Public Health Nutrition: 12(12), 2392–2399 doi:10.1017/S136898000900528X

Unhealthy dietary patterns are associated with weight gain during pregnancy among Finnish women

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Submitted 15 August 2008: Accepted 30 January 2009: First published online 27 March 2009

Abstract

Objective: To study whether the dietary patterns of Finnish pregnant women are associated with their weight gain rate during pregnancy.
Design: A validated 181-item FFQ was applied retrospectively to assess the diet during the eighth month of pregnancy, and maternal height and maternal weight at first and last antenatal visits were recalled. Information on sociodemographic characteristics, parity and smoking of the pregnant women was obtained by a structured questionnaire and from the Finnish Birth Registry. Principal components analysis was used to identify dietary patterns that described the diet of pregnant women based on their food consumption profile.
Setting: Finland.
Subjects: Subjects consisted of 3360 women who had newly delivered in 1997–2002 and whose baby carried human leucocyte antigen-conferred susceptibility to type 1 diabetes in two university hospital regions, Oulu and Tampere, in Finland.
Results: Out of seven dietary patterns identified, the 'fast food' pattern was positively associated ($\beta = 0{\cdot}010$, SE $= 0{\cdot}003$, $P = 0{\cdot}004$) and the 'alcohol and butter' pattern was inversely associated ($\beta = -0{\cdot}010$, SE $= 0{\cdot}003$, $P < 0{\cdot}0001$) with weight gain rate (kg/week) during pregnancy after adjusting for potential dietary, perinatal and sociodemographic confounding factors. Both of the dietary pattern associations demonstrated dose dependency.
Conclusions: Pregnant women should be guided to have a well-planned, balanced, healthy diet during pregnancy in order to avoid rapid gestational weight gain. The association between diet, health and maternal weight gain of the women who consumed alcohol during pregnancy should be studied further.

Keywords
Diet
Dietary pattern
Maternal weight gain rate

In economically developed countries, the mean weight gain during pregnancy has increased over the past decades[1–4]. Data from studies in the USA indicate that the mean pregnancy weight gain increased from 10 kg during the period 1940–60 to 15 kg in the 1980s[1]. In Finland the mean pregnancy weight gain increased from 13·2 kg to 14·3 kg between the 1960s and the mid-1980s. The increase was observed in all BMI categories[3]. In response to the increasing trends in maternal weight gain, the US Institute of Medicine has developed guidelines for maternal weight gain based on pre-pregnancy BMI[1]. Complications due to excessive weight gain include e.g. Caesarean deliveries and fetal macrosomia resulting in the delivery of a large-for-gestational-age infant[3,5,6]. In the long run the excessive weight gain during pregnancy contributes also to the obesity epidemic through larger rates of postpartum weight retention[7,8], which process may be further increased by relatively early termination of breast-feeding among those who gain excess weight during pregnancy[9]. The increasing global obesity rates will lay a heavy burden not only on the health-care systems of the industrialized countries but also on the economically developing countries[10].

Carmichael *et al.*[11] have presented patterns of maternal weight gain associated with good pregnancy outcome. Their conclusion is that, among normal-weight

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women, the rate of weight gain should be smallest during the first and largest during the second trimester of pregnancy with a slight decrease in the rate during the third trimester. The Institute of Medicine[1] has presented patterns of maternal weight gain according to seven studies among well-nourished women in Europe and the USA. Most of them failed to present any data before the 16th week of pregnancy because the subjects were not monitored so early. From the 16th week of pregnancy on until full term, the weight gain rate was relatively linear. Hytten[12] has estimated that, on average, water contributes approximately 62 %, fat 30 % and protein 8 % of the total maternal weight gain and that the weight gain rate accelerates after the 10th week of pregnancy for all of these body components. Lifestyle factors such as inappropriate diet may play a major role in excessive weight gain during pregnancy[13,14]. Smoking habits have also been identified as a factor contributing to the development of gestational excessive weight[15,16].

Dietary pattern analysis is an approach that aims at discerning various characteristics of the whole diet[17] and may therefore help to capture some of the complexity of diet that is often lost in nutrient-based analyses[18]. Dietary pattern analysis is considered suitable for studies aimed at examining characteristics of dietary behaviour in relation to health[19]. The present study set out to evaluate the association between dietary patterns and maternal weight gain rate during pregnancy among Finnish women.

