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Original Article

Effects of dietary counselling on food habits and dietary intake of Finnish pregnant women at increased risk for gestational diabetes – a secondary analysis of a cluster-randomized controlled trial

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Abstract

The incidence of gestational diabetes mellitus (GDM) is increasing and GDM might be prevented by improving diet. Few interventions have assessed the effects of dietary counselling on dietary intake of pregnant women. This study examined the effects of dietary counselling on food habits and dietary intake of Finnish pregnant women as secondary outcomes of a trial primarily aiming at preventing GDM. A cluster-randomized controlled trial was conducted in 14 municipalities in Finland, including 399 pregnant women at increased risk for developing GDM. The intervention consisted of dietary counselling focusing on dietary fat, fibre and saccharose intake at four routine maternity clinic visits. Usual counselling practices were continued in the usual care municipalities. A validated 181-item food frequency questionnaire was used to assess changes in diet from baseline to 26–28 and 36–37 weeks gestation. The data were analysed using multilevel mixed-effects linear regression models. By 36–37 weeks gestation, the intervention had beneficial effects on total intake of vegetables, fruits and berries (coefficient for between-group difference in change 61.6 g day^{-1}, 95% confidence interval 25.7–97.6), the proportions of high-fibre bread of all bread (7.2% units, 2.5–11.9), low-fat cheeses of all cheeses (10.7% units, 2.6–18.9) and vegetable fats of all dietary fats (6.1% -units, 2.0–10.3), and the intake of saturated fatty acids (–0.67 energy-%-units, –1.16 to –0.19), polyunsaturated fatty acids (0.38 energy-%-units, 0.18–0.58), linoleic acid (764 mg day^{-1}, 173–1354) and fibre (2.07 g day^{-1}, 0.39–3.75). The intervention improved diet towards the recommendations in pregnant women at increased risk for GDM suggesting the counselling methods could be implemented in maternity care.

Keywords: pregnancy, cluster-randomized controlled trial, dietary counselling, food habits, dietary intake, gestational diabetes mellitus.

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Introduction

Gestational diabetes mellitus (GDM) is defined as 'carbohydrate intolerance with recognition or onset during pregnancy' (Metzger & Coustan 1998) and it is one of the major pregnancy complications (American Diabetes Association 2006). GDM affects 2–14% of pregnancies and the prevalence seems to increase worldwide (Ferrara 2007). Prevention of GDM is important as GDM increases the risk for type 2 diabetes in the mother (Kim *et al*. 2002) and the risk for macrosomia and later overweight and type 2 diabetes in the offspring (Dabelea 2007). Major risk factors of GDM are high maternal age, family history of type 2 diabetes and pre-pregnancy overweight (American Diabetes Association 2003).

There is some evidence from observational studies that high intake of saturated and low intake of polyunsaturated fatty acids may increase the risk for developing GDM (Wang *et al*. 2000; Bo *et al*. 2001; Saldana *et al*. 2004), although this has not been observed in all studies (Radesky *et al*. 2008). One recent review article concludes that high intake of fat and low intake of carbohydrates appear to increase the risk of GDM (Morisset *et al*. 2010). Self-reported physical activity prior to pregnancy and in early pregnancy is associated with decreased risk of GDM (Tobias *et al*. 2011). However, more evidence is needed on the associations of diet and physical activity to the risk of GDM (Morisset *et al*. 2010). High gestational weight gain may also increase the risk of GDM (Hedderson *et al*. 2010) or impaired glucose tolerance during pregnancy, possibly by reducing insulin sensitivity (Herring *et al*. 2009).

GDM might be prevented by improving diet, keeping physically active and avoiding excessive weight gain during pregnancy. To date, 13 intervention studies have aimed at preventing GDM by dietary means (Oostdam *et al*. 2011). These studies suggest that dietary interventions may reduce the incidence of GDM, but the evidence is inconclusive because of small sample sizes, diverse interventions and diverse outcomes in these trials. On the other hand, the effects of dietary counselling on food habits and/or dietary intake in pregnant women have been reported in few trials only (Piirainen *et al*. 2006; Kinnunen *et al*. 2007; Wolff *et al*. 2008; Jackson *et al*. 2011; Korpi-Hyovalti *et al*. 2011) and counselling had some effects on the diets of the participants in all these studies.

This study is a part of a cluster-randomized controlled trial aimed at preventing GDM by counselling the participants on diet, physical activity and gestational weight gain (Luoto *et al*. 2010, 2011). The effects of the intervention on the primary outcomes of the trial, i.e. the proportion of participants developing GDM or giving birth to a large-for-gestational-age baby, or several secondary outcomes including energy-yielding nutrients and fibre intakes, have previously been reported by Luoto *et al*. (2011). We aimed to study whether intensified dietary counselling at four routine maternity clinic visits had an effect on secondary outcomes such as food habits and the intake of energy, energy-yielding nutrients, fibre, selected fatty acids and cholesterol at 26–28 and at 36–37 weeks gestation in Finnish pregnant women at increased risk for developing GDM.

Materials and methods

Study design

This study was a cluster-randomized controlled trial aiming to prevent GDM among a risk group in Pirkanmaa region, Southern Finland. The methods of this study have been reported in detail previously (Luoto *et al*. 2010). The study was conducted in primary health care maternity clinics in 14 municipalities in 2007–2009. Ten municipalities in the region were ineligible to participate because of low birth rate (<70 births/year) (Fig. 1). The participating municipalities were arranged into pairs which were matched for the size and socio-economic level of the population, annual number of births, incidence of GDM and the location (rural/urban area). Within each pair, the municipalities were randomized by computer to intervention or to usual care municipalities. Cluster randomization was applied in order to reduce the possibility of contamination of counselling practices of the nurses. No one was blinded to group assignment. The study protocol was approved by the ethical

Key messages

- Dietary counselling was effective in improving food habits, the quality of dietary fat and fibre intake among pregnant women at increased risk for GDM.
- The counselling was carried out by public health nurses at routine visits to municipal maternity care, which improves the applicability of the method and the results to usual care at least in comparable settings.
- To improve the health of mothers and their offspring, pregnant women should have access to adequate dietary counselling services with trained health care specialists.

