British Journal of Nutrition (2006), **96**, 913–920
DOI: 10.1017/BJN20061929

Dietary intake and use of dietary supplements in relation to demographic variables among pregnant Finnish women

Tuula Arkkola[1]*, Ulla Uusitalo[2], Minna Pietikäinen[3], Johanna Metsälä[3], Carina Kronberg-Kippilä[2], Maijaliisa Erkkola[3], Riitta Veijola[1], Mikael Knip[4], Suvi M. Virtanen[2,3,5] and Marja-Leena Ovaskainen[2]

[1]*Department of Paediatrics, 90014 University of Oulu, Oulu, Finland*
[2]*Department of Epidemiology and Chronic Disease Prevention, National Public Health Institute, Mannerheimintie 166, 00300 Helsinki, Finland*
[3]*Tampere School of Public Health, 33014 University of Tampere, Tampere, Finland*
[4]*Hospital for Children and Adolescents, 00014 University of Helsinki, Helsinki, Finland*
[5]*Research Unit, Tampere University Hospital, Tampere, Finland*

(Received 4 January 2006 – Revised 11 July 2006 – Accepted 14 July 2006)

Proper nutrition during pregnancy may be important for maternal health and fetal growth and development. In Finland, targeted recommendations are given to guide pregnant women in their food choice and dietary supplement use so that they may obtain adequate nutritional status and meet the increased need for nutrients. The aims of the present study were to examine food choices, nutrient intake and dietary supplement use of pregnant Finnish women in association with demographic variables. One thousand and seventy-five families were invited to a birth cohort study during 1998–9. Mothers of 797 newborns completed a validated 181-item food-frequency questionnaire from which the food and nutrient intakes were calculated. The information about supplement use was collected concerning the whole pregnancy. The results of the present study suggest that healthy food choices are rather common among pregnant Finnish women and the choices are positively correlated with age and education. Nutrient supplements were used by 85 % of the women. Supplements were favoured by the older and well-educated women and by those who had normal weight before pregnancy. Of the women in the present study, 31 % received vitamin A-containing supplements, although it is not recommended during pregnancy. Taking food and supplementation into account, the intake of vitamin D did not meet the dietary recommendation and folic acid intake was below recommendation in 44 % of the women. Therefore there seemed to be unnecessary nutrient supplementation and at the same time lack of relevant supplementation among these pregnant women.

Pregnancy: Food choice: Nutrient intake: Dietary supplement use

Nutrition during pregnancy plays an important role in the wellbeing of the mother and the fetus, and may further influence the health of the babies at a later age (Godfrey & Barker, 1995; Andersson, 2001). Nutrient status, for example, the status of vitamin D, *n*-3 and *n*-6 fatty acids, of the fetus and newborn child is shown to be dependent on maternal intake during pregnancy (Connor *et al.* 1996; Zeghoud *et al.* 1997). The increased nutrient requirements during pregnancy can be met through a healthy and balanced diet with modest adjustments. In Finland the maternal diet during pregnancy is recommended to include fresh vegetables, fruit, berries, wholegrain products, vegetable margarine or oil, fish (two to three times per week), and fat-free milk products (Hasunen *et al.* 1997). Additionally all pregnant women in Finland are recommended to use 10 μg vitamin D supplement from October to March (Advisory Committee of Government, 1998). The requirement of Fe and folate increases during pregnancy as well. The Fe status of all pregnant women is clarified by well-women clinics. If the Hb value is lower than 110 g/l during the first trimester of pregnancy, 50 mg supplemented Fe is recommended. During later stage of pregnancy the cut-off level of Hb is 100 g/l. Folate supplementation (400 μg) is recommended in women with a diet excluding fresh vegetables, fruit, berries and wholegrain products, for chronic users of certain drugs, for subjects with coeliac disease, and if the fetus is at high risk of a neural tube defect. In these cases folate supplementation is recommended from the end of contraception until the twelfth week of pregnancy. If the diet is low in milk and milk products, 500–1000 mg Ca as a supplement is recommended in Finland. If the diet of the pregnant woman is overall poor or insufficient, multivitamin supplementation excluding vitamin A is recommended. Vitamin A-containing supplements, liver and liver products are not recommended because high vitamin A intake may increase the risk of malformation and miscarriage (Hasunen *et al.* 1997). In Finland, women attend well-women clinic about thirteen times during pregnancy. The first visit is after conception, at the eighth to twelfth week of pregnancy.

