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INDIVIDUAL DIETARY COUNSELLING DURING AND AFTER PREGNANCY:

Impact on diet and body weight

by

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ABSTRACT

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Individual dietary counselling during and after pregnancy: Impact on diet and body weight

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In Finland, maternity and child health clinics play a key role in promoting health in young families. Currently, obesity causes the greatest challenges to clinics. In obese pregnant women, an increased risk for metabolic diseases exist which can affect both the mother and child. The purpose of this thesis was to explore the role of dietary counselling: in Finnish health clinics; in the regulation of dietary intake; and in affecting the body weight of women.

The main aim was to test the effect of dietary counselling and probiotic intervention on dietary intake and maternal body weight during and after pregnancy. In addition to dietary counselling, the effect of other factors, such as eating behaviour on dietary intake and body weight control after pregnancy was assessed. Another aim was also to evaluate dietary counselling practices by nurses (n = 327) in Finnish health clinics assessed by a questionnaire. At the beginning of the pregnancy, women (n = 256) enrolled in a dietary intervention study, were randomised into three groups. One group received dietary counselling with probiotics, one had counselling with placebo and the third group was the control group. The control group consisted of women whom did not receive counselling and took placebo. Probiotics and placebo supplements were used until the end of exclusive breastfeeding or six months after pregnancy. Women were followed from early pregnancy up to four years after pregnancy. Follow-up visits took place three times during pregnancy, at one and six months, and one, two and four years after pregnancy. Dietary counselling, provided by a nutritionist, aimed to influence the quality of dietary fat intake.

Dietary counselling is important to provide in clinics, as determined by the nurses, and these nurses expressed a want to improve their own nutritional knowledge through education. The nurses had varying knowledge of current dietary recommendations. Dietary counselling for women during and after pregnancy resulted in beneficial changes in dietary intake up to one year after pregnancy and body weight and waist circumference up to four years after pregnancy. Probiotics had a beneficial effect together with dietary counselling on waist circumference until one year after pregnancy, but not throughout the long term, four years after pregnancy.

Other factors, such as eating behaviour, associated with dietary intake and body weight control after pregnancy. Specifically, dietary recommendations are reached amongst women whom had high cognitive restraint in their eating behaviour and did not demonstrate uncontrolled eating. Overweight women more frequently emotionally ate compared to normal weight women and women with central adiposity related more frequently to having an uncontrolled eating behaviour than women with normal waist circumference. In addition, being overweight prior to pregnancy and excessive weight gain during pregnancy associated with increased body weight retention after pregnancy.

This study showed that individual dietary counselling is useful in influencing dietary intake which adheres to dietary recommendations and this counselling influences, favourably, body weight after pregnancy. Especially, women with the risk for weight retention, such as women who have emotional and uncontrolled eating behaviours, who were overweight prior to pregnancy or those who had excessive weight gain during pregnancy, may benefit from individual dietary counselling. This study underscores the need to develop dietary counselling practices for pregnant women and their follow-up after pregnancy in Finnish health clinics. These practices include increasing the efficacy of the counselling such as collaboration with families, having knowledgable health professionals and having sufficient resources.

Keywords: Dietary counselling, nurses' nutrition education, weight, waist circumference, dietary intake, during and after pregnancy

TIIVISTELMÄ

Johanna Jaakkola

Yksilöllinen ravitsemusohjaus raskausaikana ja sen jälkeen: Vaikutus ruokavalioon ja painoon

Lastentautioppi, Turun yliopisto; Turun yliopistollinen keskussairaala; Funktionaalisten elintarvikkeiden kehittämiskeskus, Turun yliopisto
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Nykyisin hyvin tavallinen ravitsemusongelma, lihavuus ja liiallinen ravinnonsaanti suhteessa kulutukseen, tuovat haasteita ravitsemusohjaukseen neuvoloissa. Raskausajan lihavuus lisää sekä äidin että lapsen riskiä metabolisille sairauksille, kuten äidin raskausdiabetekseen raskausaikana ja lapsen myöhemmälle lihavuudelle. Tämän työn tarkoitus oli tutkia ravitsemusneuvonnan käytäntöjä suomalaisissa neuvoloissa ja sen vaikutuksia äidin ravinnonsaantiin ja painoon.

Tutkimuksen päätavoitteena oli selvittää ravitsemusohjauksen ja maitohappobakteerivalmisteiden vaikutuksia äidin ravinnonsaantiin ja painoon raskauden aikana ja sen jälkeen. Ravitsemusohjauksen lisäksi tavoitteena oli arvioida muiden tekijöiden, kuten syömiskäyttäytymisen vaikutusta ravinnonsaantiin ja painoon raskauden jälkeen. Tavoitteena oli myös arvioida kyselytutkimuksen avulla hoitajien ravitsemusohjauskäytäntöjä suomalaisissa neuvoloissa (n = 327). Naiset (n = 256) kutsuttiin ravitsemustutkimukseen raskauden alussa ja heidät satunnaistettiin kolmeen ryhmään. Yksi ryhmä sai ravitsemusohjausta ja maitohappobakteerivalmistetta, toinen sai ravitsemusohjausta ja lumevalmistetta. Kolmas ryhmä oli verrokkiryhmä, jolle annettiin lumevalmistetta, muttei ravitsemusohjausta. Maitohappobakteeri- ja lumevalmisteita käytettiin täysimetyksen päättymiseen asti tai lopetettiin viimeistään kuusi kuukautta synnytyksen jälkeen. Seuranta aloitettiin alkuraskauden aikana ja sitä jatkettiin neljä vuotta synnytyksen jälkeen. Seurantakäynneistä kolme toteutettiin raskauden aikana, neljäs käynti yhden kuukauden ja viides käynti kuuden kuukauden kuluttua synnytyksestä. Kolme viimeistä käyntiä toteutettiin yksi, kaksi ja neljä vuotta synnytyksen jälkeen. Ravitsemustieteilijöiden antaman ravitsemusohjauksen tavoitteena oli vaikuttaa ruokavalion rasvan laatuun.

Tutkimus osoitti hoitajien kokevan ravitsemusohjauksen tärkeäksi. He tunsivat tämänhetkiset ravitsemussuositukset vaihtelevasti ja halusivat kehittää osaamistaan ravitsemuskoulutuksen avulla. Naisten ravitsemusohjaus raskausaikana ja sen jälkeen paransi ruokavalion rasvan laatua suositusten mukaisemmaksi ja vaikutus säilyi vuoden synnytyksen jälkeen. Ravitsemusohjausta saaneilla naisilla painoindeksi ja vyötärönympärys todettiin olevan alempia kuin verrokkiryhmän naisilla neljän vuoden kuluttua

synnytyksestä. Ravitsemusohjaus yhdistettynä maitohappobakteerivalmisteen käyttöön vaikutti suotuisasti vyötärönympärykseen vuoden synnytyksen jälkeen. Maitohappobakteerien käytöllä ei kuitenkaan saavutettu pitkäaikaisvaikutuksia vyötärönympärykseen tutkimusjakson aikana.

Muut tekijät, kuten syömiskäyttäytyminen vaikutti sekä ravinnonsaantiin että painoon raskauden jälkeen. Erityisesti suositusten mukainen ravinnonsaanti toteutui naisilla, joilla esiintyi tietoisen rajoittamisen syömistä eikä esiintynyt hallitsematonta syömiskäyttäytymistä. Ylipainoisilla naisilla esiintyi puolestaan yleisemmin tunteisiin liittyvää syömiskäyttäytymistä kuin normaalipainoisilla naisilla. Naisilla, joilla oli vyötärölihavuutta, esiintyi useammin hallitsematonta syömiskäyttäytymistä kuin naisilla, joilla oli normaali vyötärönympärys. Lisäksi ylipaino ennen raskautta ja liiallinen painonnousu raskausaikana ennusti painon pysyvyyttä raskauden jälkeen.

Tämä tutkimus osoitti, että yksilöllisellä ravitsemusohjauksella voitiin vaikuttaa suotuisasti ravinnonsaantiin ja painonhallintaan. Erityisesti naiset, joilla on riski ylipainolle raskauden jälkeen, saattavat hyötyä yksilöllisestä ravitsemusohjauksesta. Tutkimuksen mukaan naisilla, joilla esiintyy tunneperäistä ja hallitsematonta syömistä, ylipainoa ennen raskautta tai liiallista painonnousu raskausaikana on riski ylipainon kehittymiselle. Tämä tutkimus painottaa raskaana olevien ja synnyttäneiden äitien ravitsemusohjauskäytäntöjen kehittämisen tarvetta neuvoloissa. Ravitsemusohjauskäytäntöjen kehittämisessä keskeistä on neuvonnan tehostaminen edistämällä yhteistyötä perheiden kanssa ja sijoittamalla osaavaan neuvolahenkilökuntaan sekä riittäviin neuvolaresursseihin.

Avainsanat: Ravitsemusohjaus, hoitajien ravitsemuskoulutus, paino, vyötärönympärys, ravinnonsaanti, raskaus, imetys, imeväisikä

TABLE OF CONTENTS

ABBREVIATIONS

BMI	Body mass index
CR	Cognitive restraint
EE	Emotional eating
E %	% of energy
FA	Fatty acids
MJ	Mega Joule
MUFA	Monounsaturated fatty acids
PUFA	Polyunsaturated fatty acids
SFA	Saturated fatty acids
UE	Uncontrolled eating
WC	Waist circumference

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original publications, which are referred to in the text by the Roman numerals I-IV. Some unpublished data are also presented.

I. Ilmonen J, Isolauri E, Laitinen K. Nutrition education and counselling practices in maternity and child health clinics: study amongst nurses. Journal of Clinical Nursing 2012;21:2985-2994.

II. Ilmonen J, Isolauri E, Poussa T, Laitinen K. Impact of dietary counselling and probiotic intervention on maternal anthropometric measurements during and after pregnancy: A randomized placebo-controlled trial. Clinical Nutrition 2011;30:156-164.

