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Eating patterns and overweight in 9- to 10-year-old children in Telemark County, Norway: a cross-sectional study

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Background/Objectives: Increasing prevalence of overweight in children is a growing health problem. The aim of this study was to describe the eating patterns of 9- to 10-year-old schoolchildren, and to investigate the relationship between overweight and eating patterns.
Subjects/Methods: We recruited 1045 children for a cross-sectional study in Telemark County, Norway. The children's food, snacking and meal frequencies were reported by their parents using a retrospective food frequency questionnaire. Height and weight were measured by health professionals, and body mass index categories were calculated using international standard cutoff points (International Obesity Task Force values). Complete data were obtained for 924 children. Four distinct eating patterns were identified using principal component analysis. We used multiple logistic regression and calculated odds ratios (ORs) with 95% confidence intervals (CIs) for being overweight, and adjusted for parental characteristics and physical activity levels of the children (aORs).
Results: Parental characteristics and physical activity were associated with both obesity and eating patterns. Children adhering to a 'junk/convenient' eating pattern had a significantly lower likelihood of being overweight (aOR: 0.6; 95% CI: 0.4, 0.9), whereas children adhering to a 'varied Norwegian' or a 'dieting' eating pattern had a significantly higher likelihood of being overweight (respective values: aOR: 2.1; 95% CI: 1.3, 3.2; aOR: 2.2; 95% CI: 1.4, 3.4). No association with overweight was seen for a 'snacking pattern'.
Conclusions: The main finding was that, although family characteristics influenced both the prevalence of overweight and overall dietary behaviour, independent associations were evident between eating patterns and overweight, indicating parental modification of the diets of overweight children.
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Introduction

Increasing prevalence of overweight in children is a growing health problem worldwide. In Norway, a particular increase has been observed among young schoolchildren (Andersen *et al.*, 2005). The main dietary risk factors in relation to weight gain and obesity are energy-dense foods (high in fat and/or high in sugar) and low-fibre diets (World Health Organization, 2003). However, it has been difficult to demonstrate a consistent relationship between children's body mass index (BMI) and total energy intake or other dietary factors in observational studies (Alexy *et al.*, 2004; Reilly *et al.*, 2005). A nationwide, cross-sectional study of Norwegian children found no association between overweight and total energy intake or percentage of energy gained from fat. Rather, an inverse relationship was reported between intake of sweets and overweight (Andersen *et al.*, 2005). The same tendency was observed in a study on children from six other European countries (Janssen *et al.*, 2005; Magnusson *et al.*, 2005). A comprehensive review of studies examining the relationship between dietary intakes, eating behaviour and childhood obesity concluded that more research is needed, particularly in the form of studies that explore the joint effect of multiple dietary behaviour (Newby, 2007).

Construction of dietary patterns is an increasingly popular technique for describing overall dietary behaviour in a population. The most commonly used method of dietary pattern identification is principal component analysis (PCA), which groups correlated food variables together and thereby identifies underlying patterns in the data. The use of dietary patterns enables the study of the associations between combinations of foods and certain health conditions, and may illuminate associations that are not revealed when single nutrients or food items are used alone (Jacques and Tucker, 2001; Hu, 2002). Dietary patterns are population specific, and influenced by sociocultural factors and food availability (Balder et al., 2003). Only a few studies have identified distinct dietary patterns in European children and adolescents (North and Emmett, 2000; Aranceta et al., 2003; Roos et al., 2004; Northstone and Emmett, 2005). Typical dietary patterns of Norwegian schoolchildren have not been described previously.

The failure to identify a positive relationship between overweight and unhealthy foods in cross-sectional studies has been partly explained by changes in dietary habits and food restrictions due to children's weight gain (Andersen et al., 2005; Clark et al., 2007). It is not known whether this is a general phenomenon or is dependent on other family characteristics. Several studies have linked healthy dietary habits among children with high parental education levels (North and Emmett, 2000; Aranceta et al., 2003; Roos et al., 2004; Andersen et al., 2005; Northstone and Emmett, 2005). It is likely that dietary modification and restriction of unhealthy food items could be influenced by confounding. To our knowledge, no previous study has examined the association between overall dietary behaviour and over-weight among schoolchildren in the light of parental sociodemographic characteristics.