Methods

The present study is part of the Finnish Type 1 Diabetes Prediction and Prevention (DIPP) Nutrition Study, which aims at examining the effects of childhood diet and maternal nutrition during pregnancy and lactation on the development of β-cell autoimmunity and type 1 diabetes in the offspring. All families with newborn infants carrying increased human leucocyte antigen-conferred susceptibility to type 1 diabetes in the Oulu and Tampere University hospital regions were invited to participate. Those 5362 mothers who gave birth between 20 October 1997 and 31 December 2002 form the present study population. Of them, 3783 (71 %) took part in this nutrition study. Fifty-three mothers did not report consumption frequencies for ten or more food items (explained later) and were therefore excluded. In most cases the missing food items were those that were consumed seldom or never, but we required that the information had to be given to each food or food group separately on the questionnaire. We excluded also all twin and triplet pregnancies (*n* 98) and mothers with incomplete weight gain information (*n* 272) from the present analysis. The final sample size was 3360.

Diet during pregnancy was assessed using a validated FFQ[20]. The list comprised 181 food items, either foods or food groups, and the consumption frequency (number of times per day, week and month) as well as common serving sizes. The FFQ focused on past diet, i.e. on the diet during the eighth month of pregnancy. Mothers received the questionnaire after delivery; it was returned and checked by a trained study nurse at the visit to the study centre when the baby was 3 months old. Data collection followed the same protocol as that used in the validation study[20], where it was shown that the questionnaire administered after delivery reflects well the diet during the eighth month of pregnancy.

For dietary pattern analysis, the 181 food items in the FFQ were aggregated into fifty-two food groups[21]. Principal components analysis with varimax rotation was used to identify factors among the food groups. A plot of eigenvalues (i.e. the Scree test) indicated a break between the seventh and eighth factor which could be used as a separate criterion to the solution of seven factors that were retained for further analysis. After varimax rotation of the factors, the food groups with loadings of $\geq 0{\cdot}2$ on a factor were considered to have a strong association with that factor. Negative loading ($\leq -0{\cdot}2$) represents an inverse association between the food group and the factor. Seven factors or dietary patterns were discerned. The normally distributed dietary pattern scores were calculated for each mother in each pattern in terms of how closely they fit the pattern. These scores were used to rank individuals.

Weight and height were asked on the same questionnaire as the food frequency was recorded. Mothers recorded the results of the weight measurements during their first and last antenatal visits. The gestational weeks of the weight measurements were also recorded as well as the mother's height. Mothers came for the first weight measurement during the 10th gestational week on average (SD 2·3 weeks, range 3–33 weeks). The last measurement was carried out during the 39th gestational week on average (SD 2·0 weeks, range 24–44 weeks). The mean follow-up time was 29·2 weeks (SD 3·0 weeks, range 6–37 weeks). The initial BMI was calculated for each woman. Pregnancy weight gain rate was calculated by dividing the weight gain in kilograms by the number of weeks over which the weight gain was monitored. In addition, information on maternal age and education was collected by a structured questionnaire in the delivery clinics and information on living area, parity and smoking was received from the Finnish Birth Registry, which included adequate information on them[22].

In order to adjust the dietary patterns to energy and macronutrient intakes, intakes of total protein, total fat, saturated, monounsaturated and polyunsaturated fats, total carbohydrate and sucrose were calculated from the FFQ. Their possible independent role in weight gain rate was also studied. We used 4184 kJ (1000 kcal) as the unit of analysis for energy and percentage of energy (%E) for macronutrients.

https://doi.org/10.1017/S136898000900528X Published online by Cambridge University Press

Data were analysed using the SAS statistical software package version 8·2 (SAS Institute, Inc., Cary, NC, USA). The general linear models procedure in SAS (PROC GLM) was used to test the trends in weight gain rates between participants grouped according to quartiles of dietary pattern scores. The association between dietary patterns and maternal weight gain rates was assessed using multiple linear regression (PROC REG in SAS). Weight gain rate changes slightly after the 10th week of pregnancy[1,12] and therefore we added a dummy variable into the regression models (initial measurement in ≤10th week = 1, otherwise = 0).

