lower intrusion rates ($p=0.05$). Match rates ranged from 67 – 90 % and intrusion rates ranged from 13 – 39 % with little differences between girls and boys using the OE-Q and PC-Q methods.

Conclusion:

Dietary recall validation studies should not only consider match rates as an account of accuracy.

Intrusions contribute to over-reporting in non-validation studies and future studies should address recall accuracy and inaccuracies in relation gender and recall method.

Keywords: *intrusion rate, match rate, recall accuracy, packed lunch, school children*

Abbreviations

LRQ = Lunch Recall Questionnaire

DI = Digital Images

OE-Q = Open-Ended Questionnaire self-report

PC-Q = Pre-Coded Questionnaire self-report

INT = Individual structured interviews

Background

From a nutrition and public health perspective it is important to develop valid methods to assess children's self-reported intake during school hours. The school setting is often accentuated as an appropriate setting for health promoting interventions (1) and a large proportion of the daily food intake of school aged children is consumed in this extra-familiar context (2).

Packed lunch is the more prevalent lunch format in several countries including Denmark (3-5). In Denmark packed lunch usually consists of open sandwiches on rye bread with cold cuts and supplementary vegetables and fruits. Several studies have assessed the nutritional content of packed lunch either by using digital images (6) direct observation (7) or weighing food served and plate waste as a means of assessing energy distribution and nutritional content (8). A recent Danish study suggested that on average packed lunches contained more saturated fat compared to school lunch (9).

One well acknowledged methodological challenge in dietary assessment methods is that accuracy of self-reported recalls may differ across different population groups. Gender has been shown to be associated with diet related outcomes in terms of actual consumption (10-12) and meal pattern (13). In relation to fruit and vegetable consumption it has been argued that girls have greater knowledge and self-efficacy compared with boys although these determinants did not explain the gender differences in intake after adjusting for preferences and perceived accessibility (11). Other diet related self-reported outcomes have identified gender specific differences in groups of children in terms of drop-out rate (14), under-estimation of portion sizes (15) and body weight (10, 16) in previous studies.

Diet related self-reported outcomes have identified gender specific differences in groups of children's in terms of drop-out rate (14), under-estimation of portion-sizes (15), and body weight (10,

16) in previous studies. In addition to the individual characteristics, a range of design factors may influence the accuracy of recalls e.g. retention period, interview format, target period, and interview time (17-19).

Accuracy can conceptually be divided into *qualitative accuracy* which is accuracy at the food level and *quantitative accuracy* which concerns the aspects of quantifying amounts consumed (20).

Validation studies of children's self-reported lunch intake in which recall accuracy is addressed qualitatively distinguish between *matches* (food items reported and observed by an objective measure), *omissions* (food items not reported but observed by an objective measure) and *intrusions* (food items reported but not observed by an objective measure) (21, 22). Direct observation is a valid objective method that has been applied successfully in school settings (23-26) but the method is expensive and time consuming and thus difficult to apply in a population based setting (27, 28).

The methodological aspect of accuracy in relation to self-reported school hour consumption is understudied and needs further exploration. Existing knowledge about recall accuracy of school obtained by self-administered questionnaires among school children is limited (4, 14, 29). Most of the identified validation studies have used interviews as the primary self-reported data collection method (4, 30, 31). As an alternative to direct observation a growing number of studies have applied digital images as the objective measure of actual consumption in school settings (32-34). However, the studies have not been conducted in relation to recall accuracy.

Little is known about the association between gender and recall accuracy among school aged children. The existing studies have been conducted in relation to school meals in which gender did not influence omission rates or intrusion rates (30). However, the association in relation to packed lunch is understudied and it has been argued that it is difficult to identify the content of packed lunches with observation as a validation method (30, 31).

The objective of the present study was to assess the qualitative recall accuracy of self-reported consumption of packed lunch among Danish 11-year-olds in relation to gender and dietary assessment method.

Material and methods

Setting and design

The study was a cross-sectional study with 114 Danish 5th grade students from 3 public schools in Copenhagen (mean age = 11.1, SE = 0.01). Five schools with the highest participation rate in the School Lunch Scheme EAT were identified by the Children and Youth Administration, Municipality of Copenhagen and invited to participate. Three schools accepted the invitation and all 5th grade students received a written invitation including a parental consent form. 205 students were invited of which 189 were present at the day of the data collection. Assent was collected from the children before participation. The project was approved by the Danish Data Protection Agency before data collection was initiated.

The target period was self-reported same day intake and prompting was forward ordered from morning to lunch although only lunch intake was validated. Lunch intake data was collected immediately after the lunch break which kept the total retention period under a maximum of 1½ hours.

The LRQ consisted of an open-ended part (OE-Q) and a pre-coded part (PC-Q) and individual face-to-face interviews (INT). The LRQ was completed prior to the interviews because our primary focus was to test accuracy for recalls obtained by the questionnaires. Digital images (DI) of lunch consumption were included as an objective reference against which self-reported recalls were assessed. Lunch consumption data were complemented with self-reported information about age and gender, and objective anthropometric measures.

Digital images

Digital images (DI) were as chosen as the objective reference. The images served to identify food items and assess actual intake by comparison of a corresponding set of pre-meal and post-meal images. Members of the research team photographed students' packed lunches using a validated standard protocol as described previously (9).

The pre-meal image was taken prior to consumption and thus showed all the food items that were served on the plate. Students were instructed to unpack their lunch and place all foods on a plate with their unique identification number. Further, they were instructed to raise the cold cuts and sandwich fillings before the image was taken which enabled a subsequent identification of e.g. fat spreads. The post-meal image was taken following the consumption. The post-meal image displayed an empty plate for those who had eaten everything and plate waste in case the child had left overs. Nikon Coolpix S210 cameras with electronic VR stabilization and Motion Detection were used and images were taken using a Cubelite kit from Lastolite.

Food based non-quantitative Lunch Recall Questionnaire (LRQ)

A self-administered Lunch Recall Questionnaire (LRQ) for the purpose and recalls was restricted to the food level. The questionnaire contained the following two self-reported measures: an *open-ended* (OE-Q) where students were instructed to write down everything they had consumed for lunch and a *pre-coded* (PC-Q) in which self-reports were prompted by pre-coded food groups. Self-reported lunch consumption was obtained with a Lunch Recall Questionnaire (LRQ) developed and pre-tested on 50 11-year-olds from a school situated in the county of Copenhagen.

Food groups and food items were selected based on knowledge of lunch intake in the particular age group from the representative National Survey of Dietary Habits and Physical Activity (DANSDA) (35, 36) and Guidelines for healthy meals in Schools and Kindergartens (2, 36) . The LRQ was

administered in the class room and students completed them individually immediately after consumption or after the adjacent lunch break. Completion time ranged from 5-15 minutes mainly due to variation in time spent on their food intake.

Individual interviews

Individual face-to-face interviews were conducted by trained interviewers when the child had completed the questionnaire. Interviews (INT) followed a multi pass protocol as described in Baxter et al. (21). Initially students were asked to recall everything they had consumed for lunch, followed by a non-directive prompt, and finally recalls were prompted by food groups. Interviews were conducted in a quiet location at the school. Duration of the interviews ranged from 4-8 minutes. All interviews were recorded (Olympus WS-450S digital voice recorder) and subsequently food level recalls were transcribed.

Anthropometrics

Students were measured and weighed by a member of the research team after completion of the self-reported methods i.e. after lunch consumption. Height was measured to nearest centimeter (Soehnle 5003.01.001) and weight was measured in kilograms with 1 decimal (OBH Nordica, personal scale) following Division of Nutrition's standard protocol, i.e. students were measured without shoes and both height and weight were measured twice (Fagt, 2012 personal communication).

Intake variables and assessment of recall accuracy

The specific food items included in the Lunch Recall Questionnaire were grouped into six food groups (i.e. bread, fat spreads, cold cuts, fruit incl. nuts, vegetables, and snacks) containing a total of 18 subgroups and single food items. Consumption of food items obtained by Digital Images (DI),

Open-Ended Questionnaire (OE-Q), Pre-Coded Questionnaire (PC-Q), and Interviews (INT) were identified and characterized according to the pre-determined food groups. Actual intake was assessed by comparing the corresponding set of images. Accuracy was described as match rates and intrusion rates and was estimated in two steps. First, all food items were identified as matches, omissions, and intrusions by comparing the objectively determined food items with the self-reported consumption by the OE-Q, PC-Q and INT. A food item was defined as a *match* if the post-meal image showed that the food item identified in the pre-meal image had been consumed and was reported consumed by the student. A food item was defined as an *omission* if the food item appearing on the pre-meal digital image was not reported by the student, and finally, a food item was defined as an *intrusion* if a food item did not appear on the pre-meal digital image but the student reported it in the recall. Second, recall accuracy for the OE-Q, PC-Q or INT was assessed by calculating match rates and intrusion rates in the following way:

$$\text{Match rate} = \frac{\sum \text{matches}}{(\sum \text{matches} + \sum \text{omissions})} * 100.$$

$$\text{Intrusion rate} = \frac{\sum \text{intrusion}}{(\sum \text{matches} + \sum \text{intrusions})} * 100.$$

Statistics

Characteristics of the study population were stratified by gender and presented as means with standard error (SE). Number of food items consumed obtained by the objective reference and the self-reported measures was stratified by gender and the Kruskal-Wallis test was applied. Finally, matched t-tests were conducted to compare the mean number of food items identified by DI and self-reported recalls and to determine which self-reported method was more accurate i.e. to compare match rates and intrusion rates between methods. Statistical analyses were conducted with SAS (version 9.2 for windows, SAS Institute Inc., Cary, NC, USA).

Results

The study population characteristics are shown in Table 1. The two sample t-tests did not show significant differences between boys and girls in BMI distribution. Successive analyses were not stratified by BMI.

Table 2 shows the number of food items consumed according to the objective reference (DI) and the three self-reported measures: Open-Ended random order questionnaire (OE-Q), Pre-Coded questionnaire (PC-Q), and individual face-to-face interviews (INT). Stratification by gender showed that girls consumed significantly more food items (5.4) compared to boys (4.6) ($p=0.05$) when consumption was determined by DI. Food consumption reported by OE-Q showed significant differences, and girls reported significantly more food items (4.2) than boys (3.3) ($p=0.005$). Self-reports obtained by PC-Q and INT did not differ significantly by gender.