The aim of this study was to describe the eating patterns of 9- to 10-year-old Norwegian schoolchildren, and to investigate the relationship between overweight and eating patterns and family characteristics.

Methods

Subjects and study design
A descriptive cross-sectional study of fourth-grade pupils (9–10 years old), from primary schools in Telemark County, Norway, was performed from February to April 2007. All primary schools in Telemark were invited to participate in the study. Of the 110 invited schools, 70 (64%) agreed to participate in the study. The main reason for not participating was the work involving school staff, such as sending invitations to parents, handling written consents and questionnaires, and performing the weight and height measurements of the children. In total, 1477 children were invited to the study. Parents gave written consent for inclusion of 1045 children, which represented 50% of the county's fourth-grade pupils. Weight and height

measurements were obtained for 955 (91.4%) children. Data on dietary intake were incomplete for 31 of these, resulting in 924 (88.4%) children for the present analysis.

The research protocol was approved by the Regional Committee for Ethics in Medical Research and by the Norwegian Data Inspectorate, and informed written consent was obtained from the parents of all participating children.

Dietary information
The children's food and drink intake was reported by their parents using a retrospective food frequency questionnaire (FFQ), which asked about habitual daily consumption of 39 food items, 11 types of dinks, 13 snack items and 5 main meals during the last 6 months. The questionnaire was based on a short FFQ developed for use among fourth- and eighth-grade children in Norway, but was modified to include more dietary questions. The FFQ has not been validated for estimating total intakes of energy or nutrients but is appropriate for exploring dietary patterns on the basis of frequencies. The alternative frequencies for food and drink items were 'rarely/never', '1–3 times a month', '1–3 times a week', '4–6 times a week', 'once a day', 'twice a day' and '3 or more times per day'. Meal patterns were registered as the daily frequencies of five main meals (breakfast, lunch, afternoon meal, dinner and supper), with alternatives ranging from 'rarely/never' to 'daily'. The questions about snacking between meals had three answer categories: 'never/rarely', 'sometimes' and 'often/always'. As we used meal and snacking events in addition to food consumption frequencies as input variables in the PCA, the components were denoted as 'eating patterns' rather than 'dietary patterns'.

Other variables
In addition to providing dietary information, the parents answered questions about their own weight, height, educational level and work situation, family income and their subjective opinion regarding their child's physical activity level compared with that of other children of the same age.

Parental educational level was divided into three categories: 'primary and lower secondary education' (10 years or less), 'upper secondary education' (3–4 years of secondary education) and 'university or university college'.

Family income was also divided into three categories: 'both parents < Norwegian kroner (NOK) 300 000' (euro 33 909), 'one parent ⩾ NOK 300 000' and 'both parents ⩾ NOK 300 000'.

Parental work situation was divided into four categories: 'employed', 'unemployed/benefit recipient', 'housewife/home working' and 'others'. 'Others' included students, persons on sick leave and persons on a leave of absence.

A question categorizing activity by reference to other children was used as an indicator of the children's physical activity level. The question was taken from a battery of

validated questions used in a study on children's activity and inactivity in the Netherlands (Janz et al., 2005), and translated into Norwegian for use in this study.

Before the main study, the questionnaire was tested on a sample of parents. This was followed by qualitative interviews (Schelling and Streitlien, 2007).

BMI categories

The weight and height of the children were measured by public health nurses at each school. The children were weighed wearing light clothing (that is, trousers, T-shirt, socks), using calibrated, electronic scales measuring in 100 g increments. The BMI (kg/m^2) of each child was calculated on the basis of the measurements. Child BMI categories were calculated using International Obesity Task Force cutoff points (underweight, normal weight, overweight and obese), on the basis of growth curves and BMIs of 17, 25 and 30 kg/m^2 at age 18 years (Cole et al., 2000, 2007). The cutoff points for 9.5-year-old boys and girls were used. Parent BMI categories were calculated on the basis of self-reported height and weight and the International Obesity Task Force cutoff points for adults (overweight at BMI $\geqslant 25 kg/m^2$).