Abbreviations: DIPP, Diabetes Prediction and Prevention Study; FFQ, food-frequency questionnaire.

* **Corresponding author:** Dr Tuula Arkkola, fax +358 9 47448591, email tuula.arkkola@oulu.fi

Only a few studies have examined food choices during pregnancy. A recent Finnish study suggests that maternal age and education are associated with the composition of the diet (Erkkola *et al.* 1998). Older women had higher intakes of dietary fibre and more educated women consumed more vegetables and fruits during pregnancy (Erkkola *et al.* 1998). During pregnancy, a larger proportion of women (70–87 %) use supplements (Erkkola *et al.* 1998; Ervin *et al.* 1999) than during other phases of life (36–39 %) (Kaartinen *et al.* 1997; Helakorpi *et al.* 1999). The most typical female supplement user seems to be a well-educated woman whose diet is close to the nutritional recommendations (Kaartinen *et al.* 1997; Ervin *et al.* 1999; Kirk *et al.* 1999). Also age has been suggested to be associated with higher supplement use (Timbo *et al.* 1994). However, age and education did not differentiate supplement users and non-users during pregnancy in an earlier Finnish study (Erkkola *et al.* 1998). The most used supplement during pregnancy is Fe (Timbo *et al.* 1994; Erkkola *et al.* 1998; Rogers & Emmett, 1998; Ervin *et al.* 1999) followed by folic acid and vitamin D (Rogers & Emmett, 1998; Mathews *et al.* 2000). In several studies the total intake of vitamin A (Ortega *et al.* 1994; Voyles *et al.* 2000), folic acid (Ortega *et al.* 1994; Berg *et al.* 2001), Zn and vitamin B_{12} (Berg *et al.* 2001) have exceeded the dietary recommendations due to the use of supplements. Upper safe limits are given for the daily consumption of nutrients in order to protect from the harmful symptoms of an extended intake. In Finland the upper safe limit of total vitamin A consumption is 3000 μg/d (Advisory Committee of Government, 2005). An average intake of vitamin A in non-pregnant Finnish women was 926 μg/d in 2002 (Männistö *et al.* 2003).

In the present study we examined food choice, nutrient intake and the use of nutrient supplements in pregnant Finnish women. We also wanted to determine whether maternal age, education level or BMI influence food consumption, nutrient intake or supplement use during pregnancy. Additionally we wanted to see if nutrient supplementation is in accordance with the recommendations.

Subjects and methods

Subjects recruited for the present study are participating in the ongoing type 1 Diabetes Prediction and Prevention (DIPP) study, a large population-based birth cohort study in Finland that started in 1996. The present study has been established to predict the development of type 1 diabetes and to search for means to prevent or delay progression to clinical type 1 diabetes. Families with an infant who carry increased genetic risk (HLA DQB1*02/*0302 or HLA DQB1*0302/×; × ≠ *0301 or *0602) represent about 15 % of the total population and are invited to take part in the DIPP study. Ethical approval for the present study has been obtained from the Ethical Committees of the Universities of Oulu and Tampere (Finland). The nutrition part of the Diabetes Prediction and Prevention study aims at investigating maternal nutrition during pregnancy and lactation as well as the child's nutrition in relation to the natural progression from increased genetic susceptibility to the development of β-cell autoimmunity and eventually to clinical type 1 diabetes. A 1-year birth cohort in 1998–9, 1075 families with an infant with increased genetic risk of type 1 diabetes and born in one of the two Finnish University Hospitals (Tampere and Oulu) were invited to take part in the present study. Altogether 271 pregnant women refused to participate in the study and seven women had filled out the food-frequency questionnaire (FFQ) deficiently and were therefore excluded. Complete nutrition information was received from 797 mothers (74 % of those invited), who comprised the final study population.