Match rates and intrusion rates for recalls obtained by the self-reported measures stratified by gender are presented in Table 3. Gender specific differences were shown for recalls obtained by INT where girls' match rate was significantly higher (89.7% vs. 84.4%) and girls' intrusion rate was significantly lower compared to the corresponding rates for boys (14.6 % vs. 23.3%) ($p=0.04$ and $p=0.05$ respectively).

Comparisons between the self-reported methods showed that INT provided match rates that were significantly higher compared with self-reports from the questionnaire methods OE-Q and PC-Q. The corresponding comparisons for intrusion rates were more varied. Intrusion rates were highest for recalls obtained with PC-Q irrespective of gender.

Discussion

The study provides insight to the unexplored subject of accuracy of packed lunch recalls and pointed at several gender specific differences in actual consumption, response behavior and recall accuracy. Girls consumed more food items than boys as determined by the objective reference (DI),

and girls reported significant more food items with the open-ended recall (OE-Q) compared with boys. In addition, recalls obtained by interviews (INT) showed that girls' recalls were more accurate both in terms of a higher match rate and a lower intrusion rate.

Gender issues

Gender specific differences in consumption have been shown previously in relation to energy intake (37). However, as has been shown in an earlier study by Baxter et al. nutrient level analyses do not necessarily reveal differences in consumption at the food level and inaccurate recalls at the food level may provide accurate nutrient level analyses (30). Extensive knowledge of which food groups and food items are correctly (matches) and incorrectly (intrusions) reported can inform future advances in the methodology of self-reported recalls. The result that girls consumed more different food items than boys have been shown in relation to school meals (10), and it may overall indicate that girls consume a more varied lunch compared with boys.

Girls reported more food items with all three self-reported measures than boys although the difference was only significant for the open-ended recall (OE-Q). The result points at three potential explanations for the difference: a) consumption pattern differs between genders as discussed above or b) boys provide less accurate written recalls when recalls are not prompted, or c) boys recalls are less accurate compared with girls'. Additional analyses should identify which food groups contribute to the variation and explore if the variations contribute to differences in diet quality. In such cases inclusion of important determinants that mediate the differences in consumption e.g. preferences or perceived accessibility (11) should be taken into account in future studies.

The result that boys report fewer food items than girls with open-ended random order written recalls is in concordance with results from the Danish sample of the Pro Children study (Krolner, personal communication). Consequently, prompting may be a feasible strategy to even out the difference in

response behavior, although careful consideration regarding selection of prompting method is warranted (38, 39).

Inclusion of the objective method enabled us to distinguish between the explanations. As the reference showed a higher number of food items consumed, we would expect girls to report a higher number. The fact that girls' recalls were more accurate with INT may be explained by the fact that girls possessed a greater knowledge about foods as they are more likely to participate in meal preparations and food purchases than boys (11, 12).

Recall methods

The study indicated interesting findings regarding the methods. The interview method provided the highest match rates and lowest intrusion rates. Match rates ranged from 84-90% and similar high rates have been shown with same day recalls where retention period was restricted to a minimum of 90 minutes (30). The method is useful in small scale studies, but less feasible among larger populations.

The Lunch Recall Questionnaire (LRQ) included two measures recall measures that did not differ in the obtained match rates but the intrusion rate was significantly higher for the pre-coded recalls (PC-Q). The high intrusion rate may be explained by the fact that recalls were prompted by food groups. In contrast to the open-ended recall (OE-Q) children had to categorize single food items into pre-defined food groups. The food groups may have been similar and dissimilar to the child's own retrieval cues and consequently may have influenced recalls negatively (30) by prompting them to report food items not actually consumed or verified by the digital images. However, the OE-Q recalls were subjected to some degree of under-reporting because the number of food items was significantly lower than the number determined by the objective reference images. The advantages

and disadvantages of open-ended vs. pre-coded questionnaire recalls need further exploration to develop methods that are applicable with large samples of children in their natural contexts.

Limitation and strengths

Only children with a complete set of digital images, a completed open-ended and pre-coded recall and who had participated in the interviews from whom we have objective anthropometric measures were included in the sample. The analytic sample consisted of 67% of the potential sample and it is possible that non-participants differed in their ability to recall their intake as pointed out by Berg (14). Other factors e.g. motivation to comply with the different methods may also have influenced the participation rate.

One limitation of the present study was that the objective measures were only included for lunch. Consequently, the availability may have inflated intrusion rates because any pre-lunch consumption of food items from the packed lunch that might occur during the morning break would be classified as intrusions when reported by the children. The problem of pre-lunch consumption of packed lunch has been handled in non-validated studies in which pre-meal images have been taken in the beginning of the school day (37, 40). Another potential limitation was that the images may have served as a positive visual prompting aid and could thereby have improved all match rates from all three recall methods, as well as questionnaire recalls may have contributed to the high match rates obtained with the interview method. The fixed order of recall methods applied in the present studied also has to be acknowledged in the interpretation of the results.

The potential limitations of inclusion of digital images as objective reference method were outweighed by the fact that the digital images provided a feasible validation method to study the unexplored subject of recall accuracy in relation to self-reported packed consumption among school

children. The method provided a quick review of the content of the packed lunches at the food level where the qualitative accuracy could be determined.

Implications

The study assessed the important aspect of qualitative recall accuracy but other aspects regarding the design of an optimal dietary assessment method for public health nutrition purposes call for considerations. This study pointed at two aspects that need further exploration. The first concerns the relation between food served and food consumed in relation to packed lunches. Can a gender specific difference in food items consumed be explained by the fact that girls are served a more varied packed lunch compared to boys? If this is the case then future health promoting activities should address this for parents and other caregivers that prepare the lunch packages. The second aspect refers to the methodological question of ensuring that self-reported methods do not introduce differential recall bias insofar that the methods appeal more to girls and may render boys' recalls less accurate.

Conclusion

The study showed that variety in packed lunch consumption and response behavior differed by gender. Girls consumed a higher number of different food items compared to boys. Boys reported significantly fewer food items in OE-Q and had a higher intrusion rate when recalls were obtained by interviews compared with girls. Match rates were highest for interview recall method while match rates did not differ between the questionnaire recalls. Inclusion of intrusion rate was a valuable parameter in assessment of recall accuracy. The pre-coded recall produced the highest intrusion rate and further advances are needed in the construction of valid questionnaires to assess school hour consumption with self-reported methods.

References

1. Story M, Kaphingst KM, Robinson-O'Brien R, Glanz K. Creating healthy food and eating environments: Policy and environmental approaches. *Annu Rev Public Health*. 2008;29:253-72.
2. Biloft-Jensen A, Ygil KY, Christensen LM, Christensen SM, Christensen T. Forslag til retningslinjer for sund kost i skoler og institutioner. [guidelines for healthy meals in schools and kindergartens]. Copenhagen, Denmark: National Food Institute, Technical University of Denmark; 2005. Report No.: 14.
3. Evans CE, Greenwood DC, Thomas JD, Cade JE. A cross-sectional survey of children's packed lunches in the UK: Food- and nutrient-based results. *J Epidemiol Community Health*. 2010 11;64(0143-005; 11):977-83.
4. Miles CL, Matthews J, Brennan L, Mitchell S. Changes in the content of children's school lunches across the school week. *Health Promot J Austr*. 2010 12;21(3):196-201.
5. Prynne CJ, Handford C, Dunn V, Bamber D, Goodyer IM, Stephen AM. The quality of midday meals eaten at school by adolescents; school lunches compared with packed lunches and their contribution to total energy and nutrient intakes. *Public Health Nutr*. 2011:1-8.
6. Dresler-Hawke E, Whitehead D, Coad J. What are new zealand children eating at school? A content analysis of 'consumed versus unconsumed' food groups in a lunch-box survey. *Health Educ J*. 2009;68(1):3-13.
7. Baxter SD, Guinn CH, Royer JA, Hardin JW, MacKelprang AJ, Smith AF. Accuracy of children's school-breakfast reports and school-lunch reports (in 24-h dietary recalls) differs by retention interval. *Eur J Clin Nutr*. 2009;63(12):1394-403.
8. Evans CE, Cleghorn CL, Greenwood DC, Cade JE. A comparison of british school meals and packed lunches from 1990 to 2007: Meta-analysis by lunch type. *Br J Nutr*. 2010 08;104(4):474-87.
9. Sabinsky M, Toft U, Andersen K, Mikkelsen B, Tetens I. Ernæringsmæssig evaluering af skolemads betydning for eleveres kostindtag til frokost. [nutritional evaluation of the impact of school lunches on the dietary quality of school children's lunch]. Ballerup: Aalborg Universitet; 2010.
10. Guinn CH, Baxter SD, Hardin JW, Royer JA, Smith AF. Intrusions in children's dietary recalls: The roles of BMI, sex, race, interview protocol, and social desirability. *Obesity*. 2008;16(9):2169-74.
11. Bere E, Brug J, Klepp K-. Why do boys eat less fruit and vegetables than girls? *Public Health Nutr*. 2008;11(3):321-5.
12. Wardle J, Haase AM, Steptoe A, Nillapun M, Jonwutiwes K, Bellisle F. Gender differences in food choice: The contribution of health beliefs and dieting. *Annals of Behavioral Medicine*. 2004;27(2):107-16.