Statistical analysis

To identify the underlying eating patterns, PCA factor analysis with varimax rotation was applied to reported dietary responses. Food and drink frequencies were assigned values from 1 for 'never/rarely' to 7 for 'three or more times daily'; meal frequencies were assigned values from 1 for 'rarely/never' to 8 for 'daily'; and snacking frequencies were assigned values from 1 to 3. Missing values for a given variable were replaced by rarely/never. Respondents were excluded from the analysis if answers were missing for more than 25% of the questions about food and drink items or if answers were missing for more than two questions about meals ($n = 31$).

PCA constructs new linear factors by grouping together correlated variables. The coefficients defining the factors are called factor loadings and are the correlations of each input variable with the factors. The number of components chosen from the factor analysis was based on the scree plot, eigenvalues and the interpretability of the components (Cattell, 1966). Variables with factor loadings >0.25 or <-0.25 were considered to be the most important, providing the best interpretability of each eating pattern. Individuals are given factor scores for each of the patterns. Factor scores are standardized to a mean of zero. Positive factor scores indicate higher consumption of foods, drinks, snacks and meals in that pattern and negative factor scores indicate low consumption. The factor scores were ranked into tertiles.

Differences between group factor scores were tested using the Mann–Whitney or Kruskall–Wallis test. We used multiple logistic regression to calculate odds ratios and 95% confidence intervals (odds ratio (OR) and 95% confidence interval (CI)) for overweight in relation to parental characteristics, child gender, physical activity level and eating patterns. For all tests, $P < 0.05$ was considered significant. The questionnaires were scanned by Eyes and Hands (Readsoft Forms, Helsingborg, Sweden), and all statistical analyses were carried out using SPSS version 15.

Results

Weight and height were obtained for 955 of the 1045 participating children (91%) – 49.9% boys and 50.1% girls. The distribution between normal weight, overweight and obesity was 736 (80%), 151 (16%) and 37 (4%). We included the underweight children in the normal weight group because of the small number of individuals involved ($n = 5$). Overweight and obese children were also combined into one group, denoted 'overweight' in the analysis. The incidence of overweight/obesity was 20.6% for boys and 20.1% for girls ($P = 0.851$).

We extracted four components describing the eating patterns of the children, and named each component after the nature of the foods, beverages and meals with the highest factor loadings within it (Table 1). The eigenvalues for the four factors were 4.97, 3.56, 2.82 and 2.47, respectively. The first component, 'snacking', was characterized by snack items and sugar-sweetened drinks consumed between meals, combined with low breakfast and dinner frequency and low intake of water, vegetables and brown bread. The second component, 'junk/convenient', was characterized by high-fat and high-sugar processed fast foods such as French fries, processed pizza, processed meat products, sweets, ice cream and soft drinks. The third component, 'varied Norwegian', was characterized by food items typical of a traditional Norwegian diet, such as fish and meat for dinner, brown bread, regular white or brown cheese, lean meat, fish spread, and fruit and vegetables. The last component, 'dieting', was characterized by artificially sweetened soft drinks, low fat cheese and fat- and sugar-reduced yoghurt, and was negatively associated with sugar-sweetened soft drinks.

Overweight among the children was positively associated with paternal and maternal overweight, and inversely associated with maternal education and physical activity level (Table 2). Paternal and maternal overweight were also associated with higher 'dieting' scores, and maternal overweight with higher 'snacking' scores (Table 3). Maternal educational level was associated with lower 'snacking' scores, and increased physical activity by the child was associated with higher 'varied Norwegian' scores and lower 'dieting' scores. Boys had higher 'snacking' and 'junk/convenient' scores, whereas girls had higher 'varied Norwegian' and 'dieting' scores (Table 3).

The highest incidence of overweight was observed in the lower tertile of the 'junk/convenient' pattern (27%), and the upper tertile of the 'dieting' pattern (26%). The lowest

Table 1 Structure of the four eating patterns extracted from 924 Norwegian 9- to 10-year-old children