Results

The mean age of the participating women was 29·2 years, most of them lived in an urban area (77 %), did not smoke (88 %) and had at least one previous pregnancy (53 %; Table 1). Their initial mean BMI was 24·4 kg/m^2 and mean weight gain during pregnancy was 12·4 kg. The mean weight gain rate was 0·425 (SD 0·154) kg/week (Table 1).

Seven distinct dietary patterns were identified among the study population and they were named according to the food group loadings on them as 'Healthy', 'Fast food', 'Traditional bread', 'Traditional meat', 'Low-fat', 'Coffee' and 'Alcohol and butter'. The complete list of foods with relatively large or small loadings on the dietary patterns is presented in Table 2.

The 'Fast food' and 'Traditional bread' dietary patterns were positively associated, and the 'Traditional meat', 'Coffee' and 'Alcohol and butter' dietary patterns were inversely associated, with maternal weight gain rate (Table 3). When the models were adjusted for maternal age, initial BMI, parity, vocational education, smoking, living area, birth weight of the baby and gestational week of the first weight measurement, only three patterns remained significant in relation to weight gain rate: 'Fast food', 'Traditional bread' and 'Alcohol and butter' (Table 3). Our analysis estimates that those pregnant women who belonged to the highest quartile of the 'Fast food' dietary pattern gained 1·3 kg more weight on average during pregnancy (10th–40th week) than those who belonged to the lowest quartile. The respective figure for the 'Traditional bread' dietary pattern was 0·9 kg and for the 'Alcohol and butter' dietary pattern, −0·7 kg.

When energy and energy-yielding nutrients were studied separately, one by one, while simultaneously adjusting for potential confounding factors, only energy ($\beta = 0{\cdot}016$, $P \le 0{\cdot}0001$), percentage of energy from protein ($\beta = -0{\cdot}004$, $P = 0{\cdot}0007$), percentage of energy from SFA ($\beta = 0{\cdot}002$, $P = 0{\cdot}044$) and percentage of energy from sucrose ($\beta = 0{\cdot}002$, $P = 0{\cdot}0024$) were statistically significant contributors to the maternal weight gain rate. The effect of these covariates was studied by adding them to the final models in a sequential manner; first only the dietary pattern score was included in the model (Table 4), then energy and finally all the energy-yielding nutrients that were found to be statistically significant contributors to maternal weight gain in separate regression analyses. The 'Fast food' dietary pattern was positively associated with maternal weight gain rate even after including energy and percentage of energy from protein, SFA and sucrose in the model. In a similar manner, the 'Alcohol and butter' dietary pattern was inversely associated with the weight gain rate (Table 4).

Table 1 Characteristics of the sample population: women in the Finnish Type 1 Diabetes Prediction and Prevention (DIPP) Nutrition Study whose newborn was delivered between 1997 and 2002

	n	%	Mean	SD
Age (years)			29·2	5·2
≤24	645	19·2		
25–29	1171	34·8		
30–34	978	29·1		
≥35	566	16·9		
Living area				
Urban	2578	76·7		
Rural	436	13·0		
Population centre	321	9·6		
Missing	25	0·7		
Vocational education				
None	204	6·1		
Vocational school or course*	961	28·6		
Upper secondary vocational†	377	41·0		
Academic‡	730	21·7		
Missing	88	2·6		
Smoking during pregnancy				
Non-smokers	2950	87·8		
Quit smoking§	43	1·3		
Smokers	282	8·4		
Missing	85	2·5		
BMI, initial (kg/m^2)			24·4	4·3
≤19	121	3·6		
20–24	2095	62·3		
25–29	719	21·4		
≥30	422	12·6		
Missing	3	0·1		
Parity			0·95	1·4
0	1545	46·0		
1	1048	31·2		
2	461	13·7		
3	281	8·4		
Missing	25	0·7		
Maternal weight gain (kg)			12·4	4·6
Maternal weight gain rate (kg/week)			0·425	0·154

*Professional training without upper secondary school.
†Professional training after upper secondary school.
‡University degree.
§Quit smoking during the first trimester.