13. Øverby N, Stea TH, Vik FN, Klepp K-, Bere E. Changes in meal pattern among norwegian children from 2001 to 2008. *Public Health Nutr.* 2011;14(9):1549-54.
14. Berg C, Jonsson I, Conner MT, Lissner L. Sources of bias in a dietary survey of children. *Eur J Clin Nutr.* 1998 09;52(9):663-7.
15. Vereecken C, Dohogne S, Covents M, Maes L. How accurate are adolescents in portion-size estimation using the computer tool young adolescents' nutrition assessment on computer (YANA-C)? *Br J Nutr.* 2010 06;103(12):1844-50.
16. Elgar FJ, Roberts C, Tudor-Smith C, Moore L. Validity of self-reported height and weight and predictors of bias in adolescents. *J Adolesc Health.* 2005 11;37(1054-139; 5):371-5.
17. Baxter SD, Guinn CH, Royer JA, Hardin JW, Mackelprang AJ, Smith AF. Accuracy of children's school-breakfast reports and school-lunch reports (in 24-h dietary recalls) differs by retention interval. *Eur J Clin Nutr.* 2009;63(12):1394-403.
18. Baxter SD, Hardin JW, Guinn CH, Royer JA, Mackelprang AJ, Smith AF. Fourth-grade children's dietary recall accuracy is influenced by retention interval (target period and interview time). *J Am Diet Assoc.* 2009;109(5):846-5.
19. Baxter SD, Hardin JW, Royer JA, Smith AF, Guinn CH. Sources of intrusions in children's dietary recalls from a validation study of order prompts. *J Health Psychol.* 2008;13(8):1157-62.
20. Eck LH, Klesges RC, Hanson CL. Recall of a child's intake from one meal: Are parents accurate? -*Journal of the American Dietetic Association.* 1989;89(6):784.
21. Baxter SD, Thompson WO, Litaker MS, Frye FH, Guinn CH. Low accuracy and low consistency of fourth-graders' school breakfast and school lunch recalls. *J Am Diet Assoc.* 2002 03;102(3):386-95.
22. Armstrong AM, MacDonald A, Booth IW, Platts RG, Knibb RC, Booth DA. Errors in memory for dietary intake and their reduction. *Applied Cognitive Psychology.* 2000;14(2):183-91.
23. Baxter SD, Hardin JW, Smith AF, Royer JA, Guinn CH, Mackelprang AJ. Twenty-four hour dietary recalls by fourth-grade children were not influenced by observations of school meals. *J Clin Epidemiol.* 2009 08;62(8):878-85.
24. Matheson DM, Hanson KA, McDonald TE, Robinson TN. Validity of children's food portion estimates: A comparison of 2 measurement aids. *Arch Pediatr Adolesc Med.* 2002 09;156(9):867-71.
25. Warren JM, Henry CJ, Livingstone MB, Lightowler HJ, Bradshaw SM, Perwaiz S. How well do children aged 5-7 years recall food eaten at school lunch? *Public Health Nutr.* 2003 02;6(1):41-7.
26. Contento IR, Randell JS, Basch CE. Review and analysis of evaluation measures used in nutrition education intervention research. *J Nutr Educ Behav.* 2002 01;34(1):2-25.

27. Livingstone MB, Robson PJ. Measurement of dietary intake in children. *Proc Nutr Soc.* 2000 05;59(2):279-93.
28. McPherson RS, Hoelscher DM, Alexander M, Scanlon KS, Serdula MK. Dietary assessment methods among school-aged children: Validity and reliability. *Prev Med.* 2000;31:11-33.
29. Paxton A, Baxter SD, Fleming P, Ammerman A. Validation of the school lunch recall questionnaire to capture school lunch intake of third- to fifth-grade students. *J Am Diet Assoc.* 2011;111(3):419-24.
30. Baxter SD, Thompson WO, Davis HC, Johnson MH. 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.* 1997 11;97(11):1293-8.
31. Simons-Morton BG, Forthofer R, Huang IW, Baranowski T, Reed DB, Fleishman R. Reliability of direct observation of schoolchildren's consumption of bag lunches. *J Am Diet Assoc.* 1992;92(2):219-21.
32. Swanson M. Digital photography as a tool to measure school cafeteria consumption. *J Sch Health.* 2008 08;78(8):432-7.
33. Boushey CJ, Kerr DA, Wright J, Lutes KD, Ebert DS, Delp EJ. Use of technology in children's dietary assessment. *Eur J Clin Nutr.* 2009 02;63 Suppl 1:S50-7.
34. Subar AF, Crafts J, Zimmerman TP, Wilson M, Mittl B, Islam NG, et al. 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.* 2010 01;110(1):55-64.
35. Pedersen AN, Fagt S, Groth MV, Christensen T, Biltoft-Jensen A, Matthiessen J, et al. *Danskernes kostvaner 2003-2008: Hovedresultater.* [dietary habits in denmark 2003-2008. main results]. 1 udgave ed. Pedersen AN, editor. Copenhagen, Denmark: National Food Institute, Technical University of Denmark; 2010.
36. Fagt S, Christensen T, Groth MV, Biltoft-Jensen A, Matthiessen J, Trolle E. *Børn og unges måltidsvaner 2000-2004.* [children and adolescents' dietary habits 2000-2004]. Copenhagen, Denmark: National Food Institute, Technical University of Denmark; 2007.
37. Sanigorski AM, Bell AC, Kremer PJ, Swinburn BA. Lunchbox contents of australian school children: Room for improvement. *Eur J Clin Nutr.* 2005 11;59(11):1310-6.
38. Baxter SD, Thompson WO, Davis HC. Prompting methods affect the accuracy of children's school lunch recalls. *J Am Diet Assoc.* 2000 08;100(8):911-8.
39. Baranowski T, Baxter SD. A cognitive model of children's reporting of food intake. *Am J Clin Nutr AM J CLIN N AM J CLIN NUTR AMER J CLIN NUTR.* 1994;59(1):S212-7.

40. Martin CK, Han H, Coulon SM, Allen HR, Champagne CM, Anton SD. A novel method to remotely measure food intake of free-living individuals in real time: The remote food photography method. *Br J Nutr.* 2009 02;101(3):446-5.

Table 1. Characteristics of the study population (n=114).

	Girls (n=65)		Boys (n=49)		p-value*
	Mean	SE	Mean	SE	
Age (years)	11.1	0.35	11.1	0.39	0.40
Height (m)	1.51	0.01	1.51	0.01	0.83
Weight (kg)	40.4	1.00	44.0	1.19	0.09
BMI (kg/m ²)	17.7	0.29	19.0	0.38	0.07

*Two sample t-test for difference in mean

Table 2. Number of food items obtained by digital images (DI) and self-reported recall methods: Questionnaire Open-Ended recall (OE-Q), Questionnaire Pre-Coded recall (PC-Q), and Interviews (INT). Packed lunch consumption in 11-year-old children (N=114) (mean and standard error (SE)).

Method	Girls (n=65)		Boys (n=49)		P-value [†]
	Mean	SE	Mean	SE	
DI	5.4 ^a	0.25	4.6 ^a	0.30	0.05
OE-Q	4.2 ^b	0.22	3.3 ^b	0.22	0.005
PC-Q	5.6 ^a	0.29	5.1 ^a	0.30	0.29
INT	5.6 ^a	0.24	5.1 ^a	0.25	0.06

[†] Kruskal-Wallis test for gender difference.

Different superscript letters a-b in each column show significantly different rates ($p < 0.001$) when comparing self-reported recall methods with DI. Matched t-test.

Table 3. Match rates and intrusion rates by three self-reported recall methods: Questionnaire Open-Ended recall (OE-Q), Questionnaire Pre-Coded recall (PC-Q), and Interviews (INT). Packed lunch consumption in 11-year-old children (N=114) (mean and standard error (SE)).

Rates (%)	Self-reported recall method	Girls (n=65)		Boys (n=49)		P-value [§]
		Mean [‡]	SE	Mean [‡]	SE	
Match rate [*]	OE-Q	70.8 ^b	2.85	65.4 ^b	3.96	0.24
	PC-Q	73.8 ^b	2.83	71.5 ^b	3.70	0.62
	INT	89.7 ^a	1.95	84.4 ^a	2.40	0.04
Intrusion rate [†]	OE-Q	11.8 ^d	2.14	12.8 ^e	2.51	0.70
	PC-Q	27.2 ^e	2.86	35.9 ^e	3.76	0.09
	INT	14.6 ^d	2.17	23.3 ^d	3.41	0.05

*Match rate = $\sum \text{matches} / (\sum \text{matches} + \sum \text{omissions}) \times 100$.

† Intrusion rate = $\sum \text{intrusions} / (\sum \text{matches} + \sum \text{intrusions}) \times 100$.

Kruskal-Wallis test for gender difference.

Match rate and intrusion rate: Different superscript letters a-c in each column show significantly different ($p < 0.01$) rates when comparing self-reported recall methods. Matched t-test.

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Author contributions: All authors contributed to the study concept and design. NL carried out the data collection and MD contributed to the statistical analysis of data. All co-authors contributed to the interpretation of data. NL wrote the first draft of the manuscript and all authors provided critical feed-back and approved the final manuscript.

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Characteristics of intrusions in the reporting of packed lunch consumption by 11-year-old children: A cross-sectional dietary recall validation study from Copenhagen,

5 **Denmark**

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Abstract

Background

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Methodological improvements of methods that rely on self-report are warranted, since food consumption during school hours takes place relatively unsupervised. The study of recall accuracy in relation to packed lunch which is the dominant lunch format in many countries including Denmark is understudied. The objectives of the present study were 1) to assess intrusion rates in self-reported consumption of packed lunch in relation to objective measurements of food served and food consumed and 2) to categorize intrusions by food group.

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Materials and methods

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This cross-sectional study was conducted with 114 11-year-old 5th grade students from 3 public schools in Copenhagen (mean age (SE) =11.1 (0.36). The self-reported recall method (Lunch Recall Questionnaire, LQR) comprised an open-ended self-report (OE-Q) and a pre-coded self-report (PC-Q) that were validated against objective measures of food served and food consumed obtained by digital images.

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Intrusions (food items reported but not verified by the reference) were classified and intrusion rates (% reported but not verified by the reference) were calculated against objective measures of food served and food consumed. Intrusion rates were stratified by food group and intrusions were categorized as stretches and confabulations.

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Differences in intrusion rates for food served and food consumed and differences in distribution between stretches and confabulations for recalls obtained by OE-Q and PC-Q were tested with matched t-tests.

Results

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PC-Q resulted in significantly higher intrusion rates for food served (10.1 vs. 27.9; $p < 0.0001$) and food consumed (12.2 vs. 30.9; $p < 0.0001$) compared to OE-Q, Recalls from PC-Q were more accurate for food served vs. food consumed (27.9 vs. 30.9; $p = 0.02$) Categorization of intrusions in stretches and confabulations revealed that the majority of intrusions were confabulations (OE-Q: 84%, PC-Q: 73%). Stratification of food groups showed that fat spreads and snacks contributed substantially to the high intrusion rates.

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Conclusions

60 Intrusion rate were higher for self-reported consumption obtained with the pre-coded part (PC-Q) of the LRQ compared with the open-ended part (OE-Q) among 11-year old children. Self-reports validated against food served were more accurate than self-reports of what they actually consumed. Intrusions from snacks and fat spreads contributed substantially to the intrusion rates. The majority of intrusions were confabulations and further investigation of the origins of confabulations is needed to improve accuracy of public health nutrition methodologies of school hour consumption.

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Keywords

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Recall validation, intrusion rate, stretches, confabulations, packed lunch, school children

Background

75 From a nutritional and health perspective there is a need to develop accurate self-
reported methods to assess what children in the general population consume during
school hours since lunch and snacking occasions during school hours constitute 25-
35% of children's daily energy intake (1) and dietary intake has previously been
shown to track from childhood to adolescence and young adulthood (2-6). School
80 hour consumption takes place relatively unsupervised without the presence of parents
or other caretakers and consequently recalls obtained from the children are pertinent
(7, 8).