The diet during pregnancy was assessed using a validated FFQ (Erkkola *et al.* 2001), comprising a list of 181 food items. The FFQ assessed the use of foods and food groups by frequency of consumption during 1 month. The FFQ focused on past diet, i.e. on the diet during the eighth month of pregnancy, before the working mothers were supposed to be on maternity leave. 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 information about supplement use was collected concerning the whole pregnancy. The mothers received written instructions to record the dietary supplements with brand names, manufacturers of the supplements, amounts of supplements per d, week or month and the month of pregnancy during which the supplements were used. All kinds of dietary supplements which were used as a source of vitamins and minerals, including multivitamins and herbal products, were taken into account. Information on maternal age, education, and weight and height at the first visit in the maternity clinic was also collected. The food consumption data were entered into a dietary database by a software program of the National Public Health Institute and an in-house program was used to calculate daily nutrient intakes. Intakes of energy, protein, total fat, saturated fatty acids, MUFA, PUFA, *n*-3 fatty acids, *n*-6 fatty acids, essential fatty acids (linoleic and α-linoleic acid), carbohydrates, dietary fibre, vitamins A, D, E and C, folic acid, Ca, Fe and Zn were assessed. Information on dietary supplements was obtained from the Finnish pharmacopoeia. Information on dietary supplements other than drugs was obtained from the National Food Administration and from the manufacturers. From the supplements, the intakes of vitamin A, D, E and C, folic acid, Ca, Fe and Zn were calculated.

Statistical analysis

Statistical analysis was carried out with the SPSS for Windows 12.0 program (SPSS Inc., Chicago, IL, USA). The χ^2 test was used to evaluate the relationships between age, education, BMI, smoking status and earlier pregnancies, and supplement use or food consumption habits. ANOVA was used to evaluate the relationships between energy and nutrient intake and the maternal education level. Differences were considered significant at a two-sided $P<0{\cdot}05$.

Results

Characteristics of subjects

The mean age of the pregnant women was 29·6 (SD 5·1) years. Nutrient supplement use was more common among older, more educated, leaner and non-smoking women (Table 1). The number of earlier pregnancies did not affect supplement use.

Table 1. Characteristics of the study population

	All women (*n* 804)		Supplement users (*n* 681)		Non-supplement users (*n* 123)		
	n	%	*n*	%	*n*	%	*P**
Age (years)							0·034
<25	141	17	112	16	29	24	
25–29	278	35	231	34	47	38	
≥ 30	368	46	324	48	44	36	
Missing data	17	2	14	2	3	2	
Basic education							0·018
Less than high school	350	44	285	42	65	53	
High-school degree	426	53	373	55	53	43	
Missing data	28	3	23	3	5	4	
BMI (kg/m^2)†							0·003
< 25	502	63	445	65	57	46	
25–29	196	24	163	24	33	27	
≥ 30	67	8	50	7	17	14	
Missing data	39	5	23	4	16	13	
Smoking during pregnancy							<0·01
No	682	85	599	88	83	67	
Yes	77	9	53	8	24	20	
Missing data	45	6	29	4	16	13	
Earlier pregnancies							0·250
0	324	40	278	41	46	38	
1	258	32	211	31	47	38	
2 or more	192	24	167	25	25	20	
Missing data	30	4	25	3	5	4	

*χ^2 Test.
† Initial antenatal BMI measured at maternal healthcare centres at 6–8 weeks of pregnancy.

Dietary habits

The proportion of women consuming daily or weekly selected food items and food groups is shown by age, education and dietary supplement use in Table 2. About 30 % of the women above 30 years or with a high-school degree consumed the daily recommended portions of vegetables, fruits and berries. The respective proportions were 16 % both among the youngest and among the women with lower education. Consumption of fish and poultry was also more common among older and more educated women. Daily consumption of fruits and berries and weekly consumption of fish were more common among those women who used dietary supplements during pregnancy. Daily consumption of low-fat milk products was more common among women with a high-school degree and among non-supplement users (Table 2).

Nutrient intakes

Most of the women (85 %) complemented their diet with some nutrient supplements during pregnancy. The most common nutrient received from the supplements was Fe (78 %), followed by vitamin D (40 %) and folic acid (39 %) (Table 3). Of the women, 31 % received vitamin A supplementation, but only two women took vitamin A from a single-nutrient supplement. Fe and Ca were most commonly used as a single-nutrient supplement (Table 3). Intake of vitamins and minerals from food and supplements is seen in Table 4. The upper limit of safe intake was exceeded only with supplemental Fe. The upper safety limit of Fe intake (60 mg) was exceeded in 286 women; sixteen of the women took supplemental Fe over 250 mg. Of all the women, 85 % had total vitamin D intake below recommendation. The total folic acid intake was below recommendation in 44 % of the women (Table 4). On average, protein provided 16 %, carbohydrate 47 % and fat 36 % of the total energy intake in the diet of the pregnant women studied. Saturated fatty acids provided 15 %, MUFA 11 % and PUFA 4 % of the total energy intake. The mean intake of dietary fibre was 27·4 g. Women under 25 years received less energy ($P=0·032$), and their energy-adjusted intakes of protein ($P=0·004$) and dietary fibre ($P<0·001$) were smaller and the intake of sugar higher ($P=0·019$) than the intakes of older women. Higher basic education was associated with a higher energy-adjusted intake of carbohydrates, dietary fibre, and *n*-6 fatty acids and lower intakes of total fat and saturated fatty acids (Table 5).