III. Jaakkola J, Isolauri E, Poussa T, Laitinen K. Benefits of individual dietary counselling in long-term body weight control in women after pregnancy. Submitted (Short communication)

IV. Jaakkola J, Hakala P, Isolauri E, Poussa T, Laitinen K. Eating behaviour influences diet, body weight and central obesity in women after pregnancy. Nutrition, in press.

1. INTRODUCTION

A key mission of the health clinic system is to promote the health of the child and the whole family with an emphasis on the growth and development of foetus and child. Historically, in Finland, nutrition, at the beginning of the 1900's, was poor. For example, rickets was the main nutritional-based affliction amongst children due to insufficient intake of vitamin D. In the 1920's, in children between 3 to 7 years old, the prevalence of rickets varied from 37% to 79% (Ruotsalainen 1922). Additionally, the child mortality rate was high, approximately 10% from the turn of the century to the 1930's (Soderstrom 1933, Korpi 2010). This mortality rate improved dramatically during the late of 1900's (Kouvalainen 1995) and currently is minimal (United Nations/ Department of Economic and Social Affairs 2007)(Kouvalainen 1995)(Kouvalainen 1995). A similar trend exists in maternal mortality. The main reason for diminishing mortality rates are the establishment and development of health clinics. The improvement in the quality of nutrition, in families, associates with declining morbidities (Kouvalainen 1995).

The emergence of health clinics, with informed personnel and modern technology, in Finland advanced the overall health of Finns. The prevalence of rickets in children diminished considerably due to vitamin D supplements in the 1950's (Hallman et al. 1964) after which also margarines, formula milk and liquid milk products were supplemented. Developed diagnostics targeting the foetus in 1990's enhanced its follow-up of growth and development. Mothers' access to health care facilities improved the overall health of their children.

Increased prevalence of allergies (Sibbald et al. 1990) in 1990's caused additional challenges to clinics (Kouvalainen 1995). Food allergies were prevented in 1990's by elimination diets, including avoidance of food allergens such as fish, cow's milk, egg and wheat due to evidence that exposing food allergens may develop the food allergy of child (Cant et al. 1985, Cant et al. 1986, Chandra et al. 1986). However, health care recommendations at the end of the 1990's suggested that the avoidance of foods, which usually causes food allergies, was not useful to prevent allergies (Isolauri 1997). The avoidance of food allergens is not recommended in current recommendations (Hasunen et al. 2004;11).

In the 2000's, in Finland, the prevalence of obesity is increasing rapidly in children (Ojala et al. 2012) and adults (Aromaa et al. 2002, Saaristo et al. 2008). Obesity can cause metabolic complications during and after pregnancy (Langford et al. 2011, Yessoufou et al. 2011, Kronborg et al. 2012) which causes clinical overcapacity. Standardized instructions for obesity exist to meet current challenges and to provide guidelines to personnel at clinics.

Causal reasons explaining why obesity is so rampant in society is complex because environmental, behavioural and genetic factors all contribute to this condition. A sedentary lifestyle (Thorp et al. 2011) and a diet high in energy dense foods (Perez-Escamilla et al. 2012), are key factors that lead to obesity in both adults and children. Indeed, certain eating behaviours, such as uncontrolled eating and emotional eating have been linked with unfavourable dietary intake and increased body weight (Dykes et al. 2004, Konttinen et al. 2010, van Strien et al. 2012). In women, pregnancy is a particular trigger for onset of obesity (Linne et al. 2002). Especially, excessive gestational body weight gain increases the risk for maternal body weight retention after pregnancy (Kac et al. 2004, Linne et al. 2004) and also for their offspring (Vohr et al. 2008, Monasta et al. 2010). Being overweight increases the risk for cardiovascular diseases, metabolic syndrome and type 2 diabetes (Berg et al. 2005, Haffner 2006, Zhang et al. 2008) which all contrtibute to an economic burden (Allender et al. 2007).

In conclusion, health care clinics can help in the preventions of obesity and pregnant women are important target groups.

2. REVIEW OF LITERATURE

2.1. Health clinics in Finland

2.1.1. History of health clinics

The Finnish health clinic system was established in 1920 by a paediatrician, archiatre Arvo Ylppö (Dunn 2007) and Viljo Rantasalo was closely involved in the development of the clinic system (Kouvalainen 1995). Arvo Ylppö conducted studies amongst prematurely born infants and helped to develop the pharmaceutical industry (Laakariliitto 2007). He acted as the president of the Mannerheim League for Child Welfare, as a chief doctor of the children's hospital and as a professor of paediatrics. Arvo Ylppö perceived the important association between lifestyle and health and distributed healthy lifestyle information to the whole nation. Ylppö and Rantasalo developed a key mission for health clinics system: to promote the health of child and whole family and to follow-up the growth and development of foetus and child.

The first health clinic, which focused on children, was established in Helsinki, in 1922, and the first maternity health clinic in 1926 (Kouvalainen 1995). The establishment of legislation for the health clinics occurred in 1944 (Viljamaa 2003) and legislation concerning public health in 1972 (Finlex 1972) confirmed the position of health clinics in Finland. Child and maternity health clinics became gradually a key part of Finnish family health and consequently foetus and infant mortality became the lowest in Europe. The function of health clinics became recognised abroad.

2.1.2. Operations in health clinics

Health clinics have a key role in preventive work and promoting the health of individuals (National Institute for Health and Welfare 2012). The ministry of Social Affairs and Health is responsible for guiding the development of maternity and child health clinics. Operations are described in law by the public health service (Finlex 2010). Municipalities arrange child health clinic services for their areas (Finlex 2010) and these services are free and voluntary for families (National Institute for Health and Welfare 2012). Municipalities are responsible for arranging health clinic resources (Sosiaali- ja terveysministerio 2009). In practice, the nurses and doctors are responsible for the operation of child health clinic services in collaboration with other sectors such as special health care. A sufficient amount of staff in clinics is defined as follows: the public health nurse or the midwife should have no more than 80 customers per year who give birth, and for full-time doctors the recommendation is 800 customers who give

birth in a year (National Institute for Health and Welfare 2012). At present, less than two-thirds of the health clinics (61%) have the recommended amount of nurses (Hakulinen-Viitanen et al. 2008). Thus, nurses have to prioritise their operations and the contents of the counselling subjects. The scarcity of resources affects the contents of the health clinic activity and the methods of work. In addition, the professionals in the health clinics have a legal duty to maintain and to develop its professional upkeep (Finlex 1994).

Nurses' nutritional education is minimal in their basic education and the amount of compulsory nutritional teaching varies between the polytechnics. In Finland, three polytechnics (Turku, Savonia and Helsinki Metropolia University of Applied Sciences) have a lector in nutrition and the amount of nutritional teaching is 54 hours (2 credits) (Mattinen 2011). In other polytechnics, the amount of nutritional teaching is integrated into the other studies and the person responsible for the nutritional teaching can vary (Mattinen 2011).

Nearly all pregnant women use the clinic services with, only 0.2 – 0.3% of women not attending (Hakulinen-Viitanen et al. 2012). In order to get maternity grant from The Social Insurance Institution of Finland, a family must use the services of health maternity clinics (Kela 2013). Maternity clinics support families from the beginning of the pregnancy (Ministry of Social Affairs and Health Finland 2011). The health care personnel pay attention to a client's individual needs. The primary tasks of the health clinics are to secure the well-being of mother and health and growth of child. The tasks of maternity health clinics are presented specifically in **Table 1**.

Table 1. The tasks in maternity health clinics in Finland (Hakulinen-Viitanen et al. 2012).

Evaluation of the health of a mother and foetus
Paying attention to the welfare of the whole family
Evaluation of oral health amongst primigravida mothers
Supporting parenthood and resources of family
Supporting interaction of spouses
Promoting the healthy lifestyle of the whole family, including nutrition, physical activity and rest as well as preventing the use of alcohol, smoking and drugs

Nutrition is integral to the development and growth of foetus as well as well-being and health of women which encompass the tasks listed in **Table 1**. Subjects, which are presented in **Table 2**, are discussed based on the client's individual nutritional needs during their pregnancy term (Hasunen et al. 2004;11). To the public health nurse, the evaluation of the overall condition, the screening of nutrition risks, the client's motivation and nutrition advice belong in the nutrition matters (Hakulinen-Viitanen et

al. 2008). The dietician should give consultation and should educate nurses in the field of nutrition.

Table 2. Subjects during pregnancy at maternity health clinics (Hasunen et al. 2004;11).

	Needs of subjects
At the beginning of the pregnancy	Evaluation of nutritional status and the need of support Weight prior to pregnancy Haemoglobin Food restrictions Nutrition problems *i.e.* nausea, constipation and special diets The use of supplements Formulating the plan of individual counselling
In the middle of the pregnancy	Follow-up of maternity diet Weight gain during pregnancy Guidance of balanced diet and regular eating frequency pattern Nutritional problems Haemoglobin The use of supplements Breastfeeding
At the end of the pregnancy	Weight gain Nutritional problems; *i.e.* heartburn, constipation

2.2. Maternal dietary intake

2.2.1. Metabolic need for energy

During pregnancy

During pregnancy, energy requirements increase individually and are the greatest in late pregnancy, mainly due to the increased basal metabolic rate which is a result of increased tissue mass (Forsum et al. 2007). The greater the fat-free mass in the body, the greater the basal metabolic rate (Butte et al. 2006). The average energy cost during pregnancy is estimated to be 375 kJ per day at first, 1200 kJ per day at the second and 1950 kJ per day at the third trimester of pregnancy when the mean gestational body weight gain is 12.0 kg (Butte et al. 2005).