Most of the existing dietary recall validation studies have been conducted in relation
85 to school meals and data about actual consumption has primarily been obtained by
interviews and recalls have been validated against observation (9, 10). It has been
shown previously that visualization is the most commonly used recall strategies used
by adults (11) and visual imagery has been pointed out as a frequently used strategy
among children (12).

90 In relation to portion size validations among children it has been shown that children
recalled what they were served with higher accuracy compared with what they
consumed (13). The distinction between recalls of food served and food consumed has
been subjected to important conceptual advances in the attempt to describe intrusions
95 according to their origin (7, 14). Intrusions can be divided in two categories a)
stretches and confabulations. Stretches are food items that have been served, not
observed to be consumed, but reported consumed. Confabulations are food items that

have *not* been served, not observed consumed but reported consumed by the child (14).

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Advances from small scale validation studies to larger study populations require methodological considerations. Twenty-four hour dietary recall interviews are extensive and costly (15) and weighed intake poses a high level of respondent strain (16). Alternatively, dietary reporting through questionnaires may be a viable option in school context (8). Ensuring construct validity of questionnaire items and clear prompting is crucial, and an elaborated analysis of the intrusions can contribute to future constructions of questionnaires. Explorative results among Danish 11-year-old school children showed that a pre-coded food group prompted questionnaire recall resulted in high intrusion rates (Lyng, 2012 submitted).

110

The methodological question of school children's ability to recall packed lunch is relatively unexplored despite the wide distribution of the lunch format in UK (17), Australia (18-20), USA (21) and Denmark (22). Little is known about the characteristics of the intrusions identified in children in relation to packed lunch and

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to our knowledge the food level that the children recall has not been assessed and neither has the question as to whether they report what they are served or what they have consumed. We hypothesized that children's food level recalls were more accurate for food served compared to food consumed and that the qualitative accuracy of recalls i.e. accuracy at the food level (23) would be unevenly distributed across

120

food groups in recalls of packed lunch consumption.

Objective

The objectives were 1) to assess intrusion rates in self-reported consumption of packed lunch in relation to objective measures of food served and food consumed and
125 2) to characterize intrusions by food groups.

Methods

Setting and design

130 The study was a cross-sectional dietary recall validation study with 114 Danish 11-year-old 5th grade students from three public schools in Copenhagen (mean age (SE) = 11.1 (0.01)). The setting and design of the study have been reported earlier as described by Lyng et al. (2012, submitted). In brief, pre-meal and post-meal digital images (DI) were included as objective measures of food served and food consumed
135 and self-reported lunch consumption was collected immediately after the lunch break using a Lunch Recall Questionnaire (LRQ) developed for the purpose. The LRQ consisted of an open-ended (OE-Q) and a pre-coded recall (PC-Q). Parents were informed in writing and children gave their consent on the day of the data collection. The project was approved by the Danish Data Protection Agency before initiation of
140 the study.

Methods

Digital images

Digital images (DI) were chosen as the objective reference method. The images
145 served to identify food items served and to assess the actual intake by comparison of a corresponding set of pre-meal and post-meal images. Participants were instructed to unpack their lunch and place it on a plate and the pre-meal image was taken prior to

consumption. In addition participants were instructed to raise the cold cuts and sandwich fillings before the image was taken to enable a subsequent identification of e.g. fat spreads. The post-meal image was taken following the consumption of the meal to identify objectively the foods not consumed. A Nikon Coolpix S210 camera with electronic VR stabilization and Motion Detection were used and images were taken using a Cubelite kit from Lastolite.

155 *Food based non-quantitative Lunch Recall Questionnaire (LRQ)*

A self-administered Lunch Recall Questionnaire (LRQ) was developed for the purpose and recalls were restricted to consumption at the food level. The LRQ was pre-tested in 50 11-year-old children in 5th grade from a school situated in the county of Copenhagen. The LRQ comprised two recall measures: an open-ended recall (OE-Q) where children were asked to write down everything they had consumed for lunch in random order and a non-quantitative pre-coded recall (PC-Q) where children were instructed to answer the pre-coded food and food subgroup recalls. The LRQ was administered in the class room and students completed them individually just after consumption or after the adjacent lunch break. Completion time ranged from 5-15 minutes mainly due to variation in students' food intake.

Anthropometrics

Height was obtained to nearest centimeter with a portable stadiometer (Soehnle 5003.01.001) and body weight in kilograms with 1 decimal (OBH Nordica, personal scale) by one of four members of the research team following the standard protocol by the Division of Nutrition (Fagt, 2012, personal communication).

Intake variables and assessment of accuracy

175 The food items recalled in the questionnaire were categorized into 6 food groups
(bread, fat spreads, cold cuts, fruits & nuts, vegetables, and snacks) containing a total
of 18 food items. Food items served were identified by Digital Images (DI) and actual
consumption was assessed by comparing the corresponding set of pre-meal and post-
meal images. Intrusion rates were estimated in two steps. First, all food items divided
180 into their corresponding food groups were identified as matches and intrusions by
comparing the objectively determined food items with the self-reported food items
served and food items consumed. These results were obtained for both the OE-Q and
the PC-Q.

185 A food item was defined as a *match* when the digital image showed that the food item
had been consumed and was reported consumed by the student. A food item was
defined as an *intrusion* if a food item did not appear on the digital image but the
student reported it in the recall. Second, intrusion rates for the OE-Q and PC-Q was
assessed by calculating intrusion rates in the following way:

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$$\text{Intrusion rate} = \frac{\sum \text{intrusions}}{(\sum \text{matches} + \sum \text{intrusions})} * 100.$$

Matches and intrusions were classified according to two objective measures: Food
served (Classification 1-3) and Food consumed (Classification 2-3) as shown in Table
1 (modified after Baxter et al. (12, 14)). The table shows that two types of intrusion
195 occurred: *stretches* (food items served, but not consumed according to the objective
measure, but reported by the child) and *confabulations* (food items not served, not
consumed but reported consumed by the child). Quantification of stretches and
confabulations was determined in two steps. Initially all students with at least one

intrusion was identified and subsequently, the difference in number of intrusions for
200 food served (stretches) was subtracted from intrusions from food consumed.

Statistics

Two sample t-test statistics for difference between genders were conducted for the
205 background variables age, height, weight and BMI. Matched t-tests were conducted to
compare the difference in mean intrusion rate between food served (Classification 1-
3) and food consumed (Classification 2-3) and self-reports obtained by OE-Q and PC-
Q. Comparison of proportions of stretches and confabulations were tested with
matched t-tests. Statistical analyses were conducted with SAS Enterprise Guide 4.3,
210 (SAS Institute Inc., North Carolina, USA).

Results

Table 2 shows that BMI for boys and girls were similar and the analyses were
215 therefore not stratified by BMI in the subsequent analyses. Intrusion rate for self-
reports obtained by OE-Q did not differ significantly between the two objective
measures of food served and food consumed ($p=0.21$) (Table 3). The intrusion rate for
PC-Q self-reports was significantly higher when recalls were assessed against food
consumed compared with food served ($p=0.02$). A comparison between the OE-Q and
220 PC-Q showed significantly higher intrusion rate for food served ($p<.0001$) and food
consumed ($p<.0001$) for PC-Q self-reports.

The proportion of children with at least one intrusion differed by recall method (Table 4). Forty-five of the children had at least one intrusion with OE-Q whereas the
225 proportion was substantially higher for recalls obtained with PC-Q where 88 had at least one intrusion. However, regardless of method the intrusions comprised mostly of confabulations.

Figure 1a and 1b show how intrusions were distributed across food groups. Intrusions
230 for recalls obtained by OE-Q (Figure 1a) show that particularly fat spreads and snacks contributed to the overall intrusion rate. The significantly higher intrusion rate for PC-Q is reflected in Figure 1b where intrusion rates for all food groups except bread is higher compared with Figure 1a.

235 **Discussion**

Main findings

This study provided insight to 11-year-old children's self-reported recalls of packed lunch obtained by a Lunch Recall Questionnaire (LRQ). Pre-coded self-reports (PC-
240 Q) resulted in significantly higher intrusion rates for food served and food consumed in comparison with open-ended self-reports (OE-Q), suggesting that children are inspired to report more food items when prompted.

Recalls from both PC-Q and OE-Q were more accurate for food served vs. food
245 consumed, although only statistically significant for PC-Q, which indicated that children recalled what they were served more accurately compared with what they actually consumed i.e. with a significantly lower mean intrusion rate. .

Stretches and confabulations

250 Categorization of intrusions in stretches and confabulations revealed that the vast majority of intrusions were confabulations which indicate that children recalled consumption of food items that were not captured by the digital images. Stratification of food groups showed that snacks and fat spreads contributed substantially to the high intrusion rates.

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The possibility that pre-lunch consumption may have occurred more for snacks than for the other food groups cannot be excluded. Parents have been shown to provide 'a treat' in lunch packages to make up for their perception that packed lunches could be uninspiring (24). If children also shared that perception, it would be reasonable to

260 assume that they would consume the treat before the food items less valued. Another explanation is that consumption must comply with children's daily routines and temporal structures of the school day (24) and snack items can easily be consumed during recess. In such case the children would recall the food item correctly but due to error in temporal dating their recalls would be classified as intrusions (14, 25).

265 Although not validated by images 37% of the children reported consumption during morning recess and snacks were in the top three food groups consumed along with fruits & nuts and vegetables.

Fat spreads and fatty condiments e.g. mayonnaise also contributed to the high
270 intrusion rate. Other studies have suggested that this food group is difficult to assess with direct observation (26) and particularly difficult for children to recall accurately (12, 27). The problem of estimating sources of dietary fat accurately is important

because previous studies have shown that this indicator of diet quality often differs between school meals and packed lunch (19, 20, 28, 29).

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Limitations and strengths

Only children who had a complete set of digital images, completed both questionnaire recalls, and from whom we had obtained anthropometric measures were included in the analytic sample. This procedure restricted the sample to 67% of the students present on the day of the data collection. It is possible that non-participants differed in either consumption pattern or ability to recall their intake as pointed out by Berg (30).

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The packed lunch consumption was validated with digital images and even though the children were instructed to have extra images taken in case of food trading we may not have been able to capture all trades (31) although other studies have shown that digital images can be used as an objective method to monitor lunch consumption (32). Further, the digital images may have served as a positive prompt because of the prevalent use of visualization as recall strategy (11, 27) and may have deflated intrusion rates compared with participants in non-validation studies.