On average women received adequate amounts of the examined vitamins and minerals from food with an exception of vitamin D. Even the total intake of vitamin D (intake from food and supplements) in the supplement users did not meet the dietary recommendation (Fig. 1). Women who were younger than 25 years had lower intakes of vitamin D, vitamin E, folate, Fe, Mg (for all nutrients $P<0·001$) and Zn ($P=0·004$) than older women. Higher basic education was associated with higher intakes of vitamin D, vitamin E (both $P<0·001$) and Fe ($P=0·041$) from food.

Discussion

Nutrient supplements are supposed to be consumed by pregnant women to support their diet. However, the present study revealed that the use of nutrient supplements did not always improve the nutrient intake. Some nutrients were received cumulatively and in large amounts from different

Table 2. Food choices among pregnant women: proportion (%) consuming at least one serving of selected foods daily or weekly by age, education and the use of supplements

	Age (years)					Basic education			Supplement use		
Food or food group	All women (*n* 797)	< 25 (*n* 138)	25–29 (*n* 276)	≥30 (*n* 366)	*P* (χ^2 test)	Less than high school (*n* 373)	High-school degree (*n* 424)	*P* (χ^2 test)	Yes (*n* 679)	No (*n* 118)	*P* (χ^2 test)
Daily consumers (%)											
Low-fat milk products*	54	48	58	55	NS	49	59	<0·01	53	64	0·021
Skimmed milk	39	38	39	40	NS	33	45	<0·01	37	52	<0·01
Rye bread	76	75	74	78	NS	74	78	NS	77	71	NS
Vegetables, fruits and berries (at least five servings)†	24	16	20	29	<0·01‡	16	30	<0·01§	24	19	NS
Vegetables	88	80	88	90	<0·01	83	93	<0·01	87	85	NS
Fruits and berries‖	76	66	77	80	<0·01	69	82	<0·01	78	64	<0·01
Fat spreads	77	77	83	74	0·036	80	76	NS	77	84	NS
Butter	23	24	25	20	NS	21	23	NS	25	22	NS
Soft margarine (> 60 % fat)	43	43	46	39	NS	47	39	NS	41	53	0·014
Soft margarine (≤ 60 % fat)	22	25	19	23	NS	19	25	NS	22	20	NS
Soft drinks (sugary)	4	4	5	4	NS	4	5	NS	5	1	0·041
Sweets	18	21	16	18	NS	18	18	NS	14	19	NS
Weekly consumers (%)											
Fish	48	33	49	54	<0·01§	35	60	<0·01§	50	37	0·011
Poultry	68	51	67	75	<0·01§	58	78	<0·01§	68	68	NS
Sausage	78	78	76	80	NS	82	75	0·014	78	80	NS

* Skimmed milk and low-fat milk products (< 1 % fat).
† Recommendation is at least six servings per d when potato is included.
‡ P=0·004 in logistic regression analysis.
§ Same P value in logistic regression analysis. Apart from those marked, P> 0·05 in logistic regression analysis.
‖ Including fruit and berry juices.

Table 3. Number and proportion of all women (*n* 804) who received each respective nutrient from supplements and the type of supplement used

	Nutrient users*		Type of supplement			
			Single nutrient		Multivitamin	
Nutrient	*n*	%	*n*	%	*n*	%
Vitamin A	247	31	2	0·2	245	31
Vitamin D	325	40	21	3	304	37
Vitamin E	300	37	6	7	294	30
Vitamin C	230	29	31	4	199	25
Folic acid	316	39	37	5	279	34
Fe	623	78	547	68	76	10
Ca	123	15	84	10	39	5

* Of the women studied, 123 (15 %) did not use supplements.

supplements and at the same time some relevant supplementation was missing.

