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Seven distinct dietary patterns identified among pregnant Finnish women – associations with nutrient intake and sociodemographic factors

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Abstract

Objectives: To identify and describe dietary patterns in a cohort of pregnant women and investigate whether the dietary patterns are associated with dietary intake and sociodemographic factors.

Design: Mothers entering the Finnish Type 1 Diabetes Prediction and Prevention (DIPP) Nutrition Study in 1997–2002 were retrospectively asked to complete a food-frequency questionnaire concerning their diet during pregnancy. Principal components analysis was used to identify dietary patterns.

Setting: Finland.

Subjects: Subjects were 3730 women with a newborn infant carrying increased genetic susceptibility to type 1 diabetes mellitus.

Results: Seven factors were identified and named. Energy intake correlated positively with 'Healthy', 'Fast food', 'Traditional bread', 'Traditional meat' and 'Coffee' patterns and inversely with the 'Alcohol and butter' pattern. Intake of dietary fibre correlated positively with 'Healthy', 'Traditional bread' and 'Low-fat foods' patterns and inversely with the 'Alcohol and butter' pattern. The seven dietary patterns seemed to account for relatively large proportions of the variance in energy and nutrient intakes except for the intake of vitamin D, vitamin C, carotenoids and calcium. Maternal age and higher level of education were associated with higher scores on 'Healthy', 'Low-fat foods' and 'Alcohol and butter' patterns.

Conclusion: Principal components analysis produced seven dietary patterns which may be useful for further research concerning maternal diet and health outcomes among both mothers and their offspring.

Keywords
Dietary pattern
Maternal nutrition
Principal components analysis
Sociodemographic factors

Proper nutrition during pregnancy is considered important both for maternal health and foetal growth and development, and hence is addressed by dietary recommendations. An appropriate diet also helps the mother to recover from delivery and supports successful breast-feeding. The traditional way to assess the diet is to examine energy and nutrient intakes or the consumption of certain food items. Dietary pattern analysis is an approach that aims to describe the whole diet in combination. The use of dietary patterns might help to capture some of the complexity of diet that is often lost in nutrient-based analyses[1], and provide additional information in exploring the relationship between nutrition and health. All foods contribute to nutritional status and it is not the presence or absence of a single food but the appropriate selection of foods in suitable quantities and combinations that is important to health[2].

Maternal food and nutrient intake during pregnancy has been investigated, but as far as we know only two studies have used dietary pattern analysis[3,4]. The first was performed among Mexican American mothers and reported seven maternal eating patterns[3]. The second was

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a longitudinal study that found two stable dietary patterns from preconception to postpartum in a small cohort ($n = 80$) of Spanish women[4].

Dietary patterns identified by exploratory factor analysis are reported to account for relatively large proportions of the variance in energy and macronutrient intakes in middle-aged women and men[5], and to relate to many sociodemographic and lifestyle factors both in women and men[4–10]. There is evidence from earlier studies that older, highly educated and non-smoking pregnant women eat more healthily than others[11–15].

The aim of the present study was to identify and describe dietary patterns in a cohort of pregnant Finnish women. We also examined whether the dietary pattern scores vary by energy and nutrient intakes or sociodemographic factors.

Subjects and methods

Subject sample

This analysis represents part of the Nutrition Study within the Finnish Type 1 Diabetes Prediction and Prevention Study (DIPP), which aims to evaluate the effects of both childhood diet and maternal nutrition during pregnancy and lactation on the development of β-cell autoimmunity and type 1 diabetes mellitus in the offspring. All families with newborn infants carrying increased HLA (human leucocyte antigen)-conferred susceptibility to type 1 diabetes (genotype *HLA DQB1*02/*0302* or *HLA DQB1*0302/x*; $x \neq$ **02*, **0301* or **0602*) in the Oulu and Tampere University Hospital regions were invited to participate. The present analysis included mothers who gave birth between October 1997 and December 2002 ($n = 5362$). Complete nutrition information was received from 3730 mothers (70% of those invited), who formed the final study population. Sociodemographic data were collected using a structured questionnaire. Those women who did not provide complete nutritional information were less educated and had more children than those who provided nutritional information. Age and smoking during pregnancy did not differ between these two groups. The mean age of the mothers was 30 years, varying between 16 and 47 years. Selected sociodemographic factors are presented in Table 1.