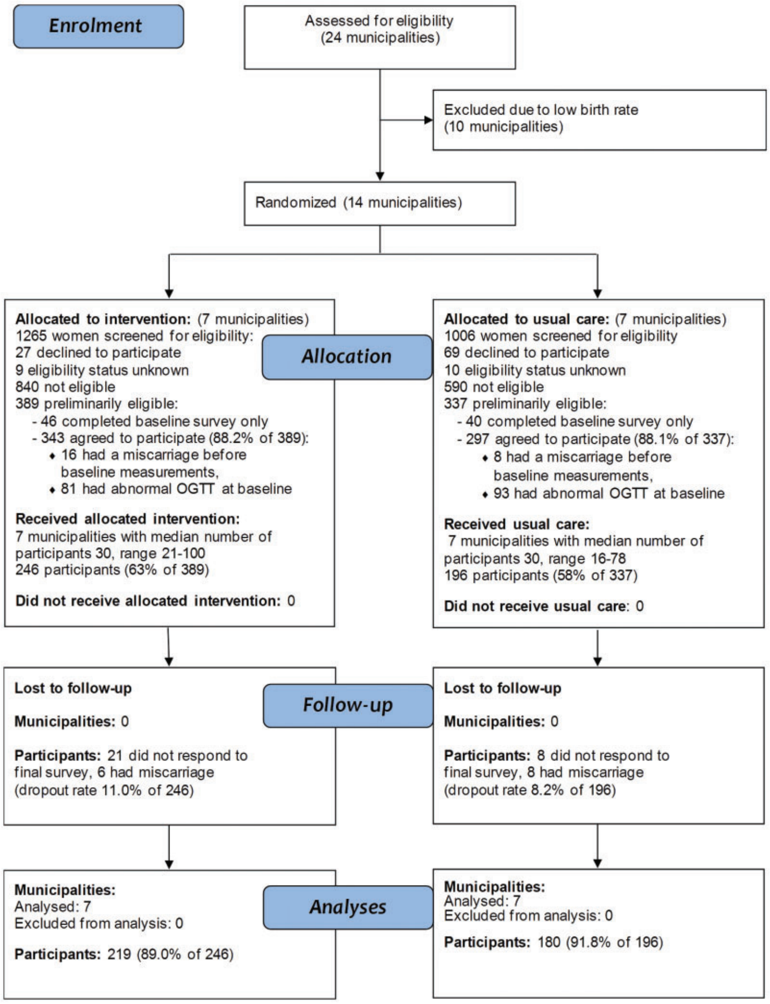

Fig. 1. Flow diagram of the cluster randomized trial. OGTT, oral glucose tolerance test.

committee of Pirkanmaa Hospital District and all participants provided a written informed consent.

Participants

At each clinic, public health nurses ($n = 53$) implemented the intervention and facilitated the data collection. Public health nurses are registered nurses with 4-year training and they are specialized, e.g. in health promotion. They recruited pregnant women at their first visit (8–12 weeks gestation) to participate in the study. Pregnant women were eligible for the study if they had at least one of the following risk factors: body mass index (BMI) $\geq$ 25 kg m^{-2}, age $\geq$40 years, GDM, or any sign of glucose intolerance or a macrosomic baby ($\geq$4500 g) in any previous pregnancy or type 1 or type 2 diabetes in first or second grade relatives. Women were excluded if they had at least one of the following: a pathological result in the baseline oral glucose tolerance test (OGTT) at 8–12 weeks gestation (Duodecim 2008), pre-pregnancy type 1 or 2 diabetes, inability to speak Finnish, age <18 years, twin pregnancy, physical restriction that prevents from exercising, substance abuse, or treatment or clinical history for major psychiatric illness or other chronic disease.

Of all 2271 women screened for the study, 389 (30.8%) in the intervention group and 337 (33.5%) in the usual care group were preliminarily eligible to participate in the study (Fig. 1). Of them, 343 (88.2%)

in the intervention and 297 (88.1%) in the usual care groups gave an informed consent to participate in the trial (numbers were corrected after Luoto *et al*. 2011 was published). However, 81 (23.6%) of the participants in intervention group and 93 (31.3%) of the participants in the usual care group were excluded because of an abnormal OGTT result already at baseline (8–12 weeks gestation). Finally, 219 participants in the intervention group and 180 participants in the usual care group were included in the analyses (89.0% and 91.8% of participants receiving the allocated intervention or usual care, respectively) (Fig. 1).

Intervention

The intervention included individual counselling on gestational weight gain, physical activity and diet by the public health nurses during five routine visits to the maternity clinics (Luoto *et al*. 2010). The recommendations on gestational weight gain (Institute of Medicine 1990) and an individual BMI-specific chart for follow-up of weight gain were introduced to the participants at the first visit (8–9 weeks gestation). Physical activity counselling was also initiated at the first visit and enhanced at four subsequent visits. Briefly, the aims of the physical activity counselling were to increase leisure time physical activity of those participants who were inadequately active to the level of the physical activity recommendations for health (Artal & O'Toole 2003) and to maintain or adjust leisure time physical activity of those participants who were adequately active as compared with the recommendations. The participants were advised to include in their plans activities for at least 800 MET (multiples of resting metabolic equivalents) min week^{-1}, which corresponds e.g. to moderate intensity activity approximately for 30 min five times a week.

The primary dietary counselling session (20–30 min) took place at 16–18 weeks gestation and at three subsequent sessions (10–15 min each) at 22–24, 32–34 and 36–37 weeks gestation. The aim of the dietary counselling was to help the participants to achieve a diet containing saturated fat ≤10% of energy intake, polyunsaturated fat 5–10% of energy intake, total fat (including saturated, monounsaturated, polyunsaturated and trans fatty acids) 25–30% of energy intake, saccharose <10% of energy intake and fibre 25–35 g day^{-1} (Wang *et al*. 2000; Bo *et al*. 2001; Tuomilehto *et al*. 2001; Saldana *et al*. 2004; National Nutrition Council 2005).