In the present study 85 % of the women used at least one dietary supplement. This proportion parallels the results from the earlier studies in Finnish pregnant women where 67 % (Kara, 1978) and 70 % (Erkkola *et al.* 1998) of the pregnant women reported use of at least one dietary supplement. Prevalence is higher than 36 % that has been found in non-pregnant Finnish women (Kaartinen *et al.* 1997). Of the women, 35 % had used single-Fe supplementation whereas Fe with some other supplement was used by 49 % of the women. Vitamin D and folic acid were the next common supplements used. Fe has been the most common nutrient gained from supplements also in the previous studies (Erkkola *et al.* 1998; Rogers & Emmett, 1998; Mathews *et al.* 2000) followed by folic acid and vitamin D (Rogers & Emmett, 1998; Mathews *et al.* 2000). The use of nutrient supplements was associated with age, education and BMI. Supplements were used mostly by the oldest age group, by the most educated women and by those women who had normal weight before pregnancy. Also in Britain, an association between maternal age and supplement use during pregnancy has been observed (Mathews *et al.* 2000), as in the present study.

Although vitamin D supplementation is recommended to all pregnant women during wintertime, only 40 % of the women studied had used vitamin D supplements during pregnancy and only 15 % of all women had an intake of at least 10 μg/d, as recommended. This is surprising because the data covered the whole year, also the wintertime. One reason for the low compliance with vitamin D supplementation might be inadequate counselling. In an earlier study related to dietary and health counselling in well-women clinics in Finland, only 60 % of the nurses had given advice to use vitamin D supplements (Piirainen *et al.* 2004). The use of vitamin A-containing supplements was surprisingly common in the present study. Vitamin A was received mostly in multivitamin supplements; only two mothers used it as a single-nutrient supplement. Of all women, 31 % received vitamin A from supplements, although vitamin A supplementation is not recommended during pregnancy (Hasunen *et al.* 1997). However, the highest vitamin A intake from supplements remained clearly lower than the highest acceptable daily intake during pregnancy (3000 μg; Nordic Working Group on Diet and Nutrition, 1996).

Table 4. Daily intake of vitamins and minerals from food and supplements during pregnancy, and proportion of the women receiving nutrients below recommendation (Mean values and standard deviations)

	Intake from food				Intake from supplements:supplement users (*n* 679)		Total intake: supplement users (*n* 679)			Recommended daily intake†	Total intake below recommendation†: all women (*n* 797)	
	Supplement users (*n* 679)		Supplement non-users (*n* 118)									
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*P**		*n*	%
Vitamin A (μg)	1731	1035	1785	1556	172	150	1793	1038	0·942	800	74	9
Vitamin D (μg)	5	2·5	4·8	2·6	3·7	3·2	6·7	3·9	<0·01	10	676	85
Vitamin E(mg)	14·4	5·1	14·3	5·2	4·6	7·5	16·5	7·6	<0·01	10	110	14
Vitamin C (mg)	217	117	235	160	64	98	238	137	0·815	70	20	3
Folic acid (μg)	403	129	398	136	111	108	454	164	<0·01	400	349	44
Fe (mg)	18	6·0	17	5·9	59	62	72	62	<0·01	–‡	–‡	–‡
Ca (mg)	1874	721	1960	784	359	267	1939	717	0·780	900	29	4

* By *t* test, comparison of the total nutrient intake between supplement users and non-users.
† Nordic Nutrition Recommendations (Nordic Working Group on Diet and Nutrition, 1996).
‡ No recommendation; approximately 500 mg stored Fe is required during pregnancy.

Table 5. Mean daily intake of energy-yielding nutrients, vitamins and minerals from food during pregnancy by basic education level

(Mean values and standard deviations)