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It has been argued that direct observation of packed lunch content is difficult (26) and consequently that the lunch format has been excluded from dietary recall validation studies conducted among school children (27). This study suggested that validation of packed lunch consumption was feasible with the digital image method and provided an alternative to direct observation as validation method.

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Implication for research

An important implication for future recall validation studies in relation to packed lunch is that the packed lunch format poses a range of additional challenges compared with school meals e.g. portions are not necessarily standard servings (33) and individual wraps and opaque containers may impede correct identification (26).

Further, the packed lunch is available throughout school hours and children can split the packed lunch in several eating occasions whereas school meals are only accessible for lunch. Field studies of children's eating practices during school hours e.g. on which occasions they eat from the packed lunch, what they eat and in which order and with whom can inform and improve self-reported methodologies to comply with the study of children's consumption in natural settings.

310 *Implication for practice*

A viable solution to overcome the problem of pre-lunch consumption in relation to packed lunch might be to assess school hour consumption instead of only studying the school lunch period. Pre-meal images of food served obtained early in the morning (19, 32) and post-meal images after lunch would capture school hour consumption.

315 Further, pre-meal images obtained in the morning would minimize the potential influence from visualization in recall validation studies.

Instead of regarding digital images as the validation method only, a mixed method approach in which digital images and questionnaires complement each other may be a feasible method to assess consumption of packed lunch. Self-reported food level recalls and researcher-driven portion size estimation (32) would overcome some of

the problems of inaccurate portion size estimations identified among school children by e.g. Guinn et al. (7).

Conclusions

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Pre-coded questionnaire self-reports resulted in significantly higher intrusion rates for food served and food consumed in comparison with open-ended questionnaire self-reports, suggesting that children are inspired to report more food items when reports of consumption are prompted. Self-reports were less inaccurate when compared to
330 food served vs. food consumed. Snacks and fat spreads contributed substantially to the high intrusion rates.

The vast majority of intrusions were confabulations indicating that children recalled consumption of food items that were not captured by the digital images. Minimizing the extent of intrusions is of utmost importance for further advances in self-reported
335 methodologies public health nutrition and this explorative study point to both conceptual and methodical improvements.

List of abbreviations

340 LRQ = Lunch Recall Questionnaire

DI = Digital images

OE-Q = Open-Ended Questionnaire self-report

PC-Q = Pre-Coded Questionnaire self-report

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Competing interests

The authors declare to have no conflict of interest.

350 **Authors' contributions**

All authors contributed to the study concept and design. NL carried out the data collection and MD contributed to the statistical analysis of data. All co-authors contributed to the interpretation of data. NL wrote the first draft of the manuscript
355 and all authors provided critical feed-back and approved the final manuscript.

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370 **References**

1. Biltoft-Jensen A, Ygil KY, Christensen LM, Christensen SM, Christensen T.
Forslag til retningslinjer for sund kost i skoler og institutioner. (Guidelines for healthy meals in schools and kindergartens). Copenhagen, Denmark: National Food Institute, Technical University of Denmark; 2005. Report No.: 14.
- 375 2. Fiorito LM, Marini M, Mitchell DC, Smiciklas-Wright H, Birch LL. Girls' early sweetened carbonated beverage intake predicts different patterns of beverage and nutrient intake across childhood and adolescence. *J Am Diet Assoc.* 2010;110(4):543-50.
3. Lien N, Lytle LA, Klepp KI. Stability in consumption of fruit, vegetables, and
380 sugary foods in a cohort from age 14 to age 21. *Prev Med.* 2001 09;33(3):217-26.
4. Cutler GJ, Flood A, Hannan P, Neumark-Sztainer D. Major patterns of dietary intake in adolescents and their stability over time. *J Nutr.* 2009 02;139(2):323-8.
5. Patterson E, Warnberg J, Kearney J, Sjostrom M. The tracking of dietary intakes of children and adolescents in sweden over six years: The european youth heart study.
385 *Int J Behav Nutr Phys Act.* 2009;6:91.
6. Lake AA, Mathers JC, Rugg-Gunn AJ, Adamson AJ. Longitudinal change in food habits between adolescence (11-12 years) and adulthood (32-33 years): The ASH30 study. *J Public Health (Oxf).* 2006 03;28(1):10-6.
7. Guinn CH, Baxter SD, Hardin JW, Royer JA, Smith AF. Intrusions in children's
390 dietary recalls: The roles of BMI, sex, race, interview protocol, and social desirability. *Obesity.* 2008;16(9):2169-74.

8. Paxton A, Baxter SD, Fleming P, Ammerman A. Validation of the school lunch recall questionnaire to capture school lunch intake of third- to fifth-grade students. *J Am Diet Assoc.* 2011;111(3):419-24.
- 395 9. Baxter SD, Smith AF, Guinn CH, Thompson WO, Litaker MS, Baglio ML, et al. Interview format influences the accuracy of children's dietary recalls validated with observations. *Nutr Res.* 2003 11;23(11):1537-46.
10. Weber JL, Lytle L, Gittelsohn J, Cunningham-Sabo L, Heller K, Anliker JA, et al. Validity of self-reported dietary intake at school meals by american indian children: 400 The pathways study. *J Am Diet Assoc.* 2004 05;104(5):746-52.
11. Chambers IV E, Godwin SL, Vecchio FA. Cognitive strategies for reporting portion sizes using dietary recall procedures. *J Am Diet Assoc.* 2000;100(8):891-7.
12. Domel SB, Thompson WO, Baranowski T, Smith AF. How children remember what they have eaten. *J Am Diet Assoc.* 1994 11;94(11):1267-72.
- 405 13. Foster E, Adamson AJ, Anderson AS, Barton KL, Wrieden WL. Estimation of portion size in children's dietary assessment: Lessons learnt. *Eur J Clin Nutr.* 2009 02;63 Suppl 1:S45-9.
14. Baxter SD, Hardin JW, Royer JA, Guinn CH, Smith AF. Insight into the origins of intrusions (reports of uneaten food items) in children's dietary recalls, based on data 410 from a validation study of reporting accuracy over multiple recalls and school foodservice production records. *J Am Diet Assoc.* 2008;108(8):1305-14.

15. Moore GF, Tapper K, Moore L, Murphy S. Cognitive, behavioral, and social factors are associated with bias in dietary questionnaire self-reports by schoolchildren aged 9 to 11 years. *J Am Diet Assoc.* 2008 11;108(11):1865-73.
- 415 16. Macdiarmid J, Blundell J. Assessing dietary intake: Who, what and why of under-reporting. *Nutr Res Rev.* 1998 12;11(2):231-53.
17. Evans CE, Cleghorn CL, Greenwood DC, Cade JE. A comparison of british school meals and packed lunches from 1990 to 2007: Meta-analysis by lunch type. *Br J Nutr.* 2010 08;104(4):474-87.
- 420 18. Miles CL, Matthews J, Brennan L, Mitchell S. Changes in the content of children's school lunches across the school week. *Health Promot J Austr.* 2010 12;21(3):196-201.
19. Sanigorski AM, Bell AC, Kremer PJ, Swinburn BA. Lunchbox contents of australian school children: Room for improvement. *Eur J Clin Nutr.* 2005 425 11;59(11):1310-6.
20. Rees GA, Richards CJ, Gregory J. Food and nutrient intakes of primary school children: A comparison of school meals and packed lunches. *J Hum Nutr Diet.* 2008 10;21(1365-277; 5):420-7.
21. Condon EM, Crepinsek MK, Fox MK. School meals: Types of foods offered to 430 and consumed by children at lunch and breakfast. *J Am Diet Assoc.* 2009 02;109(2):S67-78.
22. Fagt S, Christensen T, Groth MV, Biloft-Jensen A, Matthiessen J, Trolle E. Børn og unges måltidsvaner 2000-2004. (Children and adolescents' dietary habits 2000-

- 2004). Copenhagen, Denmark: National Food Institute, Technical University of
435 Denmark; 2007.
23. Eck LH, Klesges RC, Hanson CL. Recall of a child's intake from one meal: Are
parents accurate? -Journal of the American Dietetic Association. 1989;89(6):784.
24. Christensen PH. Børn, mad og daglige rutiner (Children, food and daily routines).
Barn. 2003;2-3:119-35.
- 440 25. Smith AF, Jobe JB, Mingay DJ. Retrieval from memory of dietary information.
Applied Cognitive Psychology. 1991;5:269-96.
26. Simons-Morton BG, Forthofer R, Huang IW, Baranowski T, Reed DB, Fleishman
R. Reliability of direct observation of schoolchildren's consumption of bag lunches. J
Am Diet Assoc. 1992;92(2):219-21.
- 445 27. Domel SB. Self-reports of diet: How children remember what they have eaten.
Am J Clin Nutr. 1997;65(4 SUPPL.):1148S-52.
28. Sabinsky M, Toft U, Andersen K, Mikkelsen B, Tetens I. Ernæringsmæssig
evaluering af skolemads betydning for eleveres kostindtag til frokost. (Nutritional
evaluation of the impact of school lunches on the dietary quality of school children's
450 lunch). Ballerup: Aalborg Universitet; 2010. Report No.: 2.
29. Evans CE, Greenwood DC, Thomas JD, Cade JE. A cross-sectional survey of
children's packed lunches in the UK: Food- and nutrient-based results. J Epidemiol
Community Health. 2010 11;64(0143-005; 11):977-83.

30. Berg C, Jonsson I, Conner MT, Lissner L. Sources of bias in a dietary survey of
455 children. *Eur J Clin Nutr.* 1998 09;52(9):663-7.

31. Baxter SD, Thompson WO, Litaker MS, Frye FH, Guinn CH. Low accuracy and
low consistency of fourth-graders' school breakfast and school lunch recalls. *J Am
Diet Assoc.* 2002 03;102(3):386-95.

32. Martin CK, Han H, Coulon SM, Allen HR, Champagne CM, Anton SD. A novel
460 method to remotely measure food intake of free-living individuals in real time: The
remote food photography method. *Br J Nutr.* 2009 02;101(3):446-5.

33. Frank GC. Taking a bite out of eating behavior: Food records and food recalls of
children. *J Sch Health.* 1991 05;61(5):198-200.

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Figure legends

Figure 1a: Intrusion rate for recalls obtained by Open-Ended Questionnaire self-
470 reports (OE-Q) assessed against digital images of Food served (Served) and Food
consumed (Consumed) stratified by food group (n=45).