The practical recommendations given to the participants were (1) to eat vegetables, fruits and berries, preferably at least five portions (a total of 400 g) a day; (2) to select mostly high-fibre bread (>6 g fibre/100 g) and other whole-meal products; (3) to select mostly fat-free or low-fat milk and milk products and of meat and meat products; (4) to eat fish at least twice a week (excluding the fish species not recommended for pregnant women); (5) to use moderate amounts of soft vegetable spreads on bread, oil-based salad dressing in salad, and oil in cooking and baking; (6) to use foods high in fat seldom and only in small portion sizes; and (7) to use snacks containing lots of sugar and/or fat seldom and only in small portion sizes.

At each counselling session, the participants set their individual plans for dietary changes, recorded them in their personal follow-up notebooks and kept record of their adherence to the plan until the next counselling session. The counselling procedure and the materials have previously been described in detail (Luoto *et al*. 2010). In the usual care clinics, the public health nurses continued their usual counselling practices.

Outcome variables and measurement of dietary intake

The secondary outcome variables related to food habits were the consumption of (1) vegetables, fruits and berries (g day^{-1}); (2) high-fibre bread (% of all bread); (3a) fat-free or low-fat milk (% of all milk), (3b) low-fat cheese (% of all cheese), (3c) low-fat meat and low-fat meat products (% of all meat and meat products); (4) frequency of eating fish per week; (5) vegetable fats (% of all dietary fat); (6) high-fat foods (g day^{-1}); and (7) snacks high in sugar and/or fat (g day^{-1}). The secondary outcome variables related to nutrients were the intake of saturated fat, polyunsaturated fat, total fat, saccharose and fibre. Food habits were assessed by using a validated self-administered, semi-quantitative 181-item food frequency questionnaire (FFQ) (Erkkola *et al*. 2001). The FFQ was originally developed to assess maternal diet at the eighth month of the pregnancy and to be completed at 1–3 months post-partum. In this study, the participants completed the FFQ at 8–12, 26–28 and 36–37 weeks gestation and the FFQ was modified to cover different time periods. At baseline, the women were asked questions about their diet during 1 month prior to the pregnancy, since their diet may have changed due to nausea or vomiting at the beginning of the pregnancy. In both follow-up questionnaires, the questions covered the previous month. The first and second FFQs were completed while attending the OGTT, and the last FFQ was completed at home and returned by mail. The FFQs were checked by a nutritionist and when there were more than 10 missing values in the frequency data, the FFQ was completed after consulting the participant on the phone. In each FFQ, detailed information was elicited on the frequency of use (per day, week, month or not at all) and the portion sizes of specific food items (in natural units, common household measures or portions). The FFQ data were firstly entered into a food database using a software program of the National Institute for Health and Welfare, Helsinki, Finland, and coded to daily food record form. All food and nutrient intakes were calculated by using the 10th release (i.e. the version updated in 2009) of the Finnish Food Composition Database Fineli (http://www.fineli.fi) and in-house software of the National Institute for Health and Welfare, Helsinki. The participants' personal choices for fat used in cooking and baking were taken into account when calculating nutrient intakes. By using this FFQ, it was possible to evaluate changes in all the dietary variables described above, except for low-fat meat and low-fat meat products.

Statistical methods

The data were analysed in the originally assigned groups as far as outcome data were available. Descriptive information is reported as means (SD) for continuous variables and as frequencies (%) for categorical variables. Between-group differences in changes in all dietary outcomes from baseline to the follow-ups were examined using multilevel mixed-effects linear regression models enabling correction of the results for between-municipality, between-clinic and between-nurse variation. In each model, the change in the particular variable from baseline to the follow-up was used as the outcome variable and the model was adjusted for the baseline level of the variable (and also baseline energy intake when analysing changes in fatty acids or cholesterol). The between-group differences in changes are described as coefficients, 95% confidence intervals (CI) and *P*-values. The coefficients describe the magnitude of the between-group differences in changes in the outcomes and the unit of the coefficient is the same as the unit of the outcome variable. We also performed models in which all analyses were adjusted for maternal age, BMI (both continuous), parity, education, smoking status and working status (all categorical), but the results were essentially similar and are therefore not presented here.

The 36–37 weeks FFQ data were available for 181 of 246 participants (73.6%) allocated to intervention and for 156 of 196 participants (79.6%) allocated to usual care. Dropout analyses were conducted by comparing all participants for whom the 36–37 weeks FFQ data were available ($n = 337$) to participants for whom it was not available ($n = 105$ including all dropouts who were eligible and had signed the informed consent). Background characteristics, food habits and dietary intakes both at baseline and at 26–28 weeks gestation were compared between these groups and tested statistically by using independent samples *t*-test or Mann–Whitney *U*-test for continuous variables and χ^2-test for categorized variables. As the study may not have had enough power for the dropout analyses, we also report the most relevant non-significant differences that might be of practical importance.

All analyses were performed using STATA software (version 11.2), StataCorp, LP, Texas, USA, except that the dropout analyses were performed using SPSS software (version PASW Statistics 18.0) for Windows (SPSS Inc., Chicago, IL, USA).