Table 1 Characteristics of 3730 pregnant Finnish women

Variable	*n*	%
Age at delivery (years)		
<25	723	19
25–29	1277	34
30–34	1103	30
≥35	628	17
Basic education		
No high school degree	1675	45
High school degree	1845	49
Missing data	211	6
Smoking during pregnancy		
No	3214	86
Yes	380	10
Missing data	137	4
Area		
Tampere	2196	59
Oulu	1535	41
Number of earlier deliveries		
0	1668	45
1	1170	31
2 or more	826	22
Missing data	67	2

Data collection and processing

Diet during pregnancy was assessed by a food-frequency questionnaire (FFQ) comprising a list of 181 food items that was validated by Erkkola *et al.*[16]. The FFQ assessed the use of foods or food groups and the consumption frequency (number of times per day, week or month) as common serving sizes. The questionnaire was specifically designed to reflect Finnish food consumption habits. Mothers were asked to answer questions concerning their diet during the month preceding the maternity leave in Finland, i.e. the eighth month of pregnancy. A notice concerning the period of interest was repeated on each page of the questionnaire. Mothers received the questionnaire after delivery and it was returned and checked by a study nurse at the infant's 3-month visit to the study centre. The food consumption data were entered into a dietary database using a software program of the National Public Health Institute, Helsinki, Finland. In-house software with the Fineli national food composition database[17] was used to calculate daily nutrient intakes. The selected frequency category for each food item in the FFQ was converted to a daily intake. The detailed content of the FFQ and data processing have been described elsewhere[16].

Statistical methods

The 181 food items were aggregated into 52 separate food groups (Table 2). The grouping scheme was based on culinary use and nutrient profiles. Principal components analysis with varimax rotation was used to identify patterns among the food groups. The factor model is driven by the idea that correlated variables belong together, and they should be recognised as distinct from groups of variables with which they are not correlated. 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 analyses. After varimax rotation of the factors, food groups with absolute factor loading ≤ -0.2 or ≥ 0.2 were considered as significantly contributing to a pattern. Factor scores were calculated for each person in each pattern in terms of how closely they fit the pattern. Factor scores were computed by weighting

Table 2 Food groupings used in the dietary pattern analysis

Food or food group	Food items included in group
Leafy vegetables	Lettuce
Cabbage	Red and white cabbage, cauliflower, kohlrabi, sauerkraut
Vegetables	Tomato, cucumber, sweet pepper, onion, garlic, corn, avocado, sprouts
Fish	Fish, canned fish, smoked fish
Vegetarian dishes	Vegetable soup, risotto, vegetarian patty
Legumes and mushrooms	Beans, lentils, green peas, mushrooms
Roots	Carrot, vegetable mix, red beet, rutabaga
Berries	Strawberry, blackcurrant, blueberry, lingonberry, gloudberry, berry soup
Salad dressing	Vegetable oil dressing, low-fat dressing, mayonnaise
Poultry	Poultry
Fruits	Orange, apple, banana, pear, peach, grapefruit, plum, pineapple, water melon, kiwi fruit, fruit salad, dried fruit
Rice and pasta	Rice, pasta
Egg	Boiled eggs, fried eggs
Sweets	Sweets
Fast food	Pizza, hamburger, deep-fried meat pasty
Snacks	Crisps, salted nuts, popcorn
Chocolate	Chocolate, chocolate sauce, hot chocolate
Fried potatoes	Fried potatoes, French fries, potato casserole
Soft drinks	Carbonated beverages
Cream	Cream in coffee, whipped cream, ice cream
Fruit juices	Orange juice, apple juice, other fruit juice
White bread	White bread, white crisp roll
Processed vegetables	Vegetable juices, ketchup, pickled vegetables
Light soft drinks	Low-energy carbonated beverages
Savoury	Carelian pastry, cream crackers, pancakes
Low-fat pastry	Low-fat cakes, traditional bunny
Whole-grain bread	Whole-grain soft bread, rye bread, crispbread
High-fat pastry	High-fat cakes, cream cakes, cookies
High-fat cheese	High-fat cheese, special cheese
Sugar and jam	Sugar in coffee, jam, sugar, honey
Berry juices	Berry juices
Meat	Steaks, stews
Nuts and seeds	Nuts, seeds
Breakfast cereals	Breakfast cereals, muesli, porridge
Meat dishes	Meat dishes including potato, rice or pasta
Sausage	Sausage dishes
Potatoes	Boiled potato, baked potato, mashed potato
Processed meat	Cold cuts, bacon, canned meat, smoked meat
Organ meat	Liver, blood
Spread 40–60%	Butter–vegetable oil 40–60%, soft margarine 40–60%
Low-fat cheese	Low-fat cheese, fat-modified cheese
High-fat milk	Whole milk, 1.9% milk
Low-fat milk	Skimmed milk, 1% milk
Butter	Butter, butter–vegetable oil 80%
Low-fat sour milk	Fat-free sour milk, low-fat yoghurt
High-fat sour milk	Sour milk, whole yoghurt
Coffee	Coffee
Milk in coffee	Milk in coffee
Tea	Tea, herbal teas
Beer	Beer, long drink
Wine, liquor	White wine, red wine, dessert wine, spirits
Soft margarine 80	Soft margarine 80%