Discussion

In the present study, we identified two dietary patterns that were associated with weight gain rate during pregnancy after adjusting for other potential weight gain-related factors. The 'Fast food' dietary pattern (characterized by higher consumption of sweets, soft drinks, hamburgers, pizza and other fast foods, and by a significantly higher

Table 2 Major food groups associated with each dietary pattern: women in the Finnish Type 1 Diabetes Prediction and Prevention (DIPP) Nutrition Study whose newborn was delivered between 1997 and 2002

Dietary pattern	Food group with positive loading (≥0·2)*	Food group with negative loading (≤−0·2)
'Healthy'	leafy vegetables cabbage vegetables fish vegetarian dishes legumes and mushrooms roots berries salad dressing breakfast cereals poultry fruits nuts and seeds rice and pasta eggs low-fat cheese low-fat sour milk meat dishes cream processed vegetables	
'Fast food'	sweets fast food snacks chocolate fried potatoes soft drinks high-fat pastry cream fruit juices white bread savoury processed meat sausage eggs	wholegrain bread potatoes
'Traditional bread'	low-fat pastry wholegrain bread high-fat pastry tea high-fat cheese sugar and jam berry juices potatoes breakfast cereals butter processed meat savoury nuts and seeds meat dishes high-fat sour milk berries	
'Traditional meat'	meat meat dishes sausage potatoes processed meat soft margarine 80 organ meat processed vegetables	nuts and seeds breakfast cereals
'Low-fat'	spread 40–60 % low-fat cheese low-fat milk processed meat wholegrain bread low-fat sour milk light soft drinks	high-fat milk high-fat sour milk soft margarine 80
'Coffee'	coffee milk in coffee high-fat milk low-fat pastry sausage	tea
'Alcohol and butter'	beer wine and liquor butter salad dressing soft drinks	soft margarine 80 fruits breakfast cereals fruit juices high-fat milk

*Starting with the highest loading.

intake of sucrose[21]) was positively associated and the 'Alcohol and butter' pattern (characterized by higher consumption of alcoholic drinks and butter[21]) was inversely associated with maternal weight gain rate. Both of them also demonstrated dose dependency. The study is unique in that it is the first to investigate the association between diet and weight gain rate in pregnancy using dietary pattern analysis.

According to the guidelines of the Institute of Medicine[1], three categories of gestational weight gain can be examined: (i) total weight gain, which is the difference between the weight before conception and the weight just before delivery; (ii) net weight gain, which is total maternal weight gain minus the birth weight of the infant; and (iii) the rate per week, which is the weight gained over a specified period divided by the duration of the corresponding period in weeks. We used the assessment of weight gain rate because in our study the monitoring of maternal weight gain started at different time points, depending on when the mother decided to start visiting the antenatal clinic, and also the timing of the final measurement varied between the mothers. The estimates of total weight gain and net weight gain would thus not have been accurate.

The maternal diet was assessed by a validated FFQ[20] that was checked by a trained study nurse when the mother returned the questionnaire, making immediate checking of missing items or errors possible. A further strength of our study is that mothers seemed to be honest with the description of their dietary habits because they reported their alcohol intake in the questionnaire even though Finnish women are recommended not to consume alcohol during pregnancy. It is a challenge to assess alcohol intake in food consumption studies[23]. However, the FFQ has been identified as sufficient for assessing alcohol intake[24], also during pregnancy[25].

Several studies have suggested that snack consumption and/or high frequency of food consumption relates to higher energy intake[26–28]. French *et al.*[29] reported that the frequency of eating at fast-food restaurants is associated with higher energy consumption and higher body weight. Our results support these findings although we

https://doi.org/10.1017/S136898000900528X Published online by Cambridge University Press

Table 3 Maternal weight gain rate in four subpopulations determined by quartiles of dietary pattern scores: women in the Finnish Type 1 Diabetes Prediction and Prevention (DIPP) Nutrition Study whose newborn was delivered between 1997 and 2002