Results

Background characteristics of the participants

The background characteristics of the participants are described in Table 1. The mean age was 30 years and

Table 1. Background characteristics of the study population, means (SD) or numbers (%)

	Intervention group ($n = 219$)*	Usual care group ($n = 180$)†
Age, years	29.5 ± 4.8	30.0 ± 4.7
Parity, *n* (%)		
0	103 (47.0)	73 (40.6)
1	76 (34.7)	62 (34.4)
≥2	40 (18.3)	45 (25.0)
Pre-pregnancy BMI, (kg m^{-2})	26.2 ± 4.9	26.4 ± 4.4
BMI categories, *n* (%)		
Underweight, BMI <20.0 kg m^{-2}	12 (5.5)	8 (4.4)
Normal weight, BMI 20.0–26.0 kg m^{-2}	109 (50.0)	82 (45.6)
Overweight, BMI >26.0 kg m^{-2}	97 (44.5)	90 (50.0)
Education, *n* (%)		
Basic or secondary education	107 (49.5)	92 (52.6)
Polytechnic education	51 (23.6)	47 (26.9)
University degree	58 (26.9)	36 (20.6)
Working fulltime, *n* (%)	147 (67.1)	104 (57.8)
Smoking status, *n* (%)		
Non-smoker	169 (77.2)	128 (71.1)
Smoker during the year before pregnancy‡	36 (16.4)	41 (22.8)
Smoker during the year before pregnancy and during pregnancy‡	14 (6.4)	11 (6.1)

BMI, body mass index; SD, standard deviation. *Number of missing values: age, BMI and BMI categories ($n = 1$), education ($n = 3$). †Number of missing values: education ($n = 5$). ‡Includes daily or occasional smoking.

mean BMI 26 kg m^{-2} in both groups. There were more women with no previous children and fewer women with at least two previous children in the intervention group than in the usual care group. The participants in the intervention group had more often a university degree and they were more often working full-time than women in the usual care group. There were more non-smokers and less previous smokers in the intervention group than in the usual care group, but the proportion of women who continued smoking during pregnancy was the same (6%) in both groups.

Changes in food habits

Table 2 shows the between-group differences in average changes in food habits related to the seven objectives of the dietary counselling. By the first follow-up at 26–28 weeks gestation, the intervention group had increased the proportion of high-fibre bread of all bread (a difference of 7% units between the groups) and vegetable fats of all dietary fat in their diet (a difference of 6% units between the groups) compared with the usual care group. The intervention group also maintained the proportion of low-fat cheeses of all cheeses in their diet and the intake of snacks high in sugar and/or fat, while the usual care group had decreased the proportion of low-fat cheeses (a difference of 11% units between the groups) and increased the intake of those snacks in their diet (a difference of 27 g day^{-1} between the groups).

The results were essentially the same when assessing average changes from baseline to the second follow-up at 36–37 weeks gestation (Table 2). The only exceptions were that the total intake of vegetables, fruits and berries increased by 62 g day^{-1} in the intervention group compared with the usual care group and the between-group differences in changes in the intake of snacks high in sugar and/or fat was no longer statistically significant. The between-group differences in average changes in food habits are described in more detail in Table 3. By 26–28 weeks gestation, the usual care group had increased the consumption of porridge and breakfast cereals by 25 g day^{-1} compared with the intervention group. The intervention group had increased the total intake of milk by 50 g day^{-1}, fish by 3 g day^{-1}, vegetable oils by 1.4 g day^{-1} and oil or mayonnaise-based salad

Table 2. Between-group differences in changes in food habits related to the objectives of dietary counselling, means (SD)

	Baseline		26–28 weeks gestation		Group difference in change from baseline to 26–28 weeks gestation			36–37 weeks gestation		Group difference in change from baseline to 36–37 weeks gestation		
	Intervention group ($n = 217–219$)	Usual care group ($n = 174–178$)	Intervention group ($n = 208–210$)	Usual care group ($n = 175–179$)	Coefficient (95% CI)	*P*-value*	ICC†	Intervention group ($n = 177–181$)	Usual care group ($n = 150–156$)	Coefficient (95% CI)	*P*-value*	ICC†
1. Vegetables, fruits and berries (g day^{-1})‡	486 (249)	525 (248)	522 (256)	521 (251)	31.3 (−7.8 to 70.5)	0.117	0.000	518 (230)	483 (217)	61.6 (25.7–97.6)	0.001	0.002
2. High-fibre bread§ (% of all bread)	63.4 (25.2)	64.4 (24.4)	67.5 (23.1)	60.9 (25.3)	7.0 (3.0–11.0)	0.001	0.000	66.7 (24.4)	60.3 (24.3)	7.2 (2.5–11.9)	0.003	0.021
3a. Fat-free or low-fat milk (% of all milk¶)	65.7 (33.6)	61.7 (35.8)	68.0 (29.8)	61.7 (35.8)	4.1 (−6.8 to 8.8)	0.093	0.001	71.0 (30.8)	67.4 (34.2)	1.3 (−4.0 to 6.6)	0.630	0.002
3b. Low-fat cheese** (% of all cheese)	44.4 (41.5)	40.9 (41.4)	43.5 (37.1)	30.2 (35.1)	10.6 (4.5–16.8)	0.001	0.005	49.9 (42.7)	37.8 (40.2)	10.7 (2.6–18.9)	0.009	0.023
4. Frequency of eating fish per week	1.3 (1.0)	1.4 (1.2)	1.4 (1.1)	1.4 (1.0)	0.18 (−0.05 to 0.41)	0.120	0.027	1.6 (1.0)	1.5 (1.1)	0.20 (−0.01 to 0.41)	0.068	0.001
5. Vegetable fats (% of all dietary fat)††	53.2 (24.1)	55.3 (23.5)	58.4 (20.8)	53.6 (23.2)	5.9 (2.3–9.5)	0.001	0.003	56.8 (22.2)	52.2 (25.4)	6.1 (2.0–10.3)	0.003	0.000
6. High-fat foods (g day^{-1})‡‡	66.4 (33.3)	76.6 (47.5)	66.0 (36.4)	69.5 (35.7)	1.5 (−5.1 to 8.1)	0.664	0.000	64.4 (32.2)	63.7 (35.7)	5.1 (−1.1 to 11.4)	0.108	0.011
7. Snacks high in sugar and/or fat (g day^{-1})§§	108 (105)	136 (125)	108 (78)	148 (138)	−27.1 (−50.4 to −3.9)	0.022	0.053	132 (153)	161 (165)	−11.7 (−50.2 to 26.8)	0.551	0.025

CI, confidence interval; ICC, intracluster correlation coefficient; SD, standard deviation. *Multilevel mixed-effects linear regression models taking into account the between-municipality, between-clinic and between-nurse variation and adjusting for the baseline level of the variable †Intracluster correlation coefficient. ‡Excluding juice and potatoes. §Including rye bread and crisp bread. ¶Including milk, sour milk and yoghurt, excluding milk used in cooking. Low-fat milk refers to milk with ≤1% of fat. **Including vegetable-fat cheese and other low-fat cheese, excluding cottage cheese. ††Dietary fat includes all fat used on bread or in cooking or baking (vegetable spreads, vegetable oils, butter, butter mixtures, solid baking margarines) and oil-based salad dressings. ‡‡Including foods such as pizza, hamburgers, French fries, chips, bacon, sausage. §§Including e.g. candies, high-sugar drinks, cookies, ice cream, sweet pastries.