each factor loading by the factor's eigenvalue, multiplying these weights with the subject's corresponding food group intake, and summing these products. Factor scores were used to rank individuals.

Pearson's correlation coefficients were calculated between dietary patterns and energy and nutrient intakes. Multiple linear regression analysis was used to test how age, educational level, smoking during pregnancy, living area and the number of earlier deliveries explained the variance in pattern scores. All statistical analyses were performed using SPSS for Windows v. 14.0 (SPSS Inc.).

Results

Dietary patterns

Seven factors were identified to describe the dietary patterns of the pregnant Finnish women (Table 3). Collectively these factors explained 29.5% of the variability within the sample. Food items with loadings of ≥0.2 on a factor were considered to have a strong association with that factor. Negative loading (≤−0.2) represents an inverse association between the food item and the factor. The seven factors were named according to the food item

Table 3 Factor loadings ≤−0.2 or ≥0.2 of different food items in the seven dietary factors identified using principal components analysis with varimax rotation

Food item	Healthy	Fast foods	Traditional bread	Traditional meat	Low-fat foods	Coffee	Alcohol and butter
% of variability	7.6	6.1	3.9	3.2	3.1	2.9	2.7
Leafy vegetables	0.577						
Cabbage	0.537						
Vegetables	0.523						
Fish	0.519						
Vegetarian dishes	0.461						
Legumes and mushrooms	0.447						
Roots	0.421						
Berries	0.408		0.204				
Salad dressing	0.398						0.302
Poultry	0.367						
Fruits	0.361						−0.276
Rice and pasta	0.301						
Egg	0.300	0.212					
Sweets		0.595					
Fast food		0.575					
Snacks		0.537					
Chocolate		0.509					
Fried potatoes		0.493					
Soft drinks		0.444					0.225
Cream	0.232	0.370					
Fruit juices		0.346					−0.214
White bread		0.330					
Processed vegetables	0.206	0.321		0.226			
Light soft drinks		0.307			0.205		
Savoury		0.251	0.214				
Low-fat pastry			0.525			0.246	
Whole-grain bread		−0.252	0.502		0.285		
High-fat pastry		0.420	0.451				
High-fat cheese			0.359				
Sugar and jam			0.358				
Berry juices			0.332				
Meat				0.553			
Nuts and seeds	0.320		0.207	−0.539			
Breakfast cereals	0.389		0.288	−0.470			−0.239
Meat dishes	0.257		0.205	0.442			
Sausage		0.222		0.405		0.202	
Potatoes		−0.252	0.310	0.365			
Processed meat		0.225	0.225	0.336	0.321		
Organ meat				0.280			
Spread 40–60%					0.577		
Low-fat cheese	0.283				0.485		
High-fat milk					−0.461	0.281	−0.203
Low-fat milk					0.450		
Butter			0.256		−0.354		0.327
Low-fat sour milk	0.280				0.282		
High-fat sour milk			0.204		−0.250		
Coffee						0.803	
Milk in coffee						0.639	
Tea			0.387			−0.463	
Beer							0.493
Wine, liquor							0.486
Soft margarine 80				0.307	−0.215		−0.371

loadings as 'Healthy', 'Fast foods', 'Traditional bread', 'Traditional meat', 'Low-fat foods', 'Coffee' and 'Alcohol and butter' (Table 3).