Interpreted eating pattern	Items	Factor loadings	Cumulative variance explained
'Snacking'	Sugar-sweetened soft drinks, carbonated (between meals)	0.62	7
	Sugar-sweetened soft drinks, non-carbonated (between meals)	0.60	
	Sweets between meals	0.58	
	Milk between meals	0.47	
	Salty snacks between meals	0.46	
	Ice cream between meals	0.43	
	Juice between meals	0.43	
	Yoghurt between meals	0.43	
	Biscuits, cakes, crackers, etc. between meals	0.41	
	Artificially sweetened soft drinks, carbonated (between meals)	0.37	
	Sugar-sweetened soft drinks, non-carbonated	0.33	
	Artificially sweetened soft drinks, non-carbonated, (between meals)	0.30	
	Water	−0.35	
	Vegetables	−0.32	
	Breakfast	−0.31	
	Pasta	−0.28	
	Dinner	−0.28	
	Brown bread	−0.28	
'Junk/ convenient'	French fries in fast food restaurants	0.60	13
	Hamburger or kebab	0.56	
	Biscuits, cakes, crackers, etc.	0.51	
	French fries for dinner	0.49	
	Waffles	0.47	
	Pancakes	0.45	
	Ice cream	0.44	
	Sausages, hot dog	0.44	
	Processed pizza	0.41	
	Biscuits, cakes, crackers, etc. between meals	0.34	
	Sugar-sweetened soft drinks, carbonated	0.34	
	White bread	0.34	
	Cereals and breakfast mixtures containing sugar	0.33	
	Salty snacks	0.32	
	Sweets	0.32	
	Chocolate spread	0.28	
	Processed meat for dinner	0.26	
	Rice	0.25	
	Ice cream between meals	0.25	
'Varied Norwegian'	Fruits and berries	0.53	17
	Vegetables	0.50	
	Fruit yoghurt	0.45	
	Fruits, berries or vegetables between meals	0.44	
	Yoghurt between meals	0.41	
	Fish for dinner	0.40	
	Fat- and sugar-reduced yoghurt	0.36	
	Low-fat meat on sandwich	0.35	
	Fish spread	0.35	
	Juice between meals	0.35	
	Cereals without sugar	0.34	
	White cheese, full fat	0.34	
	White cheese, low fat	0.33	
	Yoghurt with cereal	0.33	

Table 1 Continued

Interpreted eating pattern	Items	Factor loadings	Cumulative variance explained
	Processed fish for dinner	0.32	
	Juice	0.31	
	Brown bread	0.30	
	Non-processed meat for dinner	0.29	
	Water between meals	0.28	
	Brown cheese, full fat	0.27	
	Potatoes	0.27	
'Dieting'	Artificially sweetened soft drinks, non-carbonated (between meals)	0.66	20
	Artificially sweetened soft drinks, non-carbonated	0.65	
	Artificially sweetened soft drinks, carbonated	0.63	
	Artificially sweetened soft drinks, carbonated (between meals)	0.54	
	Fat- and sugar-reduced yoghurt	0.29	
	White cheese, low fat	0.26	
	Sugar-sweetened soft drinks, non-carbonated	−0.47	
	Sugar-sweetened soft drinks, carbonated	−0.36	

Food items, snacks and meals with factor loadings above ± 0.25 are listed.

incidence was observed in the lower tertile of the 'dieting' pattern (13%) (Table 4).

Children ranked in the two upper tertiles of the 'junk/convenient' pattern were less likely to be overweight than those in the lower tertile. Independently of this, children ranked in the two upper tertiles of the 'varied Norwegian' and 'dieting' patterns were more likely to be overweight than those in the respective lower tertiles (Table 4). These associations remained significant after adjustment for parental BMI, maternal education and physical activity level (Model 2, Table 4). No significant associations were seen between 'snacking pattern' and overweight.

The observed associations between pattern-score tertiles and overweight were basically the same for boys and girls, and for stratified parental characteristics (that is, paternal BMI, maternal BMI, maternal education and physical activity level). However, statistical significance was only achieved in strata with a sufficient number of participants (data not shown).

Discussion

The dietary pattern approach has rarely been used to examine associations between diet and overweight among children. In this cross-sectional study, we found significant differences in eating patterns between normal weight and overweight 9- to 10-year-old Norwegian children, independent of physical activity level and parental characteristics.