Table 3. Between-group differences in changes in the daily consumption (g) of the main food groups and foods, means (SD)

	Baseline		26–28 weeks gestation		Group difference in change from baseline to 26–28 weeks gestation		36–37 weeks gestation		Group difference in change from baseline to 36–37 weeks gestation	
	Intervention group ($n = 217–219$)	Usual care group ($n = 174–178$)	Intervention group ($n = 208–210$)	Usual care group ($n = 175–179$)	Unadjusted coefficient (95% CI)	*P*-value*	Intervention group ($n = 177–181$)	Usual care group ($n = 150–156$)	Unadjusted coefficient (95% CI)	*P*-value*
Vegetables	261 (138)	286 (152)	265 (139)	262 (146)	21.2 (−0.52 to 42.9)	0.056	260 (130)	247 (123)	30.7 (9.3–52.1)	0.005
Fruits and berries†	225 (157)	239 (154)	258 (181)	259 (171)	8.6 (−21.4 to 38.6)	0.575	258 (161)	236 (149)	25.4 (−7.8 to 58.7)	0.134
Potato										
Cooked potato or in dishes	105 (83)	113 (73)	106 (61)	111 (82)	−2.87 (−16.8 to 11.0)	0.686	98 (65)	111 (86)	−10.9 (−26.1 to 4.2)	0.157
French fries, chips and other fatty potato products	12.1 (10.2)	13.9 (14.1)	11.5 (9.8)	11.9 (10.6)	−0.01 (−1.94 to 1.92)	0.995	12.7 (12.5)	12.4 (11.9)	1.05 (−1.33 to 3.43)	0.388
Cereals										
Total bread	127 (60)	123 (57)	128 (61)	122 (63)	4.0 (−6.6 to 14.7)	0.459	122 (58)	112 (61)	7.8 (−3.5 to 19.2)	0.175
Porridge and breakfast cereals	79 (94)	95 (99)	79 (88)	114 (112)	−25.2 (−41.7 to −8.7)	0.003	97 (153)	109 (105)	−3.2 (−29.4 to 23.0)	0.811
Rice and pasta	74 (40)	73 (57)	67 (38)	61 (36)	7.8 (−2.0 to 17.5)	0.118	65 (40)	60 (37)	4.9 (−2.4 to 12.3)	0.187
Milk and dairy										
Total milk‡	490 (314)	505 (342)	562 (310)	528 (300)	50.2 (6.5–95.8)	0.025	523 (304)	542 (364)	4.8 (−56.0 to 65.5)	0.878
Total cheese§	49 (35)	60 (51)	57 (38)	59 (44)	3.6 (−3.5 to 10.6)	0.318	42 (37)	50 (41)	−3.4 (−10.8 to 4.0)	0.364
Meat										
Red meat and game	81 (36)	87 (42)	80 (34)	83 (40)	0.56 (−5.2 to 6.4)	0.851	76 (33)	79 (42)	−0.86 (−7.7 to 6.0)	0.806
Poultry	57 (36)	58 (45)	57 (38)	53 (45)	4.1 (−2.9 to 11.2)	0.252	57 (36)	55 (46)	2.7 (−4.8 to 10.1)	0.482
Sausages	26 (20)	33 (27)	27 (21)	31 (23)	0.26 (−3.6 to 4.1)	0.896	28 (23)	30 (19)	1.7 (−2.6 to 6.0)	0.444
Fish	18.3 (16)	19.9 (18)	20.3 (16)	18.3 (14)	3.3 (0.13–6.4)	0.041	21.9 (15)	19.5 (14)	3.1 (0.08–6.05)	0.044
Dietary fats										
Vegetable spreads	6.9 (8.3)	7.4 (9.9)	8.8 (9.8)	7.6 (9.6)	1.5 (−0.13 to 3.2)	0.071	7.2 (8.8)	6.5 (8.4)	1.1 (−0.6 to 2.8)	0.215
Vegetable oils	9.2 (5.0)	9.6 (4.5)	10.6 (5.2)	9.4 (5.4)	1.4 (0.5–2.3)	0.002	11.1 (6.5)	9.5 (5.7)	1.8 (0.6–2.9)	0.002
Butter, butter mixtures	11.4 (11.6)	11.4 (12.1)	10.0 (9.2)	11.3 (11.2)	−1.3 (−2.9 to 0.4)	0.128	11.5 (11.1)	12.4 (14.5)	−1.0 (−3.3 to 1.3)	0.417
Solid baking margarines	3.6 (2.0)	4.0 (2.4)	3.7 (2.0)	4.1 (2.1)	−0.24 (−0.6 to 0.12)	0.194	3.3 (2.0)	3.7 (2.2)	−0.25 (−0.6 to 0.14)	0.208
Oil-based salad dressings	4.4 (7.0)	3.9 (5.1)	6.8 (8.1)	4.2 (7.2)	2.2 (0.8–3.5)	0.002	6.7 (11.5)	3.7 (7.1)	2.5 (0.6–4.5)	0.010
Candies and chocolate	21 (15)	24 (27)	22 (17)	28 (23)	−4.7 (−8.2 to −1.3)	0.008	23 (20)	29 (31)	−4.5 (−10.3 to 1.4)	0.133
Sweet pastries and other sugary food items	34 (27)	44 (33)	40 (27)	50 (36)	−5.3 (−10.8 to 0.11)	0.055	41 (31)	52 (39)	−5.7 (−12.5 to 1.2)	0.104
Pizza and hamburgers	22 (14)	24 (20)	21 (15)	22 (19)	−0.60 (−3.7 to 2.5)	0.703	18 (12)	18 (13)	0.37 (−2.0 to 2.7)	0.755
Beverages										
Tea	80 (121)	113 (184)	99 (123)	112 (170)	8.2 (−13.8 to 30.2)	0.464	97 (124)	105 (150)	15.2 (−9.9 to 40.2)	0.235
Coffee	247 (202)	257 (230)	148 (155)	157 (174)	−0.34 (−22.4 to 21.7)	0.976	142 (139)	140 (141)	8.0 (−14.3 to 30.3)	0.481
Sugary soft drinks	43 (91)	53 (107)	32 (58)	55 (117)	−18.3 (−39.3 to 2.7)	0.088	48 (136)	60 (138)	−5.2 (−34.6 to 24.3)	0.730
Juice	216 (208)	256 (252)	224 (219)	207 (178)	31.3 (−5.6 to 68.1)	0.096	183 (178)	235 (254)	−35.1 (−76.1 to 6.0)	0.094