Figure 1b: Intrusion rates for recalls obtained by Pre-Coded Questionnaire self-reports
(PC-Q) assessed against digital images of Food served (Served) and Food consumed
475 (Consumed) stratified by food group (n=88).

Tables

Table1. Classification table of food items served, consumed, and reported

(Modified after Baxter, 1997; Baxter et al., 2008)

Food items			Classification of accuracy	
Served [*]	Consumed [†]	Reported [‡]	Food served [§]	Food consumed
(1)	(2)	(3)	(1) - (3)	(2) - (3)
+	+	+	Match	Match
+	-	+	Match	Stretch [#]
-	-	+	Confabulation [□]	Confabulation [□]

^{*} Food items served as determined by the pre-meal image.

[†] Food items consumed based on the difference between pre-meal and post-meal images.

[‡] Food items reported consumed in the self-reported recall.

[§] Classification of accuracy between food items served and reported.

^{||} Classification of accuracy between food items consumed and reported.

[#] Stretch = food item served, not consumed but reported consumed (intrusion).

[□] Confabulation = food item not served and not consumed but reported consumed (intrusion).

Table 2. Characteristics of the study population (n=114).

	Girls (n=65)		Boys (n=49)		P-value *
	Mean	SE	Mean	SE	
Age (years)	11.1	0.35	11.1	0.39	0.40
Height (m)	1.51	0.01	1.51	0.01	0.83
Weight (kg)	40.4	1.00	44.0	1.19	0.09
BMI (kg/m ²)	17.7	0.29	19.0	0.38	0.07

*Two sample t-test for difference in mean.

Table 3. Intrusion rates (%) for recalls obtained by the Open-Ended recall (OE-Q) and Pre-Coded recall (PC-Q) assessed against objective measures of food served and food consumed among Danish 11-year-old children (n=114).

Recall method	Intrusion rate (%)				
	Food served		Food consumed		P-value *
	Mean	SE	Mean	SE	
OE-Q	10.1 ^b	1.46	12.2 ^b	1.62	0.21
PC-Q	27.9 ^a	2.20	30.9 ^a	2.32	0.02

480 * Paired t-test for difference in mean intrusion rate for Food served and Food consumed.

Different superscript letters a-b in each column show significantly different rates (p<.0001) when comparing OE-Q with PC-Q. Matched t-test.

485 **Table 4. The proportion of children with at least one intrusion for recalls obtained by the Open-Ended (OE-Q) questionnaire self-report and Pre-Coded questionnaire self-report (PC-Q) assessed against objective measures of food served and food consumed among Danish 11-year-old children (N=114), and the distribution of intrusions into stretches and confabulations.**

	Intrusions	Stretches	Confabulations
Recall method			
OE-Q	40%	16%	84%
PC-Q	77%	27%	73%

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Accuracy of 11-year-olds reporting of packed lunch and school meal consumption

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Keywords: Packed lunch, school meals, reporting accuracy, omission rate, intrusion rate

Running head: School lunch report accuracy by lunch format

Objective: To compare the accuracy of 11-year-old children's reports of packed lunch and school meal consumption by assessing match rates, omission rates and intrusion rates.

Design: Cross-sectional dietary reporting study. Consumption of packed lunch and school meals was obtained by a non-quantitative questionnaire including an Open-Ended part (OE-Q) and a Pre-Coded part (PC-Q). Accuracy of self-reports was assessed against an objective reference of consumption obtained by digital images (DI). Accuracy measures included match rates (% reported consumed and verified by DI), omission rates (% not reported but consumed according to DI) and intrusion rates (% reported consumed but not verified by DI).

Setting: Three Danish public schools in Copenhagen, Denmark.

Subjects: 127 11-year-old children in 5th grade mean (SE) age = 11.1 (0.03) and BMI = 18.2 (0.26).

Results: Self-reports obtained with OE-Q were significantly lower compared with the DI and PC-Q reports were only lower for school meals. A small yet significant difference was seen in actual consumption including 3.8 food groups in packed lunches compared with 3.5 food groups in school meals ($p=0.001$). PC-Q self-reports differed in accuracy by lunch format and match rate for packed lunch was 88.5% compared with 55.4% for school meals. Intrusion rates were lower in both lunch formats when obtained with OE-Q compared with PC-Q.

Conclusions: OE-Q measured school meal consumption more accurately and PC-Q measured packed lunch more accurately. Inclusion of digital images enabled a description of the relation between food served, food reported and food consumed in natural settings.

Introduction

Dietary intake has been shown to track from childhood to adolescence and to early adulthood in terms of both frequency⁽¹⁻³⁾ and amount^(4,5). School hour consumption constitutes approximately one third of school children's daily energy intake⁽⁶⁾ and consequently children's school hour consumption is of public health and nutritional importance. School meal provision has been accentuated as a means of promoting healthy eating habits^(7,8) and literature shows that nutritional profiles in school meals are healthier compared to packed lunch in several diet quality indicators e.g. fat or added sugar⁽⁹⁻¹³⁾. However, in several countries including Denmark packed lunch is the prevalent lunch format^(10,11,14,15).

Dietary recall validation studies with children have predominantly been conducted in the USA where school meals are the prevalent lunch format⁽¹⁶⁾. Dietary intake is collected with 24h recalls in the School Nutrition Dietary Assessment study which is one of the largest sources of information about school lunch consumption in the USA^(16,17). Existing research about recall accuracy in child populations has primarily focused on school meals.

School lunch consumption takes place relatively unsupervised and the development of valid self-reported methods is warranted⁽¹⁸⁾. The 24h recall method which is frequently applied in the American context of school lunch consumption^(16,19) is relatively time-consuming for the investigators and the informants and instead questionnaires may be a viable alternative method as they enable data collection from a larger population⁽¹⁸⁾. Direct observations have often been chosen as validation methods in relation to school meals⁽²⁰⁾ but the observation method is difficult to apply with packed lunch because portions are not necessarily standard servings⁽²¹⁾ and may be kept in containers which puts a high strain on the observers⁽²²⁾. Recently, the application of methods that rely on digital images has shown its value as an objective means of measuring lunch consumption among school children objectively^(13,23,24).

Little is known about how accurately children report packed lunch consumption despite the high prevalence and consistent evidence of the nutritional benefits of school meals. Denmark constitutes a setting because of the prevalence of packed lunches and to a lesser degree school meals. The methodological challenges of measuring consumption in natural settings are to develop methods

that are both applicable in larger populations and measure intake at a nutritional relevant level. The methodological aspects of assessing packed lunch and school meal consumption are understudied.

The objective of this study was to compare the accuracy of 11-year-old children's reports of packed lunch and school meal consumption by assessing match rates, omission rates and intrusion rates. Accuracy was expressed as match rates (% reported consumed and verified by DI), omission rates (% not reported but consumed according to the DI) and intrusion rates (% reported consumed but not verified according to DI).

Material and methods

The study was a cross sectional dietary reporting study with Danish 5th grade students (11-year-olds) from three public schools in Copenhagen. We obtained complete data from 127 of the 205 invited students. Recruitment of schools was based on the Children and Youth Administration, Municipality of Copenhagen's identification of schools with the highest participation rate in the School Lunch Scheme EAT among 5th grade students as a means of ensuring that children had some prior experiences with the food offered. The concept of EAT concurs with national dietary guidelines and is informed by ten guiding principles e.g. that 75% of food offered should be organic and that menus should reflect seasonal variations ⁽²⁵⁾. Packed lunch and school meals were assessed on consecutive days. On the first day packed lunch brought from home was consumed and on the second day the children were offered a free school meal of their own choice from EAT.

The study was conducted according to the guidelines laid down in the Declaration of Helsinki and the study was approved by the Danish Data Protection Agency. Parents and children were informed in writing and children were additionally informed verbally. In this study double consent was sought. Parents were asked to opt out by completing the written consent form enclosed in the information leaflet if they did not want that their child participated in the study. Each child was asked to give their assent orally before the study was initiated. All parents and children could at all times withdraw from the study without providing any reason. According to the Danish National Committee on Health Research Ethics, studies with no intervention and with no invasive treatment, like the present study, in which only diet was recorded, do not require ethical approval.

Self-reported consumption was obtained with a self-administered non-quantitative Lunch Recall Questionnaire (LRQ) and reporting accuracy was determined by comparing self-reports with an objective reference of consumption obtained by digital images as previously described ⁽²⁶⁾.

Digital images

Digital images served to identify food groups and assess actual intake by comparison of a corresponding set of pre-meal and post-meal images using a validated standard protocol (29). Nikon Coolpix S210 with electronic VR stabilization and Motion Detection were used and images were taken using a Cubelite kit from Lastolite.

Food based Lunch Recall Questionnaire

The lunch recall questionnaire (LRQ) contained the following two reporting measures: a random order, open-ended part (OE-Q) where students were instructed to write down everything they had consumed for lunch and a pre-coded part (PC-Q) in which recalls were prompted by pre-coded food groups. The LRQ was administered in the class room and students completed them individually immediately after consumption or after the adjacent lunch break. Completion time ranged from 5-15 minutes and variation in completion time was mainly due to variation in students' food intake.

Anthropometrics

Students' height was measured and weighed after completion of the self-reported methods by a member of the research team. Height was measured to nearest centimeter with a portable stadiometer (Soehnle 5003.01.001) and weight was measured in kilograms with 1 decimal (OBH Nordica, personal scale) following Division of Nutrition's standard protocol (Fagt, 2012 personal communication).