Dietary intake and sociodemographic factors

Pattern scores were differently associated with energy and nutrient intakes (Table 4). Energy intake correlated positively with 'Healthy', 'Fast food', 'Traditional bread' and 'Traditional meat' patterns and inversely with the 'Alcohol and butter' pattern. Intake of dietary fibre correlated positively with 'Healthy', 'Traditional bread' and 'Low-fat foods' patterns and inversely with the 'Alcohol and butter' pattern. The seven dietary patterns seemed to account for rather large proportions (over 50%) of the variance in energy and nutrient intakes except for the intake of vitamin D, vitamin C, carotenoids and calcium (Table 4).

Dietary pattern scores were differently associated with age, educational level, smoking during pregnancy, living

Table 4 Pearson correlation coefficients between dietary pattern score and energy and energy-adjusted nutrient intakes, and proportion of explained variance in energy and nutrient intakes in pregnant Finnish women ($n = 3730$)

	Dietary pattern							
Nutrient	Healthy	Fast foods	Traditional bread	Traditional meat	Low-fat foods	Coffee	Alcohol and butter	Proportion of variance explained†
Energy (kJ)	**0.40*****	**0.52*****	**0.59*****	0.24***	0.01	0.09***	−0.12***	86.5
Protein (g)	**0.50*****	0.33***	**0.46*****	0.27***	0.19***	0.11***	−0.15***	71.5
Carbohydrates (g)	0.38***	**0.49*****	**0.59*****	0.12***	0.06***	0.07***	−0.15***	77.3
Sucrose (g)	0.16***	**0.62*****	**0.47*****	0.06***	−0.08***	−0.03	0.001	64.4
Fibre (g)	**0.62*****	0.002	**0.49*****	0.01	0.20***	0.01	−0.19***	69.2
Fat (g)	0.31***	**0.53*****	**0.53*****	0.34***	−0.12***	0.10***	−0.05**	79.3
Saturated fatty acids (g)	0.22***	**0.51*****	**0.57*****	0.26***	−0.18***	0.10***	−0.05**	74.6
n–3 fatty acids (g)	0.38***	0.39***	0.30***	0.34***	−0.08***	0.05**	−0.10***	52.0
Vitamin D (μg)	**0.50*****	0.13***	0.19***	0.19***	0.11***	0.07***	−0.02	35.3
Vitamin E (mg)	**0.61*****	**0.40*****	**0.42*****	0.18***	0.04	0.05**	−0.08***	74.6
Vitamin C (mg)	**0.47*****	0.30***	0.09***	0.05**	−0.04	−0.05**	−0.23***	38.2
Carotenoids (μg)	**0.65*****	0.03	0.06***	0.10***	0.15***	0.01	−0.09***	46.9
Folate (mg)	**0.67*****	0.21***	**0.44*****	0.18***	0.09***	0.07***	−0.19***	79.1
Iron (mg)	**0.55*****	0.21***	**0.54*****	0.21***	0.13***	0.08***	−0.13***	71.6
Magnesium (mg)	**0.55*****	0.26***	**0.50*****	0.13***	0.15***	0.21***	−0.20***	74.4
Zinc (mg)	**0.50*****	0.21**	**0.54*****	0.26***	0.13***	0.12**	−0.20***	73.3
Calcium (mg)	0.31***	0.24***	**0.40*****	0.08***	0.13***	0.11***	−0.23***	39.9
Nitrate (mg)	**0.80*****	−0.01	0.04**	0.13***	0.08***	−0.04	0.06***	67.0
Nitrite (mg)	0.24***	0.26***	0.34***	0.51***	0.16***	0.16***	−0.05**	55.5