CI, confidence interval; SD, standard deviation. *Multilevel mixed-effects linear regression models taking into account the between-municipality, between-clinic and between-nurse variation and adjusting for the baseline level of the variable. †Excluding juice. ‡Including milk, sour milk and yoghurt, excluding milk used in cooking. §Excluding cottage cheese.

Table 4. Baseline intake of energy, energy-yielding nutrients, fibre, selected fatty acids and cholesterol, means (SD)

	Baseline	
	Intervention group (n = 217–219)	Usual care group (n = 174–178)
Total energy intake (MJ day^{-1})	9.5 (2.4)	10.3 (3.0)
Total energy intake (kcal day^{-1})	2263 (571)	2458 (713)
Protein (E%)*	18.3 (2.2)	18.1 (2.3)
Carbohydrates (E%)	47.5 (4.9)	47.0 (5.6)
Saccharose (E%)	9.8 (3.3)	10.3 (3.7)
Dietary fibre (g day^{-1})	24.5 (8.6)	25.3 (8.5)
Total fat (E%)	32.2 (4.3)	32.9 (4.9)
Saturated fatty acids (E%)	12.5 (2.6)	13.1 (3.1)
Monounsaturated fatty acids (E%)	11.8 (1.9)	11.9 (1.8)
Polyunsaturated fatty acids (E%)	5.0 (0.9)	5.0 (1.0)
Linoleic acid (mg day^{-1})	8999 (2869)	9699 (3431)
Alpha-linoleic acid (mg day^{-1})	2119 (767)	2279 (867)
Eicosapentaenoic acid (mg day^{-1})	77 (54)	84 (63)
Docosahexaenoic acid (mg day^{-1})	204 (134)	221 (162)
Cholesterol (mg day^{-1})	298 (104)	318 (108)

SD, standard deviation. *E%: percentage of energy intake.

dressings by 2 g day^{-1} compared with the usual care group. The consumption of candies and chocolate increased by 5 g day^{-1} in the usual care group compared with the intervention group. The differences observed in average changes in food habits were partly different from the baseline to the 36–37 weeks gestation (Table 3). The intervention group had maintained the consumption of vegetables while the usual care group had decreased it (a group difference of 31 g day^{-1}). In contrary to the first follow-up, no differences were observed in the consumption of porridge and breakfast cereals, total milk or candies and chocolate between the groups. The differences observed in changes in consumption of fish, vegetable oils and oil or mayonnaise-based salad dressings between the groups were the same as at 26–28 weeks gestation.

Changes in dietary intake

The baseline intake of energy-yielding nutrients, fibre, selected fatty acids and cholesterol is shown in Table 4 and the between-group differences in average changes in the intake of energy-yielding nutrients in

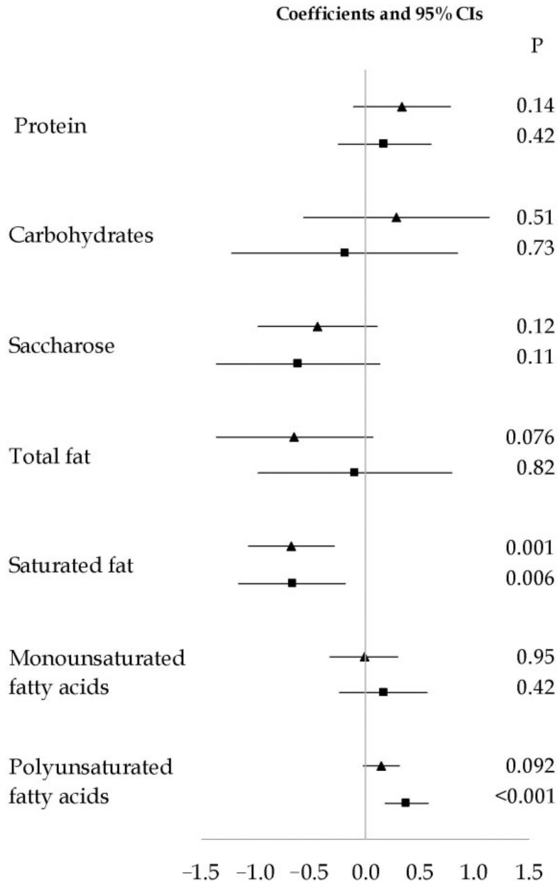

Fig. 2. Between-group differences in changes in the intake of energy-yielding nutrients (as energy percentage, E%) at 26–28 (▲) and 36–37 (■) weeks gestation, coefficient [95% confidence interval (CI)]. Multi-level mixed-effects linear regression models taking into account the between-municipality, between-clinic and between-nurse variation, and adjusting for the baseline level of the variable.