Intake variables and assessment of reporting accuracy

Food groups obtained by Digital Images (DI), Questionnaire Open-Ended recall (OE-Q), and Questionnaire Pre-Coded recall (PC-Q) were identified and characterized according to six pre-determined food groups that reflected the typical food groups consumed by Danish school children (14, 27). The selected food groups were: bread/starch, cold cut/meat/alternative protein source, fat spread/fatty condiment, vegetables, fruits & nuts, snacks. Reporting accuracy was expressed in terms of match rates, omission rates and intrusion rates and estimated in two steps. First, all food groups were identified as matches, omissions, and intrusions by comparing the objectively determined food groups with the self-reported consumption by the OE-Q and PC-Q. A food group was defined as a ***match*** if the image showed that the food group had been consumed and was reported consumed by the student. A food group was defined as an ***omission*** if the food group

appearing on the digital image was not reported by the student, and finally, a food group was defined as an *intrusion* if a food group did not appear on the digital image but the student reported it in the recall. Secondly, accuracy for the OE-Q and PC-Q was assessed by calculating match rates, omission rates and intrusion rates:

$$\text{Match rate} = \frac{\sum \text{matches}}{(\sum \text{matches} + \sum \text{omissions})} * 100.$$

$$\text{Omission rate} = \frac{\sum \text{omissions}}{(\sum \text{matches} + \sum \text{omissions})} * 100.$$

$$\text{Intrusion rate} = \frac{\sum \text{intrusions}}{(\sum \text{matches} + \sum \text{intrusions})} * 100.$$

Statistics

Characteristics of the study population were stratified by gender and presented as means and standard errors of the mean (SE). Number of food groups consumed obtained by the objective reference and the self-reported measures was stratified by lunch format statistics. Paired t-tests were conducted to compare accuracy and inaccuracy measures of self-reported consumption by lunch formats and recall methods. Statistical analyses were conducted with SAS (version 9.3 for windows, SAS Institute Inc., Cary, NC, USA).

Results

The characteristics of the 127 11-year-old children included in the analyses from which complete data about packed lunch and school meal consumption and anthropometrics were collected are shown in Table 1. No significant difference was found in anthropometric characteristics by gender.

Table 2 shows the mean number of food groups consumed as determined by the objective reference (DI) and self-reported measures. A comparison of the mean number of food items reported compared with the digital images showed that self-reported consumption of packed lunch and school lunch obtained by OE-Q included reports of significantly fewer food groups compared with the mean number of food groups consumed as determined by the digital images. PC-Q only differed from the digital images in school meal recalls. The mean number of food groups served did not differ significantly between lunch formats. Actual consumption differed and packed lunch consumption was significantly more diverse (3.8 food groups) compared with school meal consumption (3.5 food groups) ($p=0.001$).

A comparison of match rates by lunch formats showed that match rates for PC-Q self-reports of packed lunch consumption (88.5%) were significantly more accurate than PC-Q self-report of

school meal consumption (50.4%) (Table3). There was a tendency that self-reports of packed lunches were more accurate compared with self-reports of school meals when obtained with OE-Q although the difference was not significant ($p=0.06$). Omission rates were higher for school meal reports but differed only with PC-Q ($p<0.0001$). Intrusion rates for actual consumption did not differ by lunch formats and ranged from 8-9% for OE-Q to 15-20% for PC-Q self-reports. Intrusion rates for self-reports obtained with OE-Q were significantly lower than PC-Q self-reports in both lunch formats.

Discussion:

Match rates for packed lunch reports obtained with the Pre-Coded part of the questionnaire (PC-Q) were high at the food group level and intrusion rates were relatively low. The accuracy of school meal consumption obtained by PC-Q was poor and only half of the food groups consumed were accurately reported. Match rates obtained with the Open-Ended part of the questionnaire was lower for packed lunch consumption compared with self-reports obtained by PC-Q, but in terms of school meal consumption OE-Q was significantly higher than school meal reports obtained with PC-Q. Intrusion rates for OE-Q self-reports of both lunch formats were significantly lower than self-reports obtained with PC-Q. In addition, inclusion of the objective method revealed that packed lunch consumption was significantly more diverse in terms of number of food groups consumed compared with actual consumption of school meals although dietary diversity did not differ significantly between the lunch formats served.

The high match rate observed for PC-Q self-reports may be explained by the fact that in Denmark the majority of 11-year-old children consume packed lunch on school days and among the 92% of the study population that reported to eat lunch in the school every day, 77% reported to consume packed lunch every day (data not shown). A study conducted among 5-7-year-old children in UK suggested that a greater familiarity with packed lunches could explain the higher accuracy observed for packed lunch (match rates 70+/-29) compared with school meals (match rates 58 +/-27) ⁽²⁸⁾.

Children are not accustomed to describe dishes as separate food groups ⁽²⁹⁾ but by reporting the dish in their own words as they did with the Open-Ended part of the questionnaire (OE-Q) was more accurate and resulted in significantly higher match rates compared school meal reports obtained by PC-Q where approximately half of the food groups consumed were omitted.

The reporting accuracy was determined at the food group level as this level has been shown to be a feasible indicator of dietary diversity for a child population ⁽³⁰⁾. The American National School Lunch Program ⁽¹⁶⁾ operates with a menu planning tool in which standards for school meals must comply with food group level standards where meals should include milk, bread/starchy component, meat/alternative protein component, and two servings of fruit and vegetables. In the UK a cluster randomized trial to improve the content of packed lunches also focus on five elements; starch, protein, dairy, vegetables and fruit ⁽³¹⁾. Beverages were obtained on the digital images but excluded from the analyses for two reasons: Firstly, opaque drinking bottles or containers hindered identification of content and obstructed a subsequent assessment of reporting accuracy. Secondly, beverages are not included in the school meal programs in Denmark and milk can be purchased separately and contrary to the English and American context. However, the food group conceptualizing is in accordance with an initiative by The Danish Food and Veterinary Administration called “Give the packed lunch a hand” (my translation) ⁽³²⁾ that includes instructions on how to prepare a packed lunch. A healthy Danish packed lunch comprises; vegetables, bread preferably rye or whole grain, cold cut, fish and fruit.

From a previous study we expected that intrusion rates for packed lunch recalls would be higher compared with school meal reports because lunch packages are available throughout the school days enabling pre-lunch consumption ⁽²⁶⁾. An ethnographic field study from Denmark conducted with 3-16-year-old children has previously shown that children divided the content of the packed lunch in more than one eating occasions ⁽³³⁾. School meals, on the other hand, constitute a single meal and accessibility is restricted to the lunch break which would consequently deem pre-lunch consumption impracticable.

Our finding that packed lunch consumption contained a higher dietary diversity compared with school meals irrespective of the observed non-significant difference in food served indicated that plate waste from school meals was higher than for packed lunch. The extent of plate waste poses a nutritional challenge insofar that it impedes the beneficial effect of school meals. Plate waste has been shown to be closely related to children’s acceptance of food offered and food served ⁽³⁴⁾. Acceptance of food served differed across food groups and preparation method e.g. plate waste from whole pieces of fruit was higher than applesauce in a study among 6th graders in USA ⁽³⁴⁾. Further, a Swedish study with 4th, 8th and, 11th grade children showed that the children’s preferences for food combinations may be difficult to accommodate in school meals even though the children

liked the single components of the meal ⁽³⁵⁾. Children's preferences are easier to comply with in packed lunches where parents balance between offering children what they like, convenience and parents' normative perceptions of what a packed lunch should constitute ⁽³⁶⁾.

One hundred twenty seven children out of 205 were included in the analyses and inclusion required a complete set of digital images, that both the open-ended and the pre-coded part of the questionnaire were completed on both days. Further, inclusion was contingent on background information about gender and anthropometrics was available. It cannot be excluded that the strict inclusion criteria may have introduced selection bias in several ways.

The level of food based knowledge and interest in food related issues may have influenced the children's motivation to comply with data collection procedures and the accuracy of completed reports. In a Swedish dietary survey among 5th, 7th, and, 9th grade school children the number of food items reported decreased as a function of recording days ⁽³⁷⁾. Despite dissimilarities in study design a similar effect may have occurred as a function of data collection on two subsequent days. If the problem applied to the presents study then the lesser accuracy in school meal reports reflected the response strategy of satisficing in which respondents provide the least effort they consider acceptable instead of optimizing their responses ⁽³⁸⁾.

In the present study packed lunch consumption was always assessed before school meal consumption. This may be considered a methodological limitation of the design because then did not enable us to determine if the lower accuracy of school meal consumption was a result of data collection fatigue or an account of reporting difficulties with the less prevalent lunch format of school meals. The observed intrusion may also be explained by trading of foods between the children during lunch which have been observed among first and fourth grade students in a recall validations study in which fourth grade students traded foods more frequently compared with first grade student ⁽³⁹⁾. Although we were present during lunch we may not have been able to observe all trading in which case the traded food would not occur from the images.

The study was restricted to 5th grade students in a Danish context and the longstanding tradition of packed lunches including open sandwiches on rye bread may reduce the generalizability of the lunch format. However, the methodological concern of obtaining valid consumption data of both packed lunch and school meals is pertinent in all settings.

This study addressed the methodological challenge of obtaining accurate self-reported information about children's consumption of packed lunches and school meals with two different questionnaire measures. The study illustrated that different methods may be appropriate for assessing different lunch formats. Self-reports were assessed against digital images as the objective reference in this study which gave indications of which food groups were difficult to assess accurately with self-reports. Further, the digital images provided information about the close relation between food served, food consumed and food reported.

The finding that packed lunch consumption was more diverse compared with school meals warrants further exploration as a contribution to the overall assessment of the health promoting effect of school meal solutions. If the finding can be reproduced in other studies then strategies and interventions to improve the nutritional content of packed lunches may be a more cost-efficient structural means of promoting healthy eating habits in the school context.

Advances in the study of different lunch formats obtained with questionnaires are needed. The food group level reporting accuracy may be a feasible compromise between nutritional and public health considerations because dietary diversity can serve as a proxy of diet quality⁽³⁰⁾ and the level of reporting can be applied in larger settings. However, the specificity and sensitivity of future school lunch questionnaires need a thorough investigation to ensure that packed lunches and school meals can be measured with similar accuracy. Future studies that compare reporting accuracy of different lunch formats is needed as a means of assessing the health promoting effect of school meal provision in natural settings where inclusion of an objective is not feasible.

Conclusions

Self-reported school meal consumption among 11-year-old Danish school children was less accurate compared with self-reported packed lunch consumption when accuracy assessed as match rates, omission rates and intrusion rates at the food group level was obtained. Packed lunch self-reports were more accurate when obtained by the pre-coded part of the questionnaire (PC-Q) compared with an Open-Ended part of the questionnaire (OE-Q) whereas school meal self-reports were more accurate with the Open-Ended part of the questionnaire (OE-Q). Inclusion of the objective references obtained by digital images showed that despite similar diversity in the food groups served in the lunch formats, more food groups were consumed from lunch packages.