	Mean weight gain rate (kg/week)								
	1st quartile (lowest)		2nd quartile		3rd quartile		4th quartile (highest)		
Dietary pattern	Mean	SE	Mean	SE	Mean	SE	Mean	SE	*P* for trend
'Healthy'	0·427	0·005	0·435	0·005	0·431	0·005	0·416	0·005	0·059
	0·431*	0·010	0·441	0·010	0·435	0·010	0·423	0·010	0·109
'Fast food'	0·401	0·005	0·422	0·005	0·436	0·005	0·450	0·005	<0·0001
	0·412	0·010	0·429	0·010	0·439	0·010	0·455	0·010	<0·0001
'Traditional meat'	0·432	0·005	0·433	0·005	0·431	0·005	0·413	0·005	0·022
	0·431	0·010	0·434	0·010	0·440	0·010	0·426	0·010	0·262
'Traditional bread'	0·407	0·005	0·434	0·005	0·429	0·005	0·438	0·005	0·0002
	0·414	0·010	0·438	0·010	0·433	0·009	0·444	0·010	0·0002
'Low-fat'	0·434	0·005	0·419	0·005	0·433	0·005	0·423	0·005	0·123
	0·435	0·009	0·425	0·010	0·438	0·010	0·435	0·010	0·252
'Coffee'	0·429	0·005	0·436	0·005	0·429	0·005	0·415	0·005	0·046
	0·428	0·010	0·437	0·010	0·436	0·010	0·429	0·009	0·443
'Alcohol and butter'	0·443	0·005	0·436	0·005	0·423	0·005	0·407	0·005	<0·0001
	0·443	0·010	0·438	0·010	0·431	0·010	0·421	0·010	0·014

*Second row for each dietary pattern shows values adjusted for maternal age, initial BMI, parity, vocational education, smoking, living area, birth weight of the baby and gestational week of the first weight measurement.

specifically studied weight gain in pregnancy, not in the general population. Our earlier analysis indicated that younger mothers adhere to the 'Fast food' dietary pattern most frequently[20], making them vulnerable to a higher weight gain rate.

One of the potential limitations of the present study is that physical activity and psychosocial factors were not examined. These factors may affect the weight gain of pregnant women. However, according to a recent review[30], only a few studies have found an association between physical activity and gestational weight gain. A Canadian study[31] suggested that pregnancy is an event that leads to a decrease in physical activity. Exercise may not therefore be as important a factor in weight gain control during pregnancy as during other phases of life. On the other hand, the study of Olson *et al.*[32] identified physical activity as one of three behavioural determinants for gestational weight gain. The other two were change in food intake and smoking. There is increasing evidence that psychosocial factors may also affect dietary intakes. Findings by Hurley *et al.*[33] suggest that pregnant women who are more fatigued, stressed and anxious consume more foods.

The use of dietary patterns may help capture some of the complexity of diet that is often lost in nutrient-based analyses[18]. However, the complexity makes it also more prone to subjective interpretations[34]. We wanted to evaluate whether the dietary patterns carried any additional relationship with weight gain rate that was beyond detection by nutrient-level analysis. The association between two dietary patterns, 'Fast food' and 'Alcohol and butter', and weight gain rate remained significant even after adjusting for energy and macronutrient intakes. The 'Fast food' dietary pattern may also have reflected certain lifestyle characteristics, e.g. relatively low level of physical activity, or psychosocial characteristics, e.g. stressed and anxious pregnant women, who may have been more likely to eat unhealthy convenience foods and may have failed recalling all the foods they had eaten. This should be studied further.

Alcohol consumption during pregnancy was observed to be rare (28 % of all mothers) and the amounts reported were small among Finnish pregnant women[21]. Therefore even low-frequency maternal alcohol intake turned out to determine a dietary habit that was distinct enough to form an independent dietary pattern in our analyses. Our study provides limited information for explaining why the 'Alcohol and butter' pattern was related to lower weight gain rate. Literature on maternal alcohol intake and gestational weight gain is also scarce. Mothers with high scores on this dietary pattern seemed to be older, had more previous deliveries and they had higher education level[21], all factors independently associated with less maternal weight gain compared with others (to be reported separately). It is also possible that this group of mothers felt subjectively very healthy and had records of uncomplicated previous pregnancies, and thus were less strict in their adherence to dietary guidelines.

The overall problem in studies related to gestational weight gain is that they are observational in design and accordingly they cannot prove causation. However, repeated studies with consistent results can provide compelling evidence for associations. The present study could not prove the causality between diet and weight gain rate, but the results still clearly support the assumption that frequent consumption of fast foods and snacks is a risk predictor for excess maternal weight gain.