After pregnancy

In lactating women, the energy requirements increase further after pregnancy. The energy requirements during lactation depend mainly on the amount of breast milk production, the energy density of milk and the conversion efficiency of milk (Butte et al. 2005). It is, on average, 2000 kJ per day during exclusive breastfeeding in women whose milk production is about 750 g per day when storage fat (2 – 3 kg) accumulated during pregnancy has been considered (Hasunen et al. 2004;11).

Physical activity level, during and after pregnancy, must be considered when evaluating energy needs to maintain energy balance. Sustaining physical activity level during pregnancy is emphasised at the present time (Cohen et al. 2013) and counselling is useful in maintaining a client's physical activity during pregnancy (Aittasalo et al. 2008). On the contrary, in the practice, pregnant women are not encouraged to exercise moderately (Ferrari et al. 2013).

2.2.2. Dietary recommendations

From 1900's to the present

Dietary recommendations during and after pregnancy were established to secure the energy needs of the foetus and offspring. In 1901 the first published study discussing the importance between diet and pregnancy was published in Germany according to the report of Institute of Medicine (Institute of Medicine, Subcommittee on Nutritional Status and Weight Gain During Pregnancy 1990). At the beginning of the 1900's, a restricted diet during pregnancy was recommended because it was thought that a small child would develop and and easier delivery would be obtained. At this time, the maternal mortality rate was high and caesarean deliveries were precarious and thus the main goal was to limit the growth of foetus by maternal food intake. The Institute of Medicine and Food and Nutrition Board's (FBN's) formulated recommendations which considered energy intake for pregnant women during 1943 to 1989 (Institute of Medicine, Subcommittee on Nutritional Status and Weight Gain During Pregnancy 1990). The recommended energy intake varied from 2200 kcal per day in 1968 to 2700 kcal per day in 1953. In Finland, an insufficient dietary intake by pregnant and breastfeeding women occurred during the early of 1900's when the use of food was rationed (Simola 1941). Doctors may have determined that milk and butter were necessary additional portions for women who were pregnant or lactating to secure sufficient intake of nutrients. Beginning in the 1990's, the intake of vitamin D supplements were recommended for pregnant and breastfeeding women during the winter-months (Hasunen et al. 1997:7).

The recommended dietary intake during pregnancy and lactation is similar compared to the overall population recommendations except for the increased need of nutrients, such as essential fatty acids, omega-3 fatty acids, vitamin C, D, E and, folate, calcium and iron (**Table 3**) which are crucial for pregnant and lactating women in Finland. In Finland, specific recommendations for dietary intake in pregnant and lactating women were formulated for the first time in 1987 (Hasunen et al. 1989:7). Recommendations were updated regularly and the latest recommendations are from 2004 (Hasunen et al. 2004;11). Recommendations for pregnant and lactating women, based on the Nordic Nutrition Recommendations (Becker et al. 2004), are being updated, presently, and new recommendations are expected to be published in 2013. Current recommendations (Becker et al. 2004) suggest a balanced diet focusing its quality, including also restrictions for pregnant women (**Table 4**). Restrictions of certain foods are formulated to protect foetus from toxic effects. An undeveloped foetus is sensitive to the chemicals, certain bacteria and heavy metals that come from the mother's diet.

In Finland, the use of vitamin D supplements amongst pregnant and lactating women is recommended year-round (Valtion ravitsemusneuvottelukunta. 2011). The newest studies show that insufficient intake vitamin D associates with weak body weight gain during pregnancy and developmental disorders of the bones of the foetus (Kovacs 2008). It also associated with the increased risk of chronic diseases, such as asthma and allergic diseases of offspring (Nurmatov et al. 2011) as well as autoimmune diseases (Antico et al. 2012). All the women who are planning to be pregnant may need folic acid supplementation but especially women with coeliac disease and unbalanced diet (Stefanovic et al. 2010). Iron supplementation is recommended for women whose haemoglobin is below 110 g / l at early pregnancy and further on in pregnancy below 100 g / l. Calcium supplements are recommended for women who have an insufficient amount of milk products in their diet.

Table 3. The Finnish Nutrition Recommendations of the National Nutrition Council (Valtion ravitsemusneuvottelukunta 2005) which are based on the Nordic Nutrition recommendations (Becker et al. 2004) for pregnant, lactating and women aged 18 – 60 years. Intake of nutrients amongst pregnant and lactating women ([1-5]examples of the studies) with SD or confidence interval (CI) and all women aged 18 – 60 years ([6]Findiet 2007) are presented.

		Recommended intake	Dietary intake			
Dietary factor	(unit)	All women	Pregnant women		Lactating women	Women aged 18 – 60 years
			(n = 679[1])	n = 85[2] / 45[3])	(n = 39 – 41[4] / 114[5])	(n=846)[6]
Protein	(E%)	10 – 20	16[7]	17 (16 – 17)[2]	17 (3)[4]	17.2 (4.1)
Carbohydrate	(E %)	50 – 60	47[7]	50 (49 – 51)[2]	50 (7)[4]	50.2 (8.3)
Dietary fibre	(g)	25	27[7]	20 (18 – 21)[2]	20 (7)[4]	21 (9)
Fat	(E%)	25 – 35	36[7]	32 (31 – 33)[2]	31 (6)[4]	31.2 (7.4)
SFA	(E%)	10	14[7]	13 (13 – 14)[2]	13 (3)[4]	12.0 (3.9)
PUFA	(E%)	5 – 10	4[7]	5 (4.8 – 5.3)[2]	5 (2)[4]	5.7 (2.2)
MUFA	(E%)	10 – 15	13[7]	10 (10 – 11)[2]	11 (3)[4]	10.9 (3.2)
Essential FA[8]	(E%)	5[9,10] / 3	4[7]	-	-[4]	4.9 (-)
Omega-3	(E%)	1[9,10] / 0.5	0.8[7]	-	2 (0.7)[4]	1.2 (0.5)
Vitamin D	(µg)	10[9,10] / 7.5	5 (2.5)	6 (5 – 7)[3]	3 (3 – 4)[5]	5.2
Vitamin E	(α-TE)	10[9] / 11[10]/ 8	14 (5)	10 (9 – 11)[3]	9 (9 – 10)[5]	8.1
Folate	(µg)	400[9,10] / 300	400 (130)	-	257 (243 – 270)[5]	226
Vitamin C	(mg)	85[9,10] /75	220 (120)	134 (114 – 153)[3]	111 (97 – 124)[5]	118
Calcium	(mg)	900[9,10] / 800	1870 (720)	-	1149 (1069 – 1229)[5]	1007
Iron	(mg)	-[9] / 15[10] / 9	18 (6)	-	10 (10 – 11)[5]	10.3

[1](Arkkola et al. 2006), used Food Frequency Questionnaire

[2](Vahamiko et al. 2013a), used three-days food diary

[3](Vahamiko et al. 2013b), used three-days food diary

[4](Hoppu et al. 2012), used three-days food diary

[5](Hoppu et al. 2000), used four-days food diary

[6] Findiet 2007 (Mannisto et al. 2008), used Food Frequency Questionnaire

[7] Calculated of grams per MJ

[8] Linoleic and α-linolenic acid

[9] For pregnant women

[10] For lactating women

Table 4. Recommended food intakes during pregnancy and lactation and the beneficial or harmful effects for the foetus are listed.

Recommended foods		Source of nutrients	Beneficial effects
Whole grain products	Daily	Iron, folate, fibre	Folate intake during pregnancy decreases the risk of delivering infants being born with neural tube defect and pregnancy complications such as miscarriage and low birth body weight (Christian 2010, Molloy et al. 2008).
Vegetables, fruits and berries	Five to six portions per day	Vitamin C, folate, fibre	Folate as above.
Fat-free and low-fat milk and meat products	Daily	Calcium and vitamin D (except for vitamin D in organic products) and protein	Vitamin D increases the absorption of calcium (Norman 2008) which is vital for the development of the bones in the foetus (Koo et al. 1999). High-fat milk and meat products are sources of saturated fatty acids whose excessive intake has been related to the increased risk for Western-based metabolic diseases (Baum et al. 2012, Cascio et al. 2012, Nozue et al. 2012, Pan et al. 2012, Vanhala et al. 2012).
Vegetable oils and soft margarines	Daily	Essential fatty acids and vitamin D	Essential fatty acids, from mono- and polyunsaturated fatty acid, are for example, responsible for neural development (Innis 2007) and increased need occurs during pregnancy and lactation (Hornstra et al. 1995, Al et al. 2000, Szajewska et al. 2006).
Fish	Two to three times a week by varying different species	Omega-3 fatty acids, protein, vitamin D	Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) have anti-inflammatory effects (Siriwardhana et al. 2012) and DHA is crusial in brain development (Bradbury 2011).

Restricted foods		Risk factors	Harmful effect
Fish species	Pike, perch, pikeperch, burbot from inland water recommended to avoid; Baltic herring (>17cm), salmon, sea trout from Baltic Sea recommended 1-2 times in a month	High content of mercury (fish of pray), dioxin and PCB (polychlorinated biphenyl) (from fish in Baltic)	Dioxin (Petroff et al. 2011) and mercury (Clegg 1971) may transfer from mother to offspring.
Liver foods	Liver sausages and liver pate ≤ 30 grams per day, ≤ 200 grams per week[1] Avoidance of other liver foods	High content of vitamin A and harmful substances stored by the liver	Excessive vitamin A intake may damage the development of foetus (Ritchie et al. 2003).
Vacuum-packed fish and roe; unpasteurized milk and milk products; frozen vegetables and re-heated foods; fresh vegetables	Used only totally heated (above 70 Celsius degrees), fresh vegetables must be washed carefully	Risk of listeriosis	Listeriosis increases the risk of miscarriage, premature delivery, and difficult infections in offspring (Smith et al. 2009).
Raw meat and poultry	Not at all	Risk of toxoplasmosis and salmonellae	Maternal toxoplasmosis may cause serious infection of fetus and lead to stillbirth (McClure et al. 2009), salmonellae may cause intrauterine sepsis (Tam et al. 2010).
		Exposure to EHEC bacterium	EHEC infection may be detrimental to the foetus and induce abortion (Yoshimura et al. 2000).