References

1. Fiorito LM, Marini M, Mitchell DC, Smiciklas-Wright H, Birch LL. Girls' early sweetened carbonated beverage intake predicts different patterns of beverage and nutrient intake across childhood and adolescence. *J Am Diet Assoc.* 2010;110(4):543-50.
2. Lien N, Lytle LA, Klepp KI. Stability in consumption of fruit, vegetables, and sugary foods in a cohort from age 14 to age 21. *Prev Med.* 2001 09;33(3):217-26.
3. Cutler GJ, Flood A, Hannan P, Neumark-Sztainer D. Major patterns of dietary intake in adolescents and their stability over time. *J Nutr.* 2009 02;139(2):323-8.
4. Lake AA, Mathers JC, Rugg-Gunn AJ, Adamson AJ. Longitudinal change in food habits between adolescence (11-12 years) and adulthood (32-33 years): The ASH30 study. *J Public Health (Oxf).* 2006 03;28(1):10-6.
5. Patterson E, Warnberg J, Kearney J, Sjostrom M. The tracking of dietary intakes of children and adolescents in sweden over six years: The european youth heart study. *Int J Behav Nutr Phys Act.* 2009;6:91.
6. Biltoft-Jensen A, Ygil KY, Christensen LM, Christensen SM, Christensen T. Forslag til retningslinjer for sund kost i skoler og institutioner. [guidelines for healthy meals in schools and kindergartens]. Copenhagen, Denmark: National Food Institute, Technical University of Denmark; 2005. Report No.: 14.
7. Story M, Kaphingst KM, French S. The role of schools in obesity prevention. *Future Child.* 2006;16(1):109-42.
8. Cohen DA, Scribner RA, Farley TA. A structural model of health behavior: A pragmatic approach to explain and influence health behaviors at the population level. *Prev Med.* 2000 02;30(2):146-54.
9. Rogers IS, Ness AR, Hebditch K, Jones LR, Emmett PM. Quality of food eaten in english primary schools: School dinners vs packed lunches. *Eur J Clin Nutr.* 2007 07;61(7):856-64.
10. Sanigorski AM, Bell AC, Kremer PJ, Swinburn BA. Lunchbox contents of australian school children: Room for improvement. *Eur J Clin Nutr.* 2005 11;59(11):1310-6.
11. Rees GA, Richards CJ, Gregory J. Food and nutrient intakes of primary school children: A comparison of school meals and packed lunches. *J Hum Nutr Diet.* 2008 10;21(1365-277; 5):420-7.
12. Evans CE, Cleghorn CL, Greenwood DC, Cade JE. A comparison of british school meals and packed lunches from 1990 to 2007: Meta-analysis by lunch type. *Br J Nutr.* 2010 08;104(4):474-87.
13. Martin CK, Han H, Coulon SM, Allen HR, Champagne CM, Anton SD. A novel method to remotely measure food intake of free-living individuals in real time: The remote food photography method. *Br J Nutr.* 2009 02;101(3):446-5.

14. Fagt S, Christensen T, Groth MV, Biloft-Jensen A, Matthiessen J, Trolle E. Børn og unges måltidsvaner 2000-2004. [children and adolescents' dietary habits 2000-2004]. Copenhagen, Denmark: National Food Institute, Technical University of Denmark; 2007.
15. Regan A, Parnell W, Gray A, Wilson N. New zealand children's dietary intakes during school hours. *Nutr Diet*. 2008;65(3):205-10.
16. Gordon AR, Cohen R, Crepinsek MK, Fox MK, Hall J, Zeidman E. The third school nutrition dietary assessment study: Background and study design. *J Am Diet Assoc*. 2009 02;109(2):S20-3.
17. Burghardt JA. School nutrition dietary assessment study: Overview of the study design. *Am J Clin Nutr*. 1995;61(1 SUPPL.):182S-6.
18. Paxton A, Baxter SD, Fleming P, Ammerman A. Validation of the school lunch recall questionnaire to capture school lunch intake of third- to fifth-grade students. *J Am Diet Assoc*. 2011;111(3):419-24.
19. Baxter SD. Cognitive processes in children's dietary recalls: Insight from methodological studies. *Eur J Clin Nutr*. 2009 02;63 Suppl 1:S19-32.
20. Baxter SD, Hardin JW, Smith AF, Royer JA, Guinn CH, Mackelprang AJ. Twenty-four hour dietary recalls by fourth-grade children were not influenced by observations of school meals. *J Clin Epidemiol*. 2009 08;62(8):878-85.
21. Frank GC. Taking a bite out of eating behavior: Food records and food recalls of children. *J Sch Health*. 1991 05;61(5):198-200.
22. Simons-Morton BG, Forthofer R, Huang IW, Baranowski T, Reed DB, Fleishman R. Reliability of direct observation of schoolchildren's consumption of bag lunches. *J Am Diet Assoc*. 1992;92(2):219-21.
23. Swanson M. Digital photography as a tool to measure school cafeteria consumption. *J Sch Health*. 2008 08;78(8):432-7.
24. Sabinsky M, Toft U, Andersen K, Mikkelsen B, Tetens I. Ernæringsmæssig evaluering af skolemads betydning for eleveres kostindtag til frokost. [nutritional evaluation of the impact of school lunches on the dietary quality of school children's lunch]. Ballerup: Aalborg Universitet; 2010.
25. EAT [Internet].; 2012. Available from: <http://www.kk.dk/sitecore/content/Subsites/EAT/SubsiteFrontpage.aspx>.
26. Lyng N, Fagt S, Davidsen M, Hoppe C, Holstein BE, Tetens I. Recall accuracy in 11-year-old children's self-reported consumption of school lunch [submitted, 2012]. In press 2012.
27. Hoppe C, Biloft-Jensen AP, Trolle E, Tetens I. Beskrivelse af 8- til 10-årige og 12- til 14-årige børns kost – med fokus på indtag i skole og fritidsordning. [description of 8-10-year-old and 12-14-year-old children's nutrition - with focus on intake in schools and after-school facilities]. 2009.

28. Warren JM, Henry CJ, Livingstone MB, Lightowler HJ, Bradshaw SM, Perwaiz S. How well do children aged 5-7 years recall food eaten at school lunch? *Public Health Nutr.* 2003 02;6(1):41-7.
29. Benzen ML, Nielsen MH. Skolemad med mere ... børn rapporterer [what impact does knowledge and cognitive abilities have on the recall accuracy in registrations of diets] [dissertation]. Faculty of Life Science, University of Copenhagen; 2010.
30. Steyn NP, Nel JH, Nantel G, Kennedy G, Labadarios D. Food variety and dietary diversity scores in children: Are they good indicators of dietary adequacy? *Public Health Nutr.* 2006 08;9(5):644-50.
31. Evans CE, Greenwood DC, Thomas JD, Cleghorn CL, Kitchen MS, Cade JE. SMART lunch box intervention to improve the food and nutrient content of children's packed lunches: UK wide cluster randomised controlled trial. *J Epidemiol Community Health.* 2010 11;64(0143-005; 11):970-6.
32. Gi' madpakken en hånd [give the packed lunch a hand] [Internet]. Available from: <http://www.foedevarestyrelsen.dk/Publikationer/Alle%20publikationer/2010208.pdf>.
33. Christensen PH. Børn, mad og daglige rutiner. [children, food and daily routines]. *Barn.* 2003;2-3:119-35.
34. Marlette MA, Templeton SB, Panemangalore M. Food type, food preparation, and competitive food purchases impact school lunch plate waste by sixth-grade students. *J Am Diet Assoc.* 2005 11;105(11):1779-82.
35. Ahlström R, Baird JC, Jonsson I. School children's preferences for food combinations. *Food Qual Preference.* 1990;2(3):155-6.
36. Bathgate K, Begley A. 'It's very hard to find what to put in the kid's lunch': What perth parents think about food for school lunch boxes. *Nutr Diet.* 2011;68(1):21-6.
37. Berg C, Jonsson I, Conner MT, Lissner L. Sources of bias in a dietary survey of children. *Eur J Clin Nutr.* 1998 09;52(9):663-7.
38. Krosnick JA. Response strategies for coping with the cognitive demands of attitude measures in surveys. *Applied Cognitive Psychology.* 1991;5:213-36.
39. Baxter SD, Thompson DR, Davis HC. Trading of food during school lunch by first- and fourth-grade children. *Nutr Res.* 2012;21:499-503.

Table1. Characteristics of the study population (N= 127)

	Girls (n=72)		Boys (n=55)		p-value*
	Mean	SEM	Mean	SEM	
Age, years	11.1	0.35	11.1	0.39	0.40
Height, m	1.50	0.01	1.51	0.01	0.61
Weight, kg	39.6	1.00	42.4	1.19	0.65
BMI, kg/m ²	17.4	0.29	18.5	0.38	0.24

*Two sample t-test for difference in mean.

Table 2. Average number of food groups obtained by digital images (DI) and self-reported recall methods: Questionnaire Open-Ended recall (OE-Q), Questionnaire Pre-Coded recall (PC-Q) in 11-year-old children by lunch format (N=127)

Method	Packed lunch		School meals		P-value [†]
	Mean*	SE	Mean*	SE	
DI	3.8 ^a	0.11	3.5 ^a	0.10	0.001
OE-Q	3.0 ^b	0.12	2.5 ^b	0.12	0.009
PC-Q	4.0 ^a	0.13	2.3 ^b	0.13	< 0.0001

[†] Paired t-test for differences between lunch format.

Different superscript letters a-c in each column show significantly different rates (p<0.01) when comparing self-reported recall methods. Paired t-tests.

Table 3. Match rates, omission rates and intrusion rates by self-reported recall methods: Questionnaire Open-Ended recall (OE-Q), Questionnaire Pre-Coded recall (PC-Q) in 11-year-old children by lunch format (N=127)

Rates (%)	Recall	Packed Lunch		School meal		P-value [‡]
		Mean	SE	Mean	SE	
Match rate [*]	OE-Q	74.4	2.78	67.2	3.03	0.06
	PC-Q	88.5	2.13	50.4	2.62	<.0001
P-value [§]		p<0.0001		p<0.0001		
Omission rate [*]	OE-Q	25.6	2.78	32.8	3.03	0.06
	PC-Q	11.5	2.13	49.6	2.62	<.0001
P-value [§]		P<0.0001		P<0.0001		
Intrusion rate [†]	OE-Q	8.2	2.00	9.0	1.95	0.78
	PC-Q	15.4	2.13	19.7	2.75	0.25
P-value [§]		p=0.004		p=0.0001		

* Omission rate = $\sum \text{omissions} / (\sum \text{matches} + \sum \text{omissions}) \times 100$.

† Intrusion rate = $\sum \text{intrusions} / (\sum \text{matches} + \sum \text{intrusions}) \times 100$.

‡ Paired t-test for difference in mean between packed lunch and school meals.

§ Paired t-test for difference in mean between self-reported recall measures OE-Q and PC-Q.

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