	Basic education				
	Less than high school (*n* 337)		High-school degree (*n* 422)		
Nutrient	Mean	SD	Mean	SD	*P**
Energy (MJ)	11·7	4·0	11·7	3·1	0·916
Energy (kcal)	2793	959	2786	745	0·916
Protein (g/MJ)	9·4	1·2	9·6	1·3	0·277
Carbohydrates (g/MJ)	27·9	3·0	28·3	2·8	0·022
Sugar (g/MJ)	14·9	3·5	14·7	3·2	0·672
Dietary fibre (g/MJ)	2·2	0·7	2·4	0·6	<0·001
Total fat (g/MJ)	9·6	1·3	9·3	1·2	0·003
Saturated fatty acids (g/MJ)	3·8	0·7	3·6	0·6	<0·001
MUFA (g/MJ)	3·4	0·5	3·3	0·5	0·006
PUFA (g/MJ)	1·07	0·21	1·11	0·25	0·046
Total *n*-3 fatty acids (g/MJ)	0·19	0·06	0·20	0·06	0·194
Total *n*-6 fatty acids (g/MJ)	0·85	0·17	0·89	0·20	0·041
Essential fatty acids (g/MJ)	0·99	0·21	1·02	0·24	0·081

* By ANOVA; education level adjusted for mother's age.

The food-frequency method typically overestimates food consumption and nutrient intake, particularly of vegetables, but also the intake of energy and energy-yielding nutrients when compared with food records (Nelson & Bingham, 1997). Although the energy-adjusted nutrient intakes would be more reliable with this kind of method, we present absolute intakes of vitamins and minerals in comparison with the recommendations. Subjects may distort their reported diet for several reasons, which can only be revealed by careful validation of the method (Nelson & Bingham, 1997). The FFQ used in the present study is validated (Erkkola *et al.* 2001). The intake of foods and nutrients was higher as determined by FFQ than that assessed using food records. Pearson correlation coefficients for energy-adjusted nutrients ranged from 0·19 to 0·70 and, for foods, from 0·03 to 0·84. On average, 70 % of the foods and 69 % of the nutrients fell into the same or adjacent quintiles, according to the FFQ and the food record. The validation study by Erkkola *et al.* (2001) suggests that the FFQ represents a useful tool for categorising pregnant women according to their dietary intake. Other FFQ validation studies have reported similar results in pregnant women (Greeley *et al.* 1992; Forsythe & Gage, 1994; Robinson *et al.* 1996). The FFQ evaluated past diet, i.e. the women completed the questionnaire 3 months after

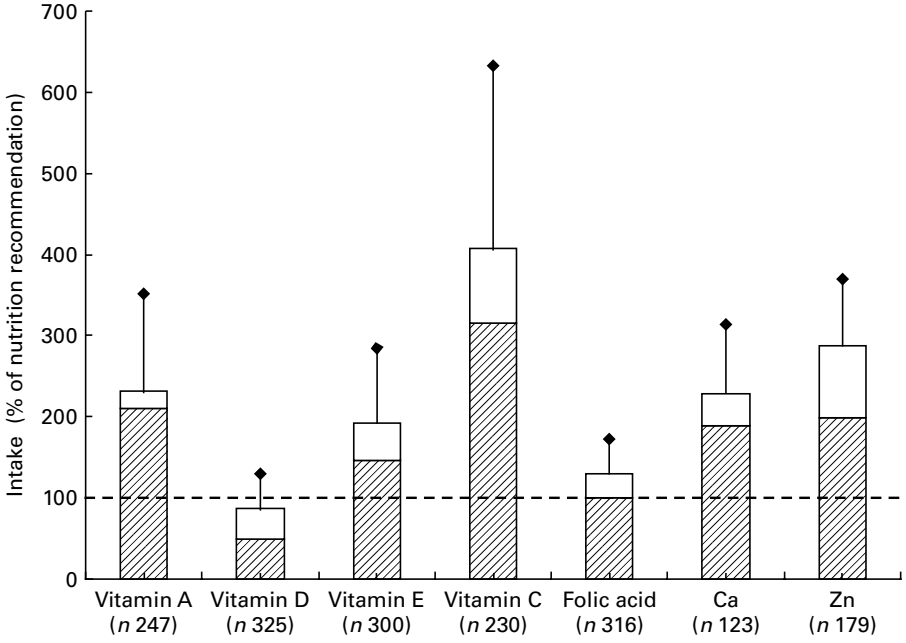

Fig. 1. Intake of vitamins and minerals by supplement users from food only (▨) and from supplements (□) compared with the recommended intake (- - -). Values are means, with their standard errors represented by vertical bars.

the eighth month of pregnancy. Earlier findings by Bunin *et al.* (2001) suggest that the diet during a past pregnancy is recalled rather well even after several years.