[1] Lavikainen et.al.

Restricted foods		Risk factors	Harmful effect
Morel mushroom	Not at all	Exposure for gyromitrine	Gyromitrine associates with poisoning and carcinogenic risk (Bergman et al. 1992).
Alcohol	< 1 – 2 portions per week	Exposure for foetal alcohol syndrome	Hinders the development and growth of foetus (Bosco et al. 2012).
Salt (NaCl)	< 6 g per day	High-salt foods	High sodium intake raises maternal blood pressure (Hooper et al. 2003).
Coffee and caffeine	Caffeine < 300 mg per day (coffee approx. 4.5 decilitre)	Caffeine	Excessive caffeine intake may have the potential for injuring the embryo (Christian et al. 2001).
Liquorice and salmiak	< 50 g per day	High content of glycyrrhizin	Heavy glycyrrhizin exposure associates with preterm delivery (Strandberg et al. 2002).
Linseed	Not at all	Exposure to cadmium and cyanogenic compounds	Cadmium may cause abnormalities in the embryo (Thompson et al. 2003, Thompson et al. 2008)
Artificial sweetener	Syclamate and sachharine is not recommended at all	Exposure to syclamate and saccharine	The use of artificially sweetened soft drinks daily may increase the risk of preterm delivery (Halldorsson et al. 2010)
Seaweed products	Not at all, if the content of iodine is not known	High content of iodine	Excessive iodine intake has been associated with adverse effects on neurodevelopment of offspring (Zhang et al. 2012) and dysfunction of maternal thyroid gland (Teng et al. 2006)
Herbs and natural products	Not at all	They may contain harmful substances naturally	Safety is not shown

Recommendations in practice

In the clinical practices, the intake of fibre and vitamin D is lower than recommended, intake of saturated fatty acids are higher than recommended, and intake of polyunsaturated fatty acids are at the lower limits of recommendations in all women (Mannisto et al. 2008, Hoppu et al. 2012, Vahamiko et al. 2013a) (**Table 3**). Amongst pregnant women, the intake of essential fatty acids, are below recommendations (Arkkola et al. 2006) whereas intakes of vitamin E, folate and iron (Hoppu et al. 2000) are below recommendations amongst lactating women. Additionally, intake of folate and iron were lower than recommended in women aged 18 – 60 (Mannisto et al. 2008).

Achieving nutritional recommendations through dietary counselling in a few studies amongst women during (Garg et al. 2006, Mottola et al. 2010, Hui et al. 2012, Korpi-Hyovalti et al. 2012) and after (Liu et al. 2009, Ostbye et al. 2009) pregnancy were successful (**Table 5**). Specifically, dietary counselling increased the intake of monounsaturated and polyunsaturated fatty acids as well as dietary fibre intake during (Hui et al. 2012, Korpi-Hyovalti et al. 2012) and after pregnancy (Liu et al. 2009) when the follow-up lasted from two to six months.

Table 5. Recent intervention studies which examined the effects of lifestyle intervention on dietary intake and body weight of women during and after pregnancy.

Reference	Study design	Content of intervention	Method used	Aims	Duration of follow-up	Effect of intervention on: Body weight	Dietary intake
Polley et al. 2002	BMI > 19.8 kg/m^2; Age 26 ± 5 y; < 20 weeks of gestation; n = 120	Diet and physical activity	FFQ	To gain body weight during pregnancy within IOM recommendations To substitute high-fat foods by fruit and vegetables To increase walking and develop a more active lifestyle	Up to the first postpartum clinic visit	Of normal weight women 63 % exceeded body weight gain recommendations in intervention and 94 % in control group ($p < 0.05$) No differences in physical activity levels; $p > 0.05$	-
Olson et al. 2004	BMI > 19.8 kg/m^2; Age >18 y; (Low-income) < 3rd trimester of pregnancy; n = 560	Guidance about gestational weight gain	-	To gain weight during pregnancy within the IOM recommendations	Up to one year after pregnancy	Gestational body weight gain did not differed between groups; $p > 0.05$ Of the women 52 % in control groups exceeded recommendations and 33 % in intervention group (OR = 0.41, 95 % CI = 0.20-0.81)	-

Reference	Study design	Content of intervention	Method used	Aims	Duration of follow-up	Effect of intervention on: Body weight	Dietary intake
Garg et al. 2006	BMI not reported; Age 24 ± 4 y; 8^{th} – 9^{th} month of pregnancy; n = 50	Diet	24-hour recall and FFQ	To behavioural changes, not described detailed	2 – 4 months		Daily intakes of energy (kcal), protein (g), calcium (mg), iron (mg) vitamin C (mg) and A (RE) increased in intervention group than control group, p < 0.001 for all
Kinnunen et al. 2007	All BMI categories; Age > 18 y; 2 months postpartum; n = 92	Diet and physical activity	FFQ	To have a regular meal pattern, to eat at least 5 portions vegetables, fruit and berries per day, to consume high-dietary fibre bread, to restrict the intake of high-sugar foods Moderate-intensity physical activity a minimum of 30 minutes per day To encourage to retain the pre-pregnancy weight	Up to 10 months postpartum	The proportion of women returning to the pre-pregnancy weight was higher in the intervention than control group; p = 0.028 Physical activity level did not differ between two groups; p > 0.05 Mean gestational body weight gain did not differ between groups; p > 0.05 Physical activity level did not differ between two groups; p > 0.05	The intakes of high-dietary fibre bread (+11.8 (0.6-23.1); p=0.04) and intakes of vegetables, fruit, berries (+0.8 (0.3-1.4); p=0.004) were higher in intervention group than control group

Reference	Study design	Content of intervention	Method used	Aims	Duration of follow-up	Effect of intervention on: Body weight	Dietary intake
Wolff et al. 2008	BMI ≥ 30 kg/m^2; Age 18-45 y; 15 ± 3 weeks of gestation; n = 50	Diet	Seven-day food diary	Fat intake ≥ 30 % of energy, protein intake 15 – 20 E%, carbohydrate intake 50 – 55 E%	Up to four weeks postpartum	Mean body weight gain difference between two groups was 6.7 kg (95 % CI 2.6-10.8, p = 0.002)	Energy (p = 0.001) and fat intake (p = 0.001) diminished and protein intake increased (p = 0.001) amongst women in intervention group
Asbee et al. 2009	BMI < 40 kg/m^2; Age 18-49 y; 6 – 16 weeks of gestation; n = 100	Diet and physical activity	-	Intakes of fat 30, protein 30 and carbohydrate 40 E% Moderate-intensity exercise at least three times per week and preferably five times per week To gain weight within the IOM recommendations	Up to the delivery	Women in intervention group gained less gestational body weight than women in control group (p = 0.01)	-
Liu et al. 2009	BMI not reported; Age 26 ± 4 y; 3rd trimester of pregnancy; n = 410	Diet and physical activity	Nine-days food diaries	To enhance the quality of diet and health behaviour, not described detailed	Until 42 days postpartum	-	Intakes of protein (g), vimtain E and calcium were higher in intervention group compared to control group ; p < 0.05

Reference	Study design	Content of intervention	Method used	Aims	Duration of follow-up	Effect of intervention on: Body weight	Dietary intake
Ostbye et al. 2009	BMI ≥ 25; Age > 18 y; 6 weeks of gestation; n = 450	Diet and physical activity	FFQ, 24-hour dietary recall and physical activity recall	To loss weight To reduce calorie-dense foods and increasing fruit and vegetable intake To increase physical activity for 30 minutes per day, five times a week	Up to 9 months after delivery	Weight loss was 0.90 intervention and 0.36 ± 5 kg in control group; $p > 0.05$ Physical activity level did not differed between two groups; $p > 0.05$	Dietary intake did not differed between groups; $p > 0.05$
Mottola et al. 2010	BMI ≥ 25 kg/m^2; Age 32 ± 4 y; 16 – 20 weeks of gestation; n = 65	Diet and physical activity	One-day food diary Step counter	Total energy intake on average 2000 kcal per day, carbohydrate intake 40 – 55 E%, fat intake 30 E%, protein intake 20 – 30 E% To walk 25 min of walking three to four times per week during the first week, exercise time increased by 2 min, until 40 min of walking was reached	Up to the delivery	Physical activity level increased from 5678 steps at the baseline to 10000 steps at the end of program; p value not reported	Daily energy and carbohydrate intake decreased and protein intake increased; $p < 0.05$

Reference	Study design	Content of intervention	Method used	Aims	Duration of follow-up	Effect of intervention on: Body weight	Dietary intake
Cragie et al. 2011	BMI 32 kg/m^2; Age 30 (4.9) y; 6 – 18 months postpartum; n = 52	Diet and physical activity	Motivational interviewing techniques	A reduction of energy intake of 500 kcals per day Moderate to vigorous physical activity 150 minutes per week	For 12 weeks	Body weight reduced by 1.6 2.0 kg in the intervention group and increased by 0.2 2.2 kg in control group (p = 0.018)	-
Huang et al. 2011	BMI 17 – 37 Age 32 y; 16 weeks of gestation or at birth; n = 189	Diet and physical activity postpartum	Three-days food diary	Dietary and physical activity intervention not described detailed Individual body weight gain during pregnancy and postpartum body weight retention	Up to six months	Gestational body weight gain and postpartum body weight retention were the lowest in intervention started at 16 weeks' gestation (14 kg, 2 kg) compared to intervention started at birth (15 kg, 4 kg) and control (16 kg, 5 kg) groups (p < 0.001)	-
Hui et al. 2011	BMI > 25 Age 30 y; 20 – 36 weeks of gestation; n = 190	Diet and physical activity	Three-days food diary	Dietary intervention not described detailed Mild-to-moderate exercise for 30 – 45 minutes per sessions was recommended three to five times per week	Two months	Physical activity level was higher in intervention group compared to control (p = 0.0001)	Total energy, fat, saturated fat and cholesterol was lower in intervention group compared to control (p = 0.00004 – 0.002)