Table 2 Associations (ORs and 95% CIs) between parental characteristics, child gender, parent-reported physical activity and overweight among 924 Norwegian 9- to 10-year-old children

Characteristics	Total	Overweight and obese children		OR crude (95% CI)	OR adjusted[a] (95% CI)
		n	%		
BMI father					
Normal weight	292	39	13	1	1
Overweight and obese	510	120	24	2.0 (1.3, 3.0)	1.8 (1.2, 2.7)
Missing	122	29	24	2.0 (1.2, 3.5)	1.7 (0.8, 3.7)
BMI mother					
Normal weight	544	83	15	1	1
Overweight and obese	314	93	30	2.3 (1.7, 3.3)	2.2 (1.5, 3.2)
Missing	66	12	18	1.2 (0.6, 2.4)	0.9 (0.4, 2.0)
Maternal education					
Primary/lower secondary	138	41	30	1	1
Upper secondary	319	65	20	0.6 (0.4, 1.0)	0.6 (0.4, 1.1)
University/university college	421	72	17	0.5 (0.3, 0.8)	0.5 (0.3, 0.9)
Missing	46	10	22	0.7 (0.3, 1.4)	0.5 (0.2, 1.2)
Paternal education					
Primary/lower secondary	120	25	21	1	1
Upper secondary	383	82	21	1.0 (0.6, 1.7)	1.5 (0.8, 2.6)
University/university college	317	54	17	0.8 (0.5, 1.3)	1.3 (0.7, 2.4)
Missing	104	27	26	1.3 (0.7, 2.5)	1.6 (0.7, 3.6)
Family income in Norwegian kroner (NOK)					
Both parents <NOK 300 000	151	32	21	1	1
One parent ⩾ NOK 300 000	421	80	19	0.9 (0.6, 1.4)	1.0 (0.6, 1.7)
Both parents ⩾ NOK 300 000	227	43	19	0.9 (0.5, 1.5)	1.3 (0.7, 2.4)
Missing	125	33	26	1.3 (0.8, 2.3)	1.6 (0.7, 3.6)
Maternal work					
Employed	688	138	20	1	1
Unemployed/benefit recipient	42	16	38	2.5 (1.3, 4.7)	1.8 (0.9, 3.7)
Housewife	39	5	13	0.6 (0.2, 1.5)	0.4 (0.1, 1.0)
Other	89	13	15	0.7 (0.4, 1.3)	0.6 (0.3, 1.1)
Missing	66	16	24	1.3 (0.7, 2.3)	1.3 (0.7, 2.6)
Paternal work					
Employed	773	152	20	1	1
Unemployed/benefit recipient	31	8	8	1.4 (0.6, 3.2)	1.0 (0.4, 2.5)
Other	40	9	23	1.2 (0.6, 2.5)	1.4 (0.6, 3.3)
Missing	80	19	24	1.3 (0.7, 2.2)	0.6 (0.2, 1.5)
Child gender					
Boy	476	98	21	1	1
Girl	448	90	20	1.0 (0.7, 1.3)	1.0 (0.7, 1.4)
Physical activity					
Less than other children	69	28	41	1	1
Same as other children	504	117	23	0.4 (0.3, 0.7)	0.5 (0.3, 0.8)
More than other children	346	42	12	0.2 (0.1, 0.4)	0.2 (0.1, 0.4)
Missing	5	1	20	0.4 (0.0, 3.5)	0.5 (0.0, 4.7)

Abbreviations: CI, confidence interval; OR, odds ratio.
[a]Adjusted for all other variables.

No studies have thus far been reported of the dietary patterns of young Norwegian schoolchildren, and there are few studies from other European countries (North and Emmett, 2000; Aranceta *et al.*, 2003; Northstone and Emmett, 2005, 2008). Differences in dietary assessments and the population specificity of dietary patterns make direct comparison difficult (Balder *et al.*, 2003), but several similarities can be observed. Most dietary pattern studies include one pattern featuring a mixture of processed and convenience/junk foods, one pattern featuring high loadings with regard to vegetables and other food items associated with a health-conscious lifestyle and one pattern characterized by traditional national foods.