The strong association between the 'Fast food' type of dietary pattern, with higher intakes of energy and sucrose, and higher weight gain rate during pregnancy

https://doi.org/10.1017/S136898000900528X Published online by Cambridge University Press

Table 4 Linear regression models explaining the association between dietary factors and maternal weight gain rate: women in the Finnish Type 1 Diabetes Prediction and Prevention (DIPP) Nutrition Study whose newborn was delivered between 1997 and 2002

	Dietary pattern																	
	'Fast food'						'Traditional bread'						'Alcohol and butter'					
	Model A*		Model B†		Model C‡		Model A*		Model B†		Model C‡		Model A*		Model B†		Model C‡	
	β	SE	*β*	SE	*β*	SE	*β*	SE	*β*	SE	*β*	SE	*β*	SE	*β*	SE	*β*	SE
Dietary pattern	0·015	0·003	0·012	0·003	0·010	0·003	0·009	0·003	0·002	0·003	0·000	0·003	−0·009	0·003	−0·008	0·003	−0·010	0·003
P value	<0·0001		<0·0001		0·004		0·001		0·480		0·924		0·001		0·002		<0·0001	
Energy§	–	–	0·008	0·004	0·007	0·004	–	–	0·013	0·004	0·012	0·004	–	–	0·014	0·003	0·010	0·003
P value			0·030		0·046				0·001		0·003				<0·0001		0·002	
%E from protein	–	–	–	–	−0·002	0·002	–	–	–	–	−0·003	0·002	–	–	–	–	−0·003	0·002
P value					0·151						0·104						0·107	
%E from SFA	–	–	–	–	0·001	0·001	–	–	–	–	0·001	0·001	–	–	–	–	0·002	0·001
P value					0·610						0·340						0·107	
%E from sucrose	–	–	–	–	0·0002	0·001	–	–	–	–	0·001	0·001	–	–	–	–	0·001	0·001
P value					0·923						0·3190						0·173	
Intercept	0·513	0·030	0·494	0·031	0·518	0·049	0·517	0·030	0·483	0·031	0·497	0·048	0·505	0·030	0·470	0·031	0·470	0·049
P value	<0·0001		<0·0001		<0·0001		<0·0001		<0·0001		<0·0001		<0·0001		<0·0001		<0·0001	
Adjusted R^2	0·115		0·116		0·116		0·113		0·112		0·114		0·109		0·115		0·117	

%E, percentage of energy.
All models adjusted for maternal age at delivery, initial maternal BMI, parity, living area, vocational education, smoking and birth weight of the infant.
*Model A: only dietary pattern in the model.
†Model B: dietary pattern and energy intake in the model.
‡Model C: dietary pattern, energy intake and percentage of energy from protein, SFA and sucrose in the model.
§Energy unit: 4184 kJ (1000 kcal).

needs to be taken into account in nutrition policy planning and implementation. This would be important also for the prevention of obesity in later life. Because nulliparous women are often very willing to change their dietary habits into healthier ones during pregnancy[35], this period of the life cycle[36] could be ideal not only for learning healthier lifestyles, but also for changing behaviour into a healthier direction.

Acknowledgements

Sources of funding: This study was supported by the Academy of Finland (grants 63672, 79685, 79686, 80846, 201988, 210632), the Finnish Diabetes Association, the Finnish Diabetes Research Foundation, the Finnish Pediatric Research Foundation, the Juho Vainio Foundation, the Yrjö Jahnsson Foundation, the Alma and K.A. Snellman Foundation, the European Foundation for the Study of Diabetes, Special Public Grants for Medical Research at the participating university hospitals, the Juvenile Diabetes Research Foundation International (grants 197032, 4-1998-274, 4-1999-731, 4-2001-435), the Novo Nordisk Foundation and EU Biomed 2 (BMH4-CT98-3314). *Conflicts of interest declaration:* The authors have no conflict of interest regarding the study. *Contributions of the authors:* U.U. conceptualized the research question, conducted the statistical analysis together with T.A. and interpreted the results, and prepared the manuscript. T.A. conducted the analyses related to dietary patterns, interpreted their results and assisted in writing the manuscript. M.-L.O. contributed to the interpretation and reporting of the results. C.K.-K. guided the data collection and data management. M.G.K. assisted in statistical design and guided the statistical analyses. R.V. and O.S. contributed to the writing of the manuscript. M.K. contributed to the analyses and writing of the results. S.M.V. contributed to the research design, interpretation of the results and writing of the manuscript. *Acknowledgements:* We express our gratitude to the families who participated in the study. We wish to thank the DIPP research nurses, doctors, nutritionists and laboratory staff for excellent collaboration. We are grateful to Sirpa Pohjola, Ilona Kalliomäki, Tommi Korhonen and Harri Sinkko for their skilful technical assistance.

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