Reference	Study design	Content of intervention	Method used	Aims	Duration of follow-up	Effect of intervention on: Body weight	Dietary intake
Vinter et al. 2011	BMI > 30 kg/m^2; Age 29 y; 10 – 14 weeks of gestation; n = 304	Diet and physical activity	-	Dietary intervention not described Moderate exercise for 30 – 60 min per day Weight gain limited to 5 kg	Up to delivery	Gestational body weight gain was lower in intervention compared to control group (p = 0.01)	-
Althuizen et al. 2012	All BMI categories; Age > 30 y; 14 weeks of gestation; n = 219	Diet and physical activity	-	Decreasing intake of high-fat foods, such as fast food items and sugar-containing soft drinks Maintenance of a healthy physical activity pattern Controlling body weight gain during and after pregnancy	Up to 52 weeks postpartum	Weight gain during pregnancy or body weight retention at postpartum did not differed between groups	-
Bertz et al. 2012	BMI 25 – 35 kg/m^2; Age 28 – 38 y; 10 – 14 week postpartum; n = 62	Diet and physical activity	Four-days food diaries	A reduction of 500 kcal per day, < 30 E% from fat, 10 – 20 E% from protein, 50 – 60 E% from carbohydrates, limiting sweets and snacks, substituting low-fat and low-sugar alternatives for regular foods, covering one-half of the plate with vegetables and reducing portion sizes 45 minutes physical activity at 60 – 70 % of the maximum heart rate 4 days per week	One year	Weight changes were -10.2 ± 5.7 kg, -2.7 ± 5.9 kg, -7.3 ± 6.3 kg and -0.9 ± 6.6 kg in diet, physical activity, diet and physical activity and control groups, respectively	-

Reference	Study design	Content of intervention	Method used	Aims	Duration of follow-up	Effect of intervention on: Body weight	Dietary intake
Korpi-Hyövälti et al. 2012	BMI ≥ 25 kg / m^2 ; Age > 40 y; (women with risk of gestational diabetes) gestational weeks 8 – 12; n = 54	Intervention and control groups	Four-days food diaries	Intake of carbohydrate 50 – 55, fat 30, and protein 15 – 20 E %, dietary fibre at least 15 g / 4.2 MJ, encouraging to consume rich in vegetables, berries and fruits and fat-free and low-fat meat, soft margarines and vegetable oils and whole-grain products in intervention group; Gestational body weight gain within recommendations (Hasunen et al. 2004;11)	Until delivery	Gestational body weight gain was lower in intervention group compared to control group, p = 0.062)	Intake of PUFA was higher in intervention group compared to control group, p = 0.008

2.3. Maternal body weight development

2.3.1. Physiology of body weight changes

During pregnancy

Gestational body weight gain is a biological progress which supports the growth and development of the foetus (Luke et al. 1981). The body weight rises due to accumulation of nutrients such as protein, fat and minerals and due to water in foetus, placenta, amniotic fluid, uterus, mammary gland, blood, and adipose tissue, slightly at early pregnancy and predominantly at the second and third trimester. The foetus, placenta, and amniotic fluid cause 35% of the total body weight gain (Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines 2009). On average, it is evaluated that 42% of total body weight gain is fat mass and 58% fat free mass (Butte et al. 2003). It is estimated that from two to 4.8 kilograms are gained fat mass (Forsum et al. 1988, Goldberg et al. 1993, Sohlstrom et al. 1995). Fat is stored subcutaneously and is mainly distributed to the trunk and partly to the thighs (Sohlstrom et al. 1995). Fat mass gain is positively correlated with gestational body weight gain (Butte et al. 2003, Lederman et al. 1997).

After pregnancy

A woman loses her body weight immediately after birth because of the removal of amniotic water, foetus and placenta (Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines 2009). Days or weeks after pregnancy extracellular and extravascular water are lost. The amount of body weight loss after pregnancy is individual. For women who have a normal body weight prior to pregnancy, it can be considered feasible for them to attain this body weight after pregnancy. Body weight retention after pregnancy is the amount of body weight which remains after a few months compared to the body weight prior to pregnancy and consists mainly of fat mass gained during pregnancy and breast tissue for breastfeeding. Body weight retention in the first months after pregnancy is approximately 3 kg to 7 kg compared to body weight prior to pregnancy (Walker et al. 2005). Fat increases in the upper trunk after pregnancy (Sohlstrom et al. 1995). Thus, pregnancy heightens the risk for pregnant women to gain visceral fat (Gunderson et al. 2008). Fat mass retention after pregnancy is positively correlated with greater body weight gain in women who have exceeded the recommended guidelines (Butte et al. 2003). Also fat mass gain during pregnancy predicts fat mass retention after pregnancy (Butte et al. 2003). Body weight retention after pregnancy exists and in women pregnancy may predispose women to be overweight (Linne et al. 2002).

2.3.2. Recommendations related to body weight

From 1900's to the present

The need for appropriate gestational body weight gain is recognized and the degree of body weight gain has varied during the decade's (Institute of Medicine, Subcommittee on Nutritional Status and Weight Gain During Pregnancy 1990). The 1930's marked the lowest amount of body weight gain and the highest was in the 1980's with, the values changing from below 7.0 kg to 15.9 kg. In the beginning of 1900's, body weight gain was restricted to avoid birth complications which were increased with birth complications due to enlarged babies (Institute of Medicine, Subcommittee on Nutritional Status and Weight Gain During Pregnancy 1990). Later, body weight gain rate was raised since reduced body weight gain resulted in smaller babies and thus increased chance for birth complications and death. Further, it was perceived that body weight, prior to pregnancy, is a major determinant for the amount of gestational body weight gain with overweight women gaining less body weight than normal or underweight women. In 1990, the recommendations of body weight gain, which considered body weight prior to pregnancy, were evaluated for the American population (**Table 6**). A European Scientific committee formulated similar recommendations for European population and these have been included in Finnish recommendations (Hasunen et al. 2004;11).

Table 6. Recommended total gestational body weight gain range for pregnant women according to the BMI prior to pregnancy in year 1990 and 2009 (Institute of Medicine, Subcommittee on Nutritional Status and Weight Gain During Pregnancy 1990, Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines 2009).

BMI prior to pregnancy (kg/ m^2)		Total body weight gain range (kg)
1990[1]	2009[2]	
< 20.0	< 18.5	12.5-18.0
20.0-26.0	18.5-24.9	11.5-16.0
> 26.0	25.0-29.9	7.0-11.5
	≥ 30.0	5.0-9.0

[1] Underweight with BMI < 20, normal body weight with BMI 20-26, overweight and obese with BMI > 26 (Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines 2009)

[2] Underweight with BMI < 18.5, normal weight with BMI 18.5-24.9, overweight with BMI 25.0-29.9, obese with BMI ≥ 30 (WHO (World Health Organisation) 2013)

Recently, in 2009, the Institute of Medicine re-evaluated the 1990's guidelines for gestational body weight gain due to the changing health conditions in women (Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines 2009) (**Table 6**). Increased obesity (Flegal et al. 1998, Mokdad et al. 1999, Kim et al. 2007) and older pregnancy age (Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines 2009) set new dietary approaches. Chronic conditions, such as hypertension or diabetes, are more common in pregnant women and may expose them to complications during pregnancy and increased morbidity later, years after pregnancy (Cleary-Goldman et al. 2005, Joseph et al. 2005, Delpisheh et al. 2008). Several studies demonstrated that women with a high BMI, prior to pregnancy, should avoid excessive body weight gain during pregnancy to prevent negative metabolic outcomes in both mother (Langford et al. 2011, Cedergren 2006, Kiel et al. 2007, Nohr et al. 2008, Viswanathan et al. 2008) and offspring (Vohr et al. 2008, Monasta et al. 2010). New guidelines also include specific recommendations for overweight and obese women. Re-evaluated recommendations (Institute of Medicine (US) and National Research Council (US) Committee to Reexamine IOM Pregnancy Weight Guidelines 2009) are applicable for European women also. Cut-off points for the BMI categories for the newest recommendations are from the World Health Organization (WHO (World Health Organisation) 2013). There are not corresponding recommendations for body weight loss after pregnancy as there are for gestational body weight gain.

Body weight loss during pregnancy and lactation is not recommended so that a sufficient intake of energy and nutrients will be provided to the offspring. Further, body weight loss during breastfeeding may disturb breastfeeding impoverishing the content of breast milk (Hoppu et al. 2012). During breastfeeding the losing of the extra storage fat 2 – 3 kg, which includes the recommended weight gain during pregnancy (Hasunen et al. 2004;11). After breastfeeding, body weight can be achieved to that prior to pregnancy. Excessive body weight retention after breastfeeding may increase the risk of diseases, such as type 2 diabetes and cardiovascular diseases (Wild et al. 2006) and is reasonable to lose. The body weight loss rate on average is 0.5 – 1.0 kilograms per week and is recommended amongst the general population (Suomalaisen Laakariseuran Duodecimin ja Suomen Lihavuustutkijat ry:n asettama tyoryhma 2011).

Recommendations in practice

Implementation of recommended gestational body weight was not evaluated in Finland. Nevertheless, body weight gain during pregnancy increased during 1960 and 1980 from 13.3 kg to 14.3 kg. In the 2000's, body weight gain during pregnancy remained at the same level, 14.3 kg (Kinnunen et al. 2003).