Table 3 Eating pattern scores by reference to parental characteristics and parent-reported physical activity among 924 Norwegian 9- to 10-year-old children[a]

	n (%)	Snacking	Junk/convenient	Varied Norwegian	Dieting
BMI father					
Normal weight	292 (32)	−0.06	−0.00	0.03	−0.11
Overweight and obese	510 (55)	−0.01	−0.00	−0.01	0.08
P-value[b]		0.453	0.860	0.669	0.011
Missing	122 (13)	0.16	0.01	−0.01	−0.06
BMI mother					
Normal weight	544 (59)	−0.09	0.02	0.00	0.12
Overweight and obese	314 (34)	0.13	−0.03	0.04	0.18
P-value[b]		0.001	0.430	0.714	<0.001
Missing	66 (7)	0.14	0.01	−0.20	0.09
Maternal education					
Primary/lower secondary	138 (15)	0.40	−0.07	−0.03	−0.05
Upper secondary	319 (35)	0.12	0.12	−0.08	0.03
University/university college	421 (45)	−0.27	−0.04	0.09	−0.06
P-value[c]		<0.001	0.035	0.094	0.328
Missing	46 (5)	0.41	−0.26	−0.13	0.53
Physical activity					
Less than other children	69 (7)	−0.08	0.06	−0.45	0.40
Same as other children	504 (55)	0.01	−0.01	−0.05	0.00
More than other children	346 (37)	−0.01	−0.00	0.16	−0.08
P-value[c]		0.891	0.866	<0.001	0.002
Missing	5 (0.5)	0.97	0.57	0.30	−0.42
Child gender					
Boy	476 (52)	0.10	0.07	−0.07	−0.07
Girl	448 (48)	−0.11	−0.08	0.07	0.07
P-value[b]		0.001	0.025	0.021	0.021

Abbreviation: PCA, principal component analysis.
[a]Values are mean factor scores obtained by extracting four dietary factors by PCA. The overall mean factor score for each pattern is zero. Positive factor scores indicate higher consumption of foods, drinks, snacks and meals in that pattern and negative factor scores indicate low consumption. The scores are not adjusted for the other variables.
[b]Mann–Whitney *U*-test, category with missing data not included.
[c]Kruskall–Wallis test, category with missing data not included.

Table 4 Associations (ORs and 95% CIs) between tertiles of pattern scores and overweight among 924 Norwegian 9- to 10-year-old children

Eating pattern	Total n = 924	Overweight and obese children		Model 1	Model 2
		n	%	OR crude (95% CI)[a]	OR adjusted (95% CI)[b]
Snacking					
Tertile 1	308	61	20	1	1
Tertile 2	307	58	19	1.1 (0.7, 1.6)	1.0 (0.7, 1.6)
Tertile 3	309	69	22	1.3 (0.8, 1.9)	1.0 (0.7, 1.6)
Junk/convenient					
Tertile 1	307	83	27	1	1
Tertile 2	308	46	15	0.5 (0.3, 0.7)	0.4 (0.3, 0.7)
Tertile 3	309	59	19	0.6 (0.4, 0.9)	0.6 (0.4, 0.9)
Varied Norwegian					
Tertile 1	307	46	15	1	1
Tertile 2	309	73	24	2.0 (1.3, 3.0)	2.3 (1.5, 3.6)
Tertile 3	308	69	22	1.7 (1.1, 2.6)	2.1 (1.3, 3.2)
Dieting					
Tertile 1	307	39	13	1	1
Tertile 2	308	68	22	2.1 (1.3, 3.2)	1.9 (1.2, 3.0)
Tertile 3	309	81	26	2.6 (1.7, 4.0)	2.2 (1.4, 3.4)

Abbreviations: CI, confidence interval; OR, odds ratio.
[a]Adjusted for the other eating patterns.
[b]Adjusted for the other eating patterns, parental BMI, maternal education and physical activity level of the child.

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Distinct snacking patterns have also been reported previously (North and Emmett, 2000; Aranceta *et al.*, 2003). In a Norwegian study using cluster analysis, a cluster labelled 'Western eaters' comprised mainly young women with children (Engeset *et al.*, 2005). The dietary characteristics of this cluster were quite similar to a combination of our 'snacking' and 'junk/convenient' eating patterns, corroborating the occurrence of this eating behaviour among Norwegian children with young mothers.

In this study, the 'varied Norwegian' pattern represents a traditional Norwegian diet close to that recommended by the national nutrition authorities. Although UK children (North and Emmett, 2000; Northstone and Emmett, 2005) displayed a traditional British dietary pattern featuring meat products and vegetables, the 'varied Norwegian' pattern is a broader combination of food items often recommended as 'a varied Norwegian diet'. Unlike other studies, we found no particular 'healthy' dietary pattern, although foods such as fruit and vegetables, brown bread, fish, fish products and non-processed meat were covered by the 'varied Norwegian' pattern. The 'dieting' pattern, on the other hand, featured food and drinks often associated with dieting and weight control.