** $P < 0.01$, ***$P < 0.001$; the strongest associations (≥0.40 and ≤−0.40) are shown in bold.
†The sum of squared correlations between absolute nutrient intake and pattern scores.

area and the number of earlier deliveries (Table 5). Positive associations were observed for age and the 'Healthy' and 'Alcohol and butter' patterns, while the 'Fast foods' and 'Traditional meat' patterns showed inverse associations. Positive associations were seen between educational level and the 'Healthy', 'Low-fat foods' and 'Alcohol and butter' patterns. Smoking during pregnancy was associated with 'Fast foods', 'Traditional meat' and with the 'Coffee' pattern, in particular. The number of earlier deliveries was positively associated with 'Traditional bread', 'Traditional meat' and 'Coffee' patterns, while inverse associations were observed for 'Fast foods' and 'Low-fat foods' patterns.

Discussion

We have identified and described seven dietary patterns among pregnant Finnish women. The patterns were differently related to energy and nutrient intakes and the sociodemographic factors of the women.

The extensive DIPP birth cohort with a high participation rate provided an excellent opportunity for examining the dietary patterns of pregnant Finnish women. The possible effects of the knowledge that the child carried increased HLA-conferred susceptibility to type 1 diabetes mellitus on maternal dietary habits should be considered. We collected information retrospectively concerning maternal diet during the eighth month of pregnancy, although diet during the early stages of pregnancy is perceived to be more important for foetal growth and development. However, earlier findings regarding maternal diet during pregnancy suggest that dietary patterns do not change significantly from preconception to 6 months postpartum[4]. The FFQ used in this study was developed for the Nutrition Study within the DIPP. To effectively study the putative effects of maternal diet during pregnancy on the development of type 1 diabetes in the offspring, we needed a dietary instrument that could be administered after delivery when the genetic disease susceptibility of the offspring had already been determined. In the validation study by Erkkola *et al.*[16], the correlation coefficients between the second questionnaire, completed 1 month after delivery, and the food records were similar to those obtained between the first questionnaire, completed during the period of interest (eighth month of pregnancy), and the food records.

The influence of current diet is an important possible source of bias for the assessment of remote diet, and the diet during past pregnancy is recalled with perhaps slightly lower accuracy than adult diet generally[18]. However, in the study of Bunin *et al.*[18] the time gap between assessment and the period of interest was 3–7 years whereas it was only a few months in our study. Some recent investigations have reported reasonable validity for questionnaires concerning adolescent diet recalled by adults many years later[19,20].

Dietary pattern analysis is used increasingly in nutritional research but it still has weaknesses. It is well known that factor analysis requires decisions to be made at several steps, starting with aggregation of dietary variables, the number of factors to be retained and

Table 5 Selected sociodemographic factors explaining the variance in dietary pattern scores among pregnant women; regression parameters (95% confidence interval) of multiple linear regression analysis†