Dietary counselling for achieving the recommended gestational body weight gain is useful (Mottola et al. 2010, Korpi-Hyovalti et al. 2012, Polley et al. 2002, Olson et al. 2004, Wolff et al. 2008, Asbee et al. 2009, Huang et al. 2011, Jackson et al. 2011, Tanentsapf et al. 2011) (**Table 5**). Evidence for the effectiveness of counselling on body weight maintenance after pregnancy exists (Mottola et al. 2010, Hui et al. 2012, Huang et al. 2011, Leermakers et al. 1998, McCrory et al. 1999, Bechtel-Blackwell 2002, O'Toole et al. 2003, Ash et al. 2006, Kinnunen et al. 2007, Keller et al. 2008, Craigie et al. 2011) (**Table 5**). Several studies show the effect of dietary counselling on body weight, up to two years after pregnancy, but fewer studies explore the effects of diet on long-term body weight, over a two year period.

High-fat dietary intake associates with excessive body weight gain during pregnancy (Hui et al. 2012, Stuebe et al. 2009, Uusitalo et al. 2009). Processed fat intake (Oken et al. 2007, Martins et al. 2011) relates to weight retention after pregnancy whereas adequate intake of dietary fibre (Drehmer et al. 2012) connects to weight loss after pregnancy.

2.4. Association of nutrition and health

2.4.1. During pregnancy

Nutrition, during pregnancy, is of the utmost importance. It affects the health of both the pregnant women and offspring. Early nutrition is vital for the growth and development of the foetus (Wu et al. 2012) and it effects the risk for diseases in offspring later (Barker 1995). Currently, being overweight during pregnancy, predisposes offspring to macrosomia (Yessoufou et al. 2011), metabolic complications and obesity later in life (Vohr et al. 2008, Monasta et al. 2010, Barker 1995, King 2006, Fall 2009, Guilloteau et al. 2009, Labayen et al. 2009, Beyerlein et al. 2012, Ehrlich et al. 2012, Kim et al. 2012). For a mother, being overweight can cause health complications (Langford et al. 2011, Kiel et al. 2007, Viswanathan et al. 2008, Thorsdottir et al. 2002) and hypertension (Thorsdottir et al. 2002) as well as gestational diabetes (Carreno et al. 2012, Gibson et al. 2012). These situations increase the risk for type 2 diabetes, cardiovascular diseases and metabolic syndrome (Vohr et al. 2008, Ehrlich et al. 2012, Verier-Mine 2010).

Excessive gestational body weight gain heightens the risk for body weight retention (Gore et al. 2003, Huang et al. 2007) and increases the chances to become overweight and gain central adiposity (Kac et al. 2004, Linne et al. 2004, Butte et al. 2006, Butte et al. 2003, Gunderson et al. 2008, Gore et al. 2003, Huang et al. 2007, Scholl et al. 1995, Gunderson et al. 2000, Rooney et al. 2002, Amorim et al. 2007b, Callaway et al. 2007, Walker 2007, Joseph et al. 2008, Lyu et al. 2009, Maddah et al. 2009, Phelan et al.

2011, Poston 2012) after pregnancy. Excessive gestational body weight gain is harmful for the later health of offspring also (Vohr et al. 2008, Monasta et al. 2010, Beyerlein et al. 2012, Ehrlich et al. 2012, Kim et al. 2012). Women who have high BMI prior to pregnancy are at risk for excessive gestational body weight gain (Joseph et al. 2008, Olafsdottir 2006) or in women whose dietary intake may consist of calorie-dense foods (Drewnowski et al. 2005). In addition, genes (Lindsay et al. 2002) may predispose these women for excessive body weight gain.

2.4.2. After pregnancy

Nutrition, after pregnancy, affects the recovery of delivery and the overall well-being of mother, for example, by increasing the risk for depression after pregnancy (Bodnar et al. 2005) and the success of breastfeeding (Yin et al. 2012). Overweight and obesity after pregnancy may hinder the success of breastfeeding and obese women most frequently cease breastfeeding (Kronborg et al. 2012). Importantly, the quality of dietary fat intake during breastfeeding associates with the risk of allergic diseases in the offspring (Hoppu et al. 2000).

Early nutrition is important since dietary habits are transferred from mother to child and eating habits are learned during childhood (Mikkila et al. 2005). Promoting a healthy diet in childhood increases the possibilities for the child to follow these habits into adulthood.

2.5. Factors related to body weight control amongst general population

2.5.1. Dietary intake

Quality of diet in intervention studies

Dietary intake is a major factor which determines body weight development. Dietary fat, protein and dietary fibre intake is linked with body weight amongst women (**Table 7**). Fat reduction in diet is useful in body weight control (Lee-Han et al. 1988, Boyd et al. 1990, Sheppard et al. 1991, Kasim et al. 1993, Weststrate et al. 1998, Saris et al. 2000). Recommended dietary fat intake is 25 – 35 E % (Becker et al. 2004) and lower dietary fat intake is not recommended. Although a few studies (Sheppard et al. 1991, Kasim et al. 1993, Lanza et al. 2001, Howard et al. 2006, Saquib et al. 2008) aimed to decrease fat intake 20 E % or below, these studies neglected to assess the quality of the dietary fat. Essential fatty acids are vital for the health of non-pregnant and non-lactating women (Deckelbaum et al. 2012).

Increased intake of dietary fibre together with reduced intake of fat is associated with lower body weight gain (Lanza et al. 2001, Saquib et al. 2008, Ludwig et al. 1999, Hays et al. 2004). Increased intake of fruits and vegetables are highly recommended (Lanza et al. 2001, Howard et al. 2006, Saquib et al. 2008). There is also evidence which shows beneficial health effects and long-term body weight control of the intake of long-term dietary fibre uptake (Ludwig et al. 1999, Liu et al. 2003). The advantage of protein intake on body weight control is controversial. High protein intake (18 – 30 E%) might have favourable effects on body weight loss in overweight or obese subjects (Westerterp-Plantenga et al. 2004, Lejeune et al. 2005, Sacks et al. 2009, Larsen et al. 2010, Evans et al. 2012, Josse et al. 2012).

A plausible mechanism in body weight loss with a diet high in dietary fibre and in protein and low in fat might be that the energy density is low in these diets. There is evidence that low energy density diets promote body weight loss (Yao et al. 2001). The mechanisms related to dietary fibre (Howarth et al. 2001) and protein (Leidy et al. 2007) in body weight control may be explained by satiety which reduces hunger and limits energy intake resulting in body weight loss.

Table 7. Examples of intervention studies which examine the effect of a low-fat diet on weight and cohort studies which examine high fibre intake on weight in normal and overweight pre-menopausal women. Mean values are presented with standard deviations (in parenthesis) and standard error of the mean (±).

Reference	Study design	Dietary aim	Method used	Duration of follow-up	Effect of intervention on weight change
(Boyd et al. 1990)	All BMI categories; Age 44 ± 8 y; n = 206	To reduce dietary fat intake individually by 15 %, substituting it by carbohydrates	Three-days food diary	1 year	Weight reduced from 60 ± 8 kg to 59 ± 7 kg in intervention group, and remained unchanged in control group; $p > 0.05$
(Sheppard et al. 1991)	All BMI categories; Age 56 ± 6 y; n = 303	Fat reduction from 39 E % to 20 E %, substituting non-fat sources of energy intake	FFQ and four-days food diary	2 years	Weight changed at year 1: -3.0 ± 4.8 kg in intervention, and -0.4 ± 3.5 kg in control group at year 2: -1.9 ± 4.9 kg in intervention, and -0.1± 4.1 kg in control group; p values not known
(Kasim et al. 1993)	All BMI categories; Age 46 ± 2 y; n = 72	To reduce fat intake to 15 % E %[1]	Three-days food diary	1 year	Weight reduced from 67 ± 2 kg to 63 ± 1.9 kg in intervention group, and from 73 ± 2 kg to 72 ± 1.9 kg in control group; p value not known
(Ludwig et al. 1999)	All BMI categories; Age 18 – 30; n =1602	high *vs* low dietary fibre combined with low fat (< 33 E%) intake	FFQ	10 years	The lowest intake of dietary fibre (in tertiles) associated with +10 kg weight change and the highest intake of dietary fibre, +7 kg weight change; p value not known

[1] % of total energy

Reference	Study design	Dietary aim	Method used	Duration of follow-up	Effect of intervention on weight change
(Lanza et al. 2001)	All BMI categories; Age 61 y; n = 2079	Fat intake 20 E %, fibre intake 4.3 g / MJ, fruits and vegetables 5 – 8 servings per day according to the energy intake	FFQ and four-days food diary	4 years	Weight changed (compared to baseline) at year 1: -2.0 ± 0.1 kg in intervention, +0.01 ± 0.1 kg in control group at year 2: -1.3 ± 0.2 kg in intervention, +0.1 ± 0.1 kg in control group at year 3: -1.1 ± 0.2 kg in intervention, +0.3 ± 0.2 kg in control group at year 4: -0.7 ± 0.2 kg in intervention, +0.3 ± 0.2 kg in control group; $p < 0.001$
(Liu et al. 2003)	BMI 25 ± 5 kg/m^2; Age 50 ± 5 y; n = 74091	High *vs* low dietary fibre intake	FFQ	12 years	The lowest intake of dietary fibre (in quintiles) associated with +5.2 kg weight change and the highest intake of dietary fibre with +4.3 kg weight change in normal weight subjects; $p = 0.01$ The lowest intake of dietary fibre (in quintiles) associated with +5 kg weight change and the highest intake of dietary fibre with +3 kg weight change in overweight subjects; $p < 0.0001$
(Hays et al. 2004)	BMI 31 (2) kg/m^2; Age 66 ± 1 y; n = 34	Food products were provided, not reported	Five-days food diaries	3 months	Weight reduced by diet, including 18 E % from fat, 62 E % from carbohydrates and 57 g / d dietary fibre -3.2 ± 1.2kg, and by diet, including 41 E % from fat, 44 E % from carbohydrates and 18 g / d fibre -0.1 ± 0.6 kg; $p = 0.02$