Fig. 2. By 26–28 weeks gestation, the intervention group had decreased the intake of saturated fatty acids (a group difference of 0.7 energy-%-units) and increased the intake of eicosapentaenoic acid by 11.1 mg day^{-1} (95% CI 0.3–21.9, $P = 0.045$) compared with the usual care group. When assessing differences in average changes from baseline to 36–37 weeks gestation, the intervention group had maintained the intake of saturated fatty acids and eicosapentaenoic acid while the usual care group had increased the intake of saturated fatty acids (a group difference of 0.7 energy-%-units) and decreased the intake of eicosapentaenoic acid by 9.4 mg day^{-1} (95% CI 0.2–

18.6, $P = 0.044$). The intervention group had also increased the intake of polyunsaturated fatty acids (a group difference of 0.4 energy-%-units), linoleic acid by 764 mg day^{-1} (95% CI 173–1354, $P = 0.011$) and fibre by 2.07 g day^{-1} (95% CI 0.39–3.75, $P = 0.016$) compared with the usual care group. No differences were observed between the groups in changes in the intake of energy or the other nutrients.

Dropout analyses

As compared with participants for whom the FFQ data at 36–37 weeks gestation were available ($n = 337$), the participants with no FFQ data at 36–37 weeks gestation ($n = 105$) were more often previous smokers (31.6% vs. 18.4%) and less often non-smokers (67.3% vs. 74.5%, $P = 0.003$), they had more often basic or secondary education only (58.7% vs. 50.6%, $P = 0.39$) and were more often working full-time (40.8% vs. 35.9%, $P = 0.38$). No other differences were observed in the background characteristics of these two groups.

The following differences were observed between these groups in the main outcomes related to food habits or dietary intake at 26–28 weeks gestation. The participants with no FFQ data at 36–37 weeks gestation had a lower proportion of high-fibre bread of all bread (58.8% vs. 69.1%, $P = 0.016$), a lower proportion of fat-free or low-fat milk of all milk (70.7% vs. 76.2%, $P = 0.14$), higher intake of high-fat foods (68.3 vs. 58.9 g day^{-1}, $P = 0.20$), a lower proportion of energy from protein (17.4 vs. 18.1 E%, $P = 0.005$), a higher proportion of energy from carbohydrates (49.2 vs. 48.0 E%, $P = 0.07$) and saccharose (10.6 vs. 10.1 E%, $P = 0.27$), lower fibre intake (21.9 vs. 24.7 g day^{-1}, $P = 0.18$), and a lower intake of monounsaturated fatty acids (11.8 vs. 12.1 E%, $P = 0.24$) and polyunsaturated fatty acids (4.9 vs. 5.1 E%, $P = 0.15$) as compared with women who completed the FFQ at 36–37 weeks gestation. At baseline, the diets of these two groups were very similar.

Discussion

Intensified dietary counselling carried out by public health nurses in maternity care had effects on four out of the seven objectives of the counselling, both in the first and the second follow-ups. Regarding these objectives, differences were observed between the intervention group and the usual care group in changes in the consumption of high-fibre bread, vegetable fats, low-fat cheeses, snacks high in sugar and/or fat, and in vegetables, fruits and berries. The changes observed in food habits caused changes in the intake of several nutrients, especially by the second follow-up. The intervention group decreased the intake of saturated fatty acids and increased that of polyunsaturated fatty acids, eicosapentaenoic acid, linoleic acid and fibre compared with the usual care group.

Of all previous dietary counselling interventions in pregnant women, few have measured and reported the effects of the intervention on changes in food habits and/or dietary intake (Piirainen *et al*. 2006; Kinnunen *et al*. 2007; Wolff *et al*. 2008; Jackson *et al*. 2011; Korpi-Hyovalti *et al*. 2011). In all these studies, the control group received the usual care. In our own pilot study ($n = 105$), intensified dietary counselling at four routine maternity clinic visits had favourable effects on the consumption of vegetables, fruits and berries, and high-fibre bread, but not on high-sugar snacks as compared with usual care (Kinnunen *et al*. 2007). The counselling in the pilot study did not focus on fat intake and changes in dietary intake were assessed by a 57-item FFQ.

In another trial in Finland (Piirainen *et al*. 2006), the counselling was carried out by a nutritionist at three visits during pregnancy and it focused on the amount and type of fat and the amount of fibre in diet. Importantly, the participants ($n = 209$) were also provided food products with favourable fat and fibre content to help them adhere to the recommended diet. Based on 3-day food records, the intervention group had higher overall consumption of vegetables, fruits, soft margarines, and vegetable oils, and lower consumption of butter than the control group. The intervention group also had lower energy intake from saturated fatty acids, higher energy intake from polyunsaturated fatty acids and higher intake of fibre than the control group. The magnitudes of the changes were very similar to those observed in the present study.

Wolff *et al*. (Wolff *et al*. 2008) studied the effect of ten 1-h dietary consultations with a trained dietitian on dietary intake in 50 obese pregnant women in Denmark. The participants in the intervention group were advised to eat according to the official Danish dietary recommendations and the energy requirements were estimated individually to restrict total gestational weight gain to 6–7 kg. Dietary intake was assessed using 7-day weighed food records. As compared with the control group, the participants in the intervention group decreased their energy intake and the proportion of fat of total energy intake, and increased the proportion of carbohydrates and protein of total energy intake. Changes in the type of fat, dietary fibre intake or food habits were not reported.

The effects of six consultations with a clinical nutritionist on dietary intake were recently reported among Finnish pregnant women at high risk for GDM ($n = 35$) (Korpi-Hyovalti *et al*. 2011). Based on 4-day food records, the intervention increased the intake of polyunsaturated fatty acids, but had no effect on the intake of other nutrients.