To link the regularity of meals to certain combinations of food items, we used meal frequency, along with the food frequency data, as an input variable in the PCA. The 'snacking' pattern was negatively associated with breakfast and dinner consumption, which is consistent with the previously reported association between low meal frequency, snacking and the consumption of unhealthy foods (Sjöberg *et al.*, 2003; Northstone and Emmett, 2005)

The development of overweight and obesity in children is a result of genetic and environmental factors, including individual, familial and structural variables (Lobstein *et al.*, 2004). Our results showed that children with overweight mothers and mothers with lower educational attainment had significantly higher scores on the unhealthy 'snacking pattern'. Children who were more physically active than others had significantly higher scores on the 'varied Norwegian pattern'. Significant gender differences were seen for all the eating patterns, suggesting higher health consciousness among girls than among boys. The results emphasize the need for promoting healthy eating habits in families with certain sociodemographic characteristics.

One strength of this study is the objective measurement of weight and height. Furthermore, it includes a broad range of background variables, which are likely to capture a significant proportion of the variability in socioeconomic background and health behaviour. In addition, we had a reasonably large sample and a relatively high response rate. However, some bias may arise because of the underrepresentation of overweight and obese children in the analysis. The present study was conducted in one county only, but the incidence of overweight and obesity in this study was comparable to that of other Norwegian studies on children, and similar to objective measurements of the height and

weight of 8-year-old children in Oslo (Andersen *et al.*, 2005; Vilimas *et al.*, 2005; Juliusson *et al.*, 2007).

A limitation of this study is its cross-sectional design. The design eliminates the possibility of identifying causal relationships between eating patterns and the risk of being overweight. The association between high 'varied Norwegian' and 'dieting' scores and a high likelihood of being overweight indicates dietary modification in the case of overweight children, whereas the association between high 'junk/convenient' scores and a low likelihood of being overweight may indicate less dietary restraint in the case of children of normal weight. Dietary modification was evident in all strata of parental characteristics, and among both boys and girls. Efforts to adopt a healthier diet, and the introduction of low-energy food products in overweight children, have been highlighted and discussed by others (Andersen *et al.*, 2005; Clark *et al.*, 2007). Parental restriction of food intake has even been suggested as a possible risk factor for weight gain in children (Clark *et al.*, 2007; Van Strien *et al.*, 2009).

We cannot exclude the possibility of dietary reports being influenced by parental misreporting. The problem of underreporting is relevant to food pattern analysis, as a bias in the reporting of, for example, foods high in fat or sugar will be reflected in lower factor scores. Underreporting has been found to increase with overweight in both adult and adolescent populations (Johansson *et al.*, 1998; Vance *et al.*, 2009). Food items high in sugar and fat are underreported more often than food items perceived as healthy (Olafsdottir *et al.*, 2006). Any underreporting of unhealthy food and drink items is likely to have attenuated the association between unhealthy eating behaviour and overweight.

In this study the FFQ was completed by the parents and not by the children. It is a problem that parents may not know what 9- to 10-year olds eat throughout the day, especially when they are away from home. Consequently, the dietary data in this study reflect the parents 'dietary image' rather than the true habitual diet of the children (Drewnowski, 2001). However, answering an FFQ challenges respondents with rather complex cognitive skills that most 9- to 10-year-old children have not developed (Livingstone and Robson, 2000).

Although most cross-sectional studies of children have found negative associations between energy-rich foods and overweight, some longitudinal studies have reported a positive association between weight gain over time and consumption of high-fat foods and sugar-sweetened drinks (Ludwig *et al.*, 2001; Nicklas *et al.*, 2003; Johnson *et al.*, 2008). Additional research is needed to examine the longitudinal relationship between eating behaviour, dieting and weight development in children, and we aim to repeat the study when the children in the study group reach the age of 12–13 years.

Our main finding was that, although family characteristics influenced both the prevalence of overweight and overall dietary behaviour, independent associations between eating

patterns and overweight were evident. Further, the associations between eating patterns and overweight indicated parental modification of the diets of overweight children.

Conflict of interest

The authors declare no conflict of interest.

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