Reference	Study design	Dietary aim	Method used	Duration of follow-up	Effect of intervention on weight change
(Howard et al. 2006)	BMI 29 (6) kg/m^2; Age 62 (7) y; n = 48835	Fat intake 20 E%, intakes of fruits and vegetables 5 or more servings per day	FFQ	7 years	Weight changed (compared to baseline) at year 1: -2.2 kg in intervention, and remained unchanged in control group, p < 0.001 at year 7: -0.8 (10.1) kg in intervention, -0.1 (10.1) kg in control group, p < 0.001
(Saquib et al. 2008)	BMI 27 (6) kg/m^2 ; Age 53 (9) y; n = 2718	Intake of fat 15-20 E %, fibre 30 g, vegetables at least 5 and fruit 3 servings per day	24-h dietary recalls	1 year	Weight changed (compared to baseline) at year 1: -0.1 in intervention, +0.7 in control group, p < 0.001 at year 4: +1.8 in intervention and +1.4 in control group, p = 0.25
(Tucker et al. 2009)	All BMI categories; Age 40y; n = 252	High *vs* low dietary fibre intake	Seven-days food diaries	20 months	8 g dietary fibre / 1000 kcal associated with weight change -2 kg in 20 months; p = 0.0061
(Du et al. 2010)	BMI 26 ± 4 kg/m^2; Age 53 ± 9 y; n = 89432	High *vs* low dietary fibre intake	FFQ	6.5 (1.9 – 12.5) years	10 g / d total dietary fibre intake associated with annual weight change of -39 g / y (95 % CI -71, -7 g / y); p = 0.01

Probiotics

The advantages of probiotics towards diarrhoea diseases are well known (Heyman 2000). The newest finding is that probiotics may be useful in modulating body weight gain since microbiota differs between in obese and normal body weight according to the animal and humans studies (Ley et al. 2005, Turnbaugh et al. 2006, Collado et al. 2008, Kalliomaki et al. 2008).

Probiotics enable the hydrolysis of indigestible polysaccharides and thus increase energy yield from the diet. Further, this influences fat absorption and accumulation and this affect energy yield (Backhed et al. 2004, Hamad et al. 2009). Another explanation may be found from endotoxemia which is linked to obesity (Fantuzzi 2005). In metabolic endotoxemia, the amount of lipopolysaccharides in plasma increases due to lipopolysaccharide-containing microbiota which results from a high-fat diet (Cani et al. 2007). Systemic endotoxemia in obesity is linked to increased intestinal permeability (Cani et al. 2008). Probiotics have the capacity to normalize increased intestinal permeability (Hamad et al. 2009, Isolauri et al. 2008) and thus reduce the systemic endotoxemia.

Low-grade inflammation relates to obesity (Fantuzzi 2005). Probiotics produce anti-inflammatory cytokines which reduce inflammation (Isolauri et al. 2008) and thus may be influence the accumulation of pro-inflammatory cytokines produces from visceral fat (Tchernof et al. 2013). In addition, inflammation is associated with a high-fat diet consisting of saturated and polyunsaturated, especially n 6 fatty acids (Cani et al. 2008) and individual fatty acids have immunomodulatory properties (de Vries et al. 2009). Indeed, probiotics may restrain inflammation and dietary fatty acids may utilize the same signalling pathways as microbiota (Yu et al. 1997). Omega–3 fatty acids are advantageous due to anti-inflammatory effects (Mori et al. 2004). Thus, a low ratio of omega-6 / omega-3 fatty acids (3 / 1 *vs.* 10 / 1) is important when reducing the risk for chronic diseases (Simopoulos 2008).

2.5.2. Other factors

Certain eating behaviours associate with body weight. Especially, disinhibition scores are observed more frequently in overweight and obese individuals compared with normal weight individuals (Boschi et al. 2001, Provencher et al. 2003) which predicts weight gain (Hays et al. 2002). Disinhibition is also a good predictor for unhealthy food consumption, such as high-fat and sweet foods (Lahteenmaki et al. 1995, Contento et al. 2005) and thus may be unfavourable when considering weight control. Similarity, uncontrolled eating may be unfavourable eating behaviour in weight control (Dykes et al. 2004, Keranen et al. 2009). On the contrary, cognitive restraint associates with the

consumption of fewer energy-dense foods and more healthy foods (de Lauzon et al. 2004, Keranen et al. 2011). Cognitive restraint associates with lower BMI (Cappelleri et al. 2009). Nevertheless, this finding is controversial. In normal weight population, cognitive restraint associates with adiposity (de Lauzon-Guillain et al. 2006) and higher BMI (Elfhag et al. 2005, Angle et al. 2009) whereas amongst the overweight it may be useful (de Lauzon-Guillain et al. 2006, Konttinen et al. 2009). Emotional eating associates with a higher body mass (van Strien et al. 2012, de Lauzon-Guillain et al. 2006, Keskitalo et al. 2008, Koenders et al. 2011). Emotional eating, similar to uncontrolled eating, is related to a higher consumption of sweet foods (Konttinen et al. 2010) which may be related to weight gain.

Increased physical activity increases body weight loss (Thorogood et al. 2011) but not as effectively as a weight-loss based diet. Physical activity together with diet is more effective than diet alone (Shaw et al. 2005). The amount of physical activity in body weight control is individually based on the caloric intake of diet.

3. AIMS OF THE STUDY

The main purpose of this series of studies was to evaluate the effect of individual dietary counselling on maternal dietary intake and long-term body weight after pregnancy.

The itemised specific aims were:

1. To collect the nurses' opinions of the present dietary counselling practices in Finnish maternity and child health clinics (I).

2. To evaluate the effect of dietary counselling and probiotic intervention during and after pregnancy on dietary intake and maternal body weight control, up to four years after pregnancy (II, III).

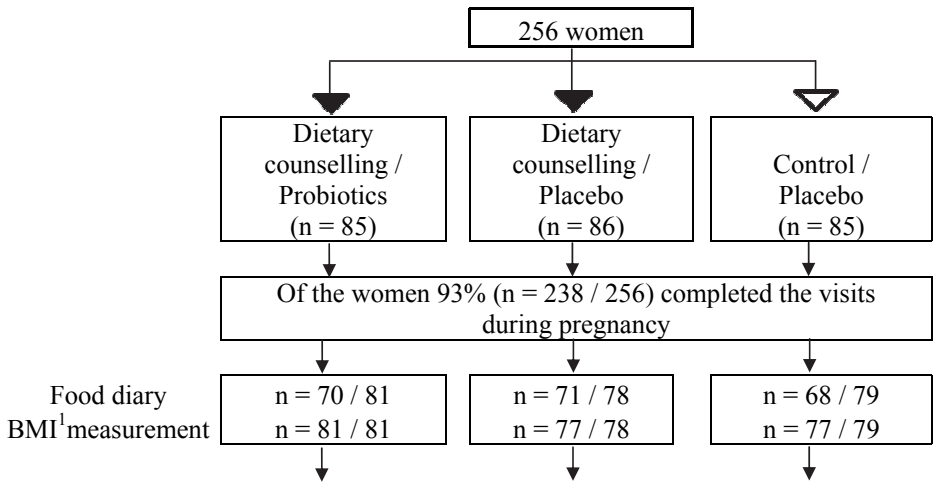
3. To assess, other factors influencing weight gain such as eating behaviour, body weight prior to pregnancy and gestational body weight gain that might affect dietary intake and body weight up to four years after pregnancy (IV).

4. STUDY DESIGN AND METHODS

4.1. Subjects

The first study (I) comprised of nurses (n = 327) working at nationwide Finnish health clinics. Subjects in the health clinic study were recruited *via* e-mail. Inclusion criteria were working at a maternity and / or child health clinics. Nurses' clinical practices were examined by a previously tested questionnaire.

In mother-infant nutrition and probiotic intervention studies (II-IV), a cohort of 256 women was recruited and gestation at less than 17 weeks was required. Pregnant women were randomized to receive dietary counselling with probiotics or placebo and controls with placebo at entry and they were followed-up until four years after pregnancy. **Figure 1** shows the subjects who completed their food diary and anthropometric measurements, such as body weight and waist circumference at different study visits. Of the women, 76% (195 / 256) were followed up to six months after pregnancy, 74% (189 / 256) up to one year after pregnancy (II), 68% (173 / 256) up to two years after pregnancy and 49% (125 / 256) up to four years after pregnancy (III, IV). Twenty-three women were re-pregnant at one year after pregnancy, 23 at two years and 9 at four years after pregnancy and therefore excluded from the analysis. In addition, reasons for interrupting the study were migration to an outer locality, scheduling conflicts and illnesses and diseases in mother or child.