Age and education were positively associated with daily consumption of vegetables, fruits and berries in the present study. The same association was found earlier in US pregnant women (Bodnar & Siega-Riz, 2002). Nevertheless, pregnant women consumed fewer servings of vegetables, fruits, berries, and fish than recommended. The consumption of these foods was low also in another study among pregnant US women (Borrud *et al.* 1993). The healthier food choices of the women with higher basic education were reflected in their higher intakes of dietary fibre, and of some vitamins. Type of fat in the diet was also closer to recommendations among the more educated women. Food intake in non-pregnant women using supplements has been characterised with ample use of vegetables and fruits (Elmståhl *et al.* 1996; Kaartinen *et al.* 1997; Lyle *et al.* 1998; Kirk *et al.* 1999), as seen also in the present study.

Our findings suggest that healthy food choices are rather common among Finnish pregnant women and that the increased nutrient requirements during pregnancy are mostly covered by a balanced diet. The use of nutrient supplements did not support the diet in every respect. The present study discovered both unnecessary nutrient supplementation and lack of relevant supplementation among Finnish pregnant women. Vitamin A was received, mostly in multivitamin supplements, although it is not recommended. The intake of vitamin D (food and supplementation) did not meet the dietary recommendation and almost half of the women received folic acid below recommendation. These results suggest that the proper assessment of pregnant women's dietary habits is important for targeted counselling and more precise advice on supplement use in well-women clinics.

Acknowledgements

We are grateful to all the mothers, study nurses and research scientists who took part in the present study. The DIPP Nutrition study was supported by the Academy of Finland, the Finnish Diabetes Association, the Finnish Diabetes Research Foundation, the Finnish Paediatric Research Foundation, the Häme Foundation of the Finnish Culture Fund, the Juho Vainio Foundation, the Medical Research Fund of Tampere University Hospital, the Yrjo Jahnsson Foundation and the Alma and K.A. Snellman Foundation. The DIPP Core study was supported by Special Public Grants for Medical Research at the participating university hospitals, the Academy of Finland (grants 63672, 79685, 79686, 80846, 201988, 210632), the Juvenile Diabetes Research Foundation International (grants 197032 and 4-1998-274), the Novo Nordisk Foundation and EU Biomed 2 (BMH4-CT98-3314).

References

Advisory Committee of Government (1998) *Finnish Nutrition Recommendations* (publication in Finnish). Helsinki: Edita.

Advisory Committee of Government (2005) *Finnish Nutrition Recommendations – Diet and physical activity in balance*. Helsinki: Edita.

Andersson AS (2001) Symposium on nutritional adaptation to pregnancy and lactation: pregnancy as a time for dietary change? *Proc Nutr Soc* **60**, 497–504.

Berg MJ, van Dyke DC, Chenard C, Niebyl JR, Hirankarn S & Bendich A (2001) Folate, zinc, and vitamin B_{12} intake during pregnancy and postpartum. *J Am Diet Assoc* **101**, 242–245.

Bodnar LM & Siega-Riz AM (2002) A diet quality index for pregnancy detects variation in diet and differences by sociodemographic factors. *Public Health Nutr* **5**, 801–809.

Borrud LG, Krebs-Smith SM, Friedman L & Guenther PM (1993) Food and nutrient intakes of pregnant and lactating women in the United States. *J Nutr Educ* **4**, 176–185.

Bunin GR, Gyllstrom ME, Brown JE, Kahn EB & Kushi LH (2001) Recall of diet during past pregnancy. *Am J Epidemiol* **154**, 1136–1142.

Connor WE, Lowensohn R & Hatcher L (1996) Increaced docosahexaenoic acid levels in human newborn infants by administration of sardines and fish oil during pregnancy. *Lipids* **31**, S183–S187.

Elmståhl S, Wallström P, Berglund G, Janson L, Johansson U & Larsson SA (1996) The use of dietary supplements in relation to dietary habits in a Swedish middle-aged population. *Scand J Nutr* **38**, 94–97.

Erkkola M, Karppinen M, Järvinen A, Knip M & Virtanen SM (1998) Folate, vitamin D, and iron intakes are low among pregnant Finnish women. *Eur J Clin Nutr* **52**, 742–748.

Erkkola M, Karppinen M, Javanainen J, Räsänen L, Knip M & Virtanen SM (2001) Validity and reproducibility of a food frequency questionnaire for pregnant Finnish women. *Am J Epidemiol* **154**, 466–476.