In contrary to these previous face-to-face counselling interventions, a US study (Jackson *et al*. 2011) examined the effect of delivering brief messages about diet, exercise and weight gain by an actor-portrayed computerized Video Doctor counselling tool twice during pregnancy. Based on a non-validated 18-item FFQ, the intervention group ($n = 158$) increased their consumption of fruits and vegetables, whole grains, fish, avocado, and nuts, and decreased their consumption of sugary foods, refined grains, high-fat meats, fried foods, solid fats and fast food, whereas no changes were observed in the usual care group ($n = 163$). A direct comparison of the results of these four studies and our study is challenging because of differences in measurement of diet, statistical analyses and the way the results were presented.

The present study has several strengths. Firstly, the intervention was carried out by public health nurses as a part of routine visits to public maternity clinics, utilized by almost all pregnant women in Finland, improving the applicability of the counselling method to usual care. Secondly, the present study is the largest of the previous dietary counselling studies among pregnant women and we were able to observe several statistically significant differences between groups, despite using power-consuming multilevel analyses. Thirdly, the participation rate was very high (88%) and the dropout rate also acceptably low (8–11%) among those who finally were eligible to participate and received the allocated intervention (Fig. 1). Fourthly, changes in food habits and dietary intake were measured using a validated FFQ (Erkkola *et al*. 2001) and reported in more detail than in most of the previous dietary counselling interventions.

Some methodological aspects need to be considered when interpreting the dietary data. The validation study (Erkkola *et al*. 2001) showed that 70% of the foods and 69% of the nutrients fell into the same or the adjacent quintiles as compared with two 5-day food records. With respect to the reproducibility of the questionnaire (filled in twice 1 month apart), the average of all intraclass correlation coefficients for foods and nutrients was 0.65, being higher for foods consumed daily and lower for foods eaten rarely. The participants in the validation study filled in the questionnaire 1–3 months after delivery and recalled their diet during the eighth month of pregnancy. As we modified the FFQ to assess diet during the previous month in the follow-up questionnaires, our participants may have recalled their diet more accurately, and therefore the validity of our version of the FFQ might have been slightly better. As FFQs are known to have a tendency to overestimate food intake in general (Willett 1998), the absolute amounts of foods and nutrients consumed should be interpreted with caution. Another weakness of the FFQ was that it was not accurate enough in categorizing bread based on fibre content or meat based on fat content. Nevertheless, these misclassifications are likely to be non-differential and consequently the inaccuracies in measuring food intake are likely to bias the between-group differences towards null. On the other hand, it is possible that the participants have overreported healthy food habits and underreported unhealthy habits, especially in the intervention group. This may happen in behavioural studies when the participants are aware of the expectations.

There were some differences in the baseline characteristics of the participants between the groups. However, after adjustment for age, BMI, parity, education, smoking and working status, the results were very similar. The only exceptions were that the non-significant beneficial effects of the intervention on saccharose intake (at both follow-ups, Fig. 2), sweet pastries and sugary soft drinks (at the first follow-up, Table 3) now became statistically significant, but the effect of fish intake (at the first follow-up, Table 3) was no longer statistically significant (results not shown). Despite the differences in the background characteristics, the quality of diet at baseline was essentially similar between the intervention and the usual care groups.

In longitudinal studies, a selective loss to follow-up may also cause some bias in the results. In our study, the outcome data were not available at 36–37 weeks gestation for 105 (23.8%) of the 442 participants who were eligible and signed the informed consent. The dropout analysis showed that participants who did not provide the outcome data were more often previous smokers, with lower education and working full-time than participants who did. The participants with no outcome data also seemed to have somewhat unhealthier diet in mid-pregnancy, especially regarding the quality of fat and fibre intake. This suggests that if the participants with no outcome data could have been included in the analyses and if they had not improved their diet in later pregnancy, both the intervention and the usual care group would have had slightly unhealthier diet on average at 36–37 weeks gestation. Because the intervention group had 6% units more participants with no outcome data than the usual care group, it is possible that between-group differences in dietary changes were actually slightly smaller than we observed.

Diet is a complex exposure and food and nutrient intakes are often correlated. As in most studies focusing on dietary intake, we reported several outcomes related to food habits and nutrient intakes. As a consequence, it is possible that some of the statistically significant differences may have occurred by chance due to multiple testing. Therefore, the effects with P-values > 0.01 should be interpreted with caution.

Regarding the clinical significance of the observed effects, the changes mostly occurred in foods and nutrients that are very relevant in terms of dietary quality in general (Valtion ravitsemusneuvottelukunta, 2005) and prevention of GDM (Wang *et al*. 2000; Bo *et al*. 2001; Tuomilehto *et al*. 2001; Saldana *et al*. 2004). Many of the observed differences were relatively small, partly reflecting the low frequency and/or low average daily amount the particular food or food group typically eaten. However, it is of importance that a large number of small changes in diet can contribute to effects observed in clinical outcomes. As reported previously by Luoto *et al*. (2011), the combined intervention in the present study (i.e. including counselling on diet, physical activity and weight gain) was effective in decreasing the proportion of high-birthweight babies, although not in decreasing the incidence of GDM by 28 weeks gestation. Therefore, these between-group differences observed in diet especially in later pregnancy seem to have contributed to prevention of high-birthweight babies, given that effects of the intervention on leisure time physical activity and gestational weight gain were more modest (Luoto *et al*. 2011). To have adequate biological effect also on prevention of GDM by 28 weeks gestation, changes in diet should probably have occurred much earlier in pregnancy or preferably already before pregnancy. This should be addressed in future trials even if it may be challenging.

In conclusion, intensified dietary counselling was effective in improving food habits and the quality of dietary fat and fibre intake among pregnant women at increased risk for GDM. To improve the health of mothers and their offspring, it would be wise to offer more dietary counselling during pregnancy especially for women who are overweight or have other risk factors for GDM. This study provides one good example of counselling implemented in usual care and the counselling methods are worth being applied in wider scale in other settings with comparable populations as well.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

TIK, MA, RL and SMV designed the research; TIK, JP and RL conducted the research; SMV and SA were responsible for the FFQ method and for dietary calculations; JR and TIK performed the statistical analyses; TIK wrote the paper and TIK and RL have the primary responsibility for the final content. All authors read, commented and approved the final manuscript.

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