Sociodemographic factor	Dietary pattern Model 1 Healthy	Model 2 Fast foods	Model 3 Traditional bread	Model 4 Traditional meat	Model 5 Low-fat foods	Model 6 Coffee	Model 7 Alcohol and butter
Age							
25–29 years vs. <25 years	0.16* (0.06, 0.25)	−0.08 (−0.18, 0.01)	0.07 (−0.03, 0.16)	−0.15* (−0.25, −0.06)	0.21* (0.12, 0.31)	0.05 (−0.05, 0.14)	0.16* (0.06, 0.25)
30–34 years vs. <25 years	0.37* (0.27, 0.47)	−0.18* (−0.28, −0.08)	0.13* (0.03, 0.24)	−0.23* (−0.33, −0.13)	0.24* (0.14, 0.35)	0.17* (0.07, 0.27)	0.37* (0.26, 0.47)
≥35 years vs. 25 years	0.58* (0.46, 0.70)	−0.34* (−0.46, −0.23)	0.12 (−0.002, 0.24)	−0.24* (−0.36, −0.11)	0.17* (0.04, 0.29)	0.14* (0.02, 0.26)	0.59* (0.47, 0.71)
Basic education							
High school graduates vs. no high school degree	0.19* (0.12, 0.26)	−0.09* (−0.16, −0.02)	−0.01 (−0.08, 0.06)	−0.13* (−0.20, −0.06)	0.17* (0.10, 0.24)	−0.21* (−0.28, −0.14)	0.20* (0.13, 0.27)
Smoking during pregnancy							
Smokers vs. non-smokers	−0.27* (−0.38, −0.16)	0.28* (0.18, 0.39)	−0.18* (−0.30, −0.07)	0.19* (0.08, 0.30)	−0.19* (−0.30, −0.08)	0.58* (0.47, 0.69)	−0.05 (−0.16, 0.06)
Area							
Oulu vs. Tampere	−0.19* (−0.26, −0.13)	−0.22* (−0.28, −0.15)	0.21* (0.14, 0.28)	0.06 (−0.01, 0.13)	0.14* (0.07, 0.21)	0.24* (0.17, 0.30)	−0.14* (−0.20, −0.07)
Number of earlier deliveries							
One vs. none	−0.12 * (−0.19, −0.04)	−0.05 (−0.13, 0.02)	0.06 (−0.01, 0.14)	0.38* (0.30, 0.46)	−0.09* (−0.17, −0.01)	0.18* (0.10, 0.26)	0.20* (0.12, 0.27)
Two or more vs. none	−0.10 * (−0.19, −0.003)	−0.30* (−0.39, −0.21)	0.17* (0.07, 0.26)	0.45* (0.35, 0.54)	−0.14* (−0.23, −0.05)	0.35* (0.25, 0.44)	0.14* (0.05, 0.23)
	$R^2 = 0.078$ $F = 36.2$ $P < 0.01$	$R^2 = 0.064$ F 9.1 $P < 0.01$	$R^2 = 0.021$ $F = 9.9$ $P < 0.01$	$R^2 = 0.053$ $F = 23.7$ $P < 0.01$	$R^2 = 0.028$ $F = 13.1$ $P < 0.01$	$R^2 = 0.09$ $F = 43.2$ $P < 0.01$	$R^2 = 0.077$ $F = 35.6$ $P < 0.01$

* Significant ($P < 0.05$).
†Pattern score as a dependent variable and the sociodemographic variables as independent variables.

concluding with naming the factors[21]. These decisions may affect the final results. Patterns are retained in an explorative way rather than established *a priori*, and are therefore unlikely to be reproducible in populations with different dietary habits[5]. On the other hand, Balder *et al.*[22] suggest that some important eating patterns may be shared by various populations.

Dietary patterns have not been reported previously in pregnant Finnish women. In three Finnish cohort studies among women and men[22–24] two important dietary patterns emerged: healthy and traditional. The dietary data of these studies were collected in the 1960s[24] and the 1980s[22,23]. Compared with our results of seven dietary patterns, it can be presumed that today there is more variation in peoples' eating habits than before. This is partly due to the wider selection of food products available and the presence of different eating styles, even during pregnancy.

According to our results it seems that age and education are positively correlated with 'Healthy' and 'Alcohol and butter' dietary patterns, whereas 'Fast foods' shows an inverse association. Earlier findings also revealed that healthy eating patterns are related to older age[6,8,25,26] and higher educational level[6,26] in women and men. However, in the study by Sánchez-Villegas *et al.*[9], higher educational level among women was associated with greater adherence to a 'Western' dietary pattern (similarities with our 'Fast foods' pattern). Smoking was strongly associated with the 'Coffee' and 'Fast foods' dietary patterns. The consumption of coffee was highly correlated with smoking also in pregnant Mexican American women[3], although in that study coffee was omitted from the dietary pattern analysis. Furthermore, social, demographic and lifestyle factors related to the mother have been implicated to have an influence on the early eating patterns of the offspring[2]. It is suggested that food behaviour and concrete food choices are already established in childhood or adolescence and may track significantly into adulthood[23]. This emphasises the importance of identifying risk groups for targeted dietary guidance among mothers.

The seven dietary patterns identified provide a meaningful interpretation of the dietary data among pregnant Finnish women. Dietary patterns offer a framework for further research concerning diet and health outcomes among both mothers and their offspring. Next we will focus on the associations between dietary patterns and maternal weight gain during pregnancy.

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