Ervin RB, Wright JD & Kennedy-Stephenson J (1999) Use of dietary supplements in the United States, 1988–94. *Vital Health Stat* **11**, 1–14.

Forsythe HE & Gage B (1994) Use of a multicultural food-frequency questionnaire with pregnant and lactating women. *Am J Clin Nutr* **59**, S203–S206.

Godfrey KM & Barker DJP (1995) Maternal nutrition in relation to fetal and placental growth. *Eur J Obstet Gynecol Reprod Biol* **61**, 15–22.

Greeley S, Storbakken L & Mael R (1992) Use of a modified food frequency questionnaire during pregnancy. *J Am Coll Nutr* **11**, 728–734.

Hasunen K, Kalavainen M & Keinonen H (1997) Lapsi, perhe ja ruoka. *Dietary Recommendations for Children aged 0-5 and Pregnant and Lactating Women* (publication in Finnish). Helsinki: Ministry of Social Affairs and Health.

Helakorpi S, Uutela A & Prättälä R (1999) *Health Behaviour Among Finnish Adult Population* (publication in Finnish). Helsinki: National Public Health Institute.

Kaartinen P, Ovaskainen ML & Pietinen P (1997) The use of dietary supplements among Finnish adults. *Scand J Nutr* **41**, 13–17.

Kara R (1978) *Food Consumption in Lactating Mothers in Helsinki and Effect of Trace Nutrients in Milk Composition* (in Finnish). Masters Thesis, Department of Nutrition, University of Helsinki.

Kirk SF, Cade JE, Barrett JH & Conner M (1999) Diet and lifestyle characteristics associated with dietary supplement use in women. *Public Health Nutr* **2**, 69–73.

Lyle BJ, Mares-Perlman JA, Klein BE, Klein R & Greger JL (1998) Supplement users differ from nonusers in demographic, lifestyle, dietary and health characteristics. *J Nutr* **128**, 2355–2362.

Männistö S, Ovaskainen M & Tapanainen L (2003) *Finnravinto 2002 – Study*. National Public Health Institute B3/2003. Helsinki: National Public Health Institute.

Mathews F, Yudkin P, Smith RF & Neil A (2000) Nutrient intake during pregnancy: the influence of smoking and age. *J Epidemiol Community Health* **54**, 17–23.

Nelson M & Bingham SA (1997) Assessment of food consumption and nutrient intake. In *Design Concepts in Nutritional Epidemiology*,

pp. 123–169 [BM Margetts and M Nelson, editors]. Oxford, UK: Oxford University Press.

Nordic Working Group on Diet and Nutrition (1996) Nordic Nutrition Recommendations. *Scand J Nutr* **40**, 161–165.

Ortega RM, Gaspar MJ & Moreiras O (1994) Dietary assessment of a pregnant Spanish women group. *Int J Vit Nutr Res* **64**, 130–134.

Piirainen T, Isolauri E, Huurre A, Hoppu U & Laitinen K (2004) Dietary and health counselling in well-women (WW) and well-baby (WB) clinics in Finland (article in Finnish). *Suomen Lääkärilehti* **59**, 2047–2053.

Robinson S, Godfrey K, Osmond C, Cox V & Barker D (1996) Evaluation of a food frequency questionnaire used to assess nutrient intakes in pregnant women. *Eur J Clin Nutr* **50**, 302–308.

Rogers I & Emmett P (1998) Diet during pregnancy in a population of pregnant women in South West England – Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC). *Eur J Clin Nutr* **52**, 246–250.

Social and Health Ministry (1995) *Folic Acid and Neural Tube Defect*. Recommendations from the Expert Group (in Finnish). Helsinki: Ministry of Health and Social Affairs.

Timbo B, Altekruse S, Hyman F, Klontz K & Tollefson L (1994) Vitamin and mineral supplementation during pregnancy. *Mil Med* **159**, 654–658.

Voyles LM, Turner RE, Lukowski MJ & Langkamp-Henken B (2000) High levels of retinol intake during the first trimester of pregnancy result from use of over-the-counter vitamin/mineral supplements. *J Am Diet Assoc* **100**, 1068–1070.

Zeghoud F, Vervel C, Guillozo H, Walrant-Debray O, Boutignon H & Garabedian M (1997) Subclinical vitamin D deficiency in neonates: definition and response to vitamin D supplements. *Am J Clin Nutr* **65**, 771–778.