[1] Body mass index

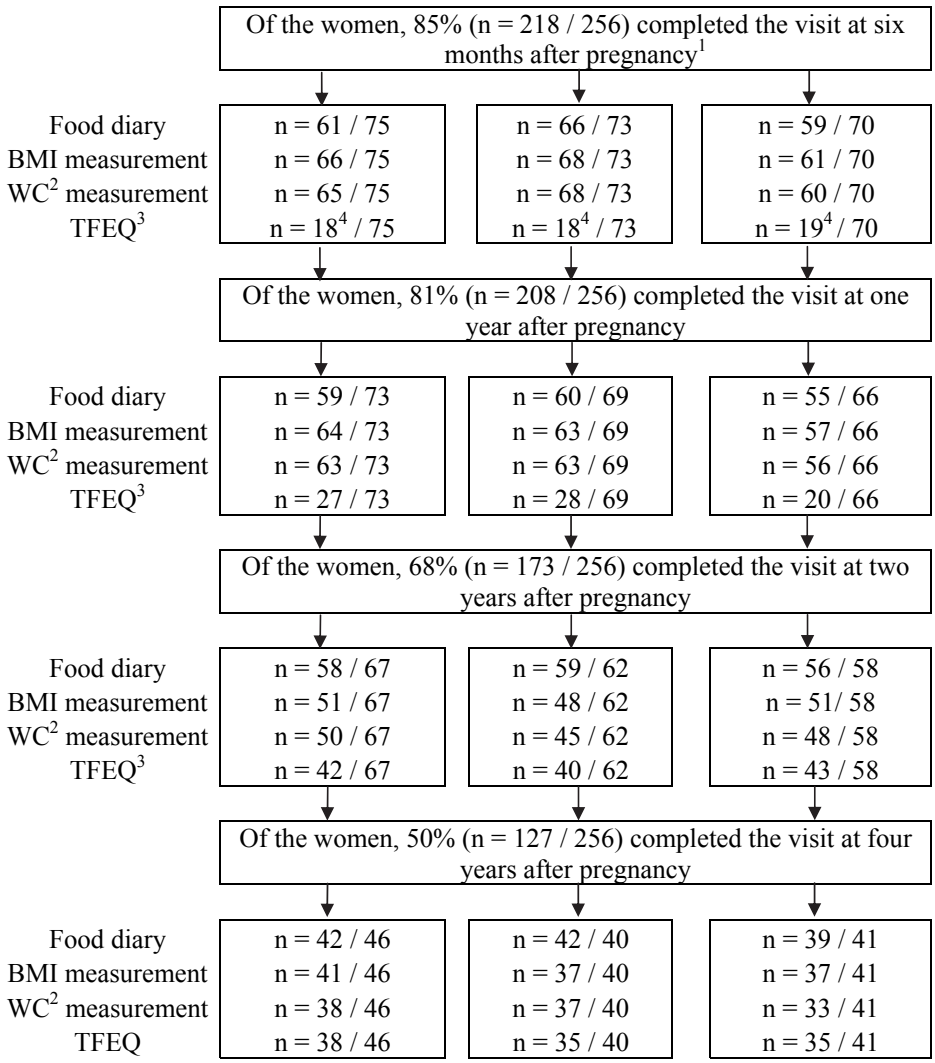


Figure 1. Flow chart of participated women at different study visits in follow-up study (II-IV). Women who were re-pregnant are excluded from the flow chart. Women were randomised to receive dietary counselling (from the 1st trimester of pregnancy until the 4 y after pregnancy) or controls and to receive probiotics or placebo in a ▽ single-blind or ▼ double-blind manner.

[1] The use of capsules ended until the end of exclusive breastfeeding, a maximum of six months after pregnancy

[2] Waist circumference

[3] Three Factor Eating Questionnaire

[4] TFEQ was brought into the use after that as follow-up visits at six months had been started

4.2. Study design

The questionnaire, used in Study I, was designed to evaluate nurses' nutrition education and current dietary counselling practices. It was formulated and sent to nurses in maternity and child health clinics (n = 650) nationwide in the form of e-mail links using the WEBROPOL computerised program (Webropol Oy, Helsinki, Finland). Questionnaires were tested to check the intelligibility of questions prior to sending these to the nurses. Questionnaires were re-sent to non-respondents twice. Nurses' identity data were obtained from the Union of Public Health Nurses of Finland, and e-mail addresses to which the questionnaires were sent were taken from the catalogue of health services.

The studies II – IV are part of the larger follow-up study which was conducted in the city of Turku and neighbouring areas in South-West Finland. Women with allergic families (mother, father or sibling of unborn child with allergy) were recruited from April 2002 to November 2005. The women were informed of the study by leaflets outlining its aims and requirements, these being distributed during their first visit to a maternity health clinic. Interested recipients contacted the research nurse for information and an appointment at the study clinic in Turku University Hospital. Mothers were healthy with no metabolic diseases such as diabetes while allergy was allowed.

Subjects at the follow-up study (II-IV) were randomly assigned to a prospective, parallel-group nutrition and probiotics intervention study with three groups. The randomisation (**Figure 1**) was conducted according to computer-generated block randomisation to receive dietary counselling with probiotic capsules (dietary counselling / probiotics) or placebo (dietary counselling / placebo) and controls (control / placebo) by a statistician, who was not involved in recruitment or study visits. Randomization to receive probiotics or placebo in the dietary intervention groups was conducted in double-blind manner and to receive placebo in the control group in single-blind manner. Probiotics were administered as capsular preparations, one capsule per day, containing Lactobacillus rhamnosus GG (ATCC 53103, Valio Ltd., Helsinki, Finland) and Bifidobacterium lactis 1010 cfu / d each (B. lactis Bb12, Christian Hansen A/S, Hoersholm, Denmark) and placebo in capsules containing microcrystalline cellulose and dextrose anhydrate (Chr. Hansen, Hoersholm, Denmark). Probiotics and placebo capsules and contents looked, smelled and tasted identical. Compliance in consumption was good; more than 95% of the subjects consumed the capsules.

After baseline, during the first trimester of pregnancy, the subsequent study visits took place at each trimester of pregnancy, and at one and six months and one, two and four years after pregnancy (II-IV). At each visit, the intervention groups received dietary counselling supported by provision of food products for use at home and probiotics or

placebo capsules (**Table 8**). Food products and capsules were consumed from the first trimester of pregnancy until the end of exclusive breastfeeding, a maximum of six months after pregnancy. All pregnant women participating in the study also attended municipal maternity health clinics.

Table 8. Summary of collected dietary and anthropometric measurements of women and delivered brochures for mothers at different study visits.

	1st, 2nd and 3rd trimester of pregnancy		1, 6 mo and 1 year after pregnancy		2 and 4 years after pregnancy	
	with counselling	without counselling	with counselling	without counselling	with counselling	without counselling
Measurements						
Height	x	x	-	-	-	-
Weight	x	x	x	x	x	x
Waist circumference	-	-	x	x	x	x
Three-days food diary	x	x	x	x	x	x
Questionnaires						
The use of fish	x	x	x	x	x	x
The use of food products	x	-	x[1]	-	-	-
The use of the commercially available fats in diet	-	-	x	x	x	x
Three factor eating	-	-	x[2]	x[2]	x	x
Questionnaire concerning views of own weight	-	-	x[3]	x[3]	x	x

[1] At one and six months after pregnancy
[2] Initiated after six months follow-up visits had started
[3] At one year after pregnancy

4.3. Dietary counselling (II-IV)

Dietary counselling given by a nutritionist at all study visits, *i.e.* 1st, 2nd and 3rd trimester of pregnancy and six months, one, two and four years after pregnancy for women in dietary intervention groups. The counselling aimed to modify dietary intake to conform to dietary recommendations, providing 55-60 percentage of energy (E%) from carbohydrates 10-15 E% from protein and 30 E% from fat. Dietary counselling focused especially on the amount and type of fat and dietary fibre and aimed to recommend the sufficient intake of vegetable oils, margarines and fruit and vegetables in the diet. Brochures concerning fat, fish, dietary fibre and vegetables intakes (formulated by the The Association of Clinical and Public Health Nutritionists in Finland, RTY; Finnish Horticultural Products Society; The Finnish Fish Farmers' Association) were delivered during pregnancy for women receiving dietary counselling. All women received brochures concerning dietary intake during pregnancy (formulated by the nutritional scientists). Brochures concerning weight control and diet (formulated by RTY) for all overweight women were delivered at one year after pregnancy, if needed.

Dietary counselling aimed to give comprehensive and individual counselling in which mother's individual gestational body weight gain and overweight after pregnancy was considered. Counselling was based on food diaries taking into account the women's preferences and individual's current meal frequency. In cases where excessive gestational body weight gain or overweight after pregnancy occurred, dietary counselling focused on regular meal frequencies, smaller portion sizes and reduction in consumption of sweet or savoury delicacies.

Concomitant with dietary advice the women were encouraged to undertake regular physical activity and exercise according to their capabilities, making allowance for the stage of pregnancy. For overweight women (BMI > 25), body weight loss rate, on average, 0.5 kilograms per week was recommended after pregnancy and lactation. This was recommende by dietary changes combined with physical activity.

4.4. Measurements

4.4.1. Questionnaire for nurses (I)

The questionnaire comprised 33 items including single-choice, multiple-choice, open questions and claims. Background information such as working place, age and education and the sources of nutrition information was asked by single- and multiple choice questions and by dietary counselling practices. Claims included a 5-grade scale: strongly agree, agree, neither agree nor disagree, disagree and strongly disagree. Claims concerned nutrition and dietary recommendations. It provided knowledge about the

treatment and prevention of food allergies, compositions of breast milk and formula milk, treatment of hyperglycaemia during pregnancy and maternal energy requirement during breastfeeding and the recommended duration of exclusive breastfeeding. Claims were alphabetized A and B and were presented according to current recommendations and other claims C – G were presented against the recommendations of the questionnaire.

Prior to dispatch, the questionnaires were evaluated for clarity and comprehensibility by nurses (n = 16), dieticians and nutritionists (n = 4) and physicians (n = 2). After testing, questions on background and education were drafted and open questions to investigate topics for in-service training (post-qualification education) were formulated.

4.4.2. Questionnaires for mothers (II-IV)

Background information concerning age, smoking, education (whether comprehensive school or college-level training or university/college), parity and body weight prior to pregnancy was collected by interview at the first study visit which took in the place 1st trimester of pregnancy.

Physical activity level, including weekly programs of at least 30 minute sessions of exercise which caused perspiration and breathlessness, was recorded at each study visit. Women's views of their own body weight were interviewed in scale suitable or unsuitable (too less or too much) at two and four years after pregnancy.

4.4.3. Dietary intake (II-IV)

Dietary intake was assessed at each study visit with consecutive three-day food diaries, including one weekend day. Days were self-selected. Food diaries including only one of two days, or consisting defective information, were excluded. Subjects were instructed to fill in the food diaries by telephone before the first visit. The use of supplements was queried in food diaries also. The nutritionist checked food diaries at all study visits and specified the information in diaries, if necessary. Daily intake of energy, energy-yielding nutrients and nutrients, which are crucial during pregnancy and lactation, including vitamins C, D, E and folate, calcium and iron from food were calculated by the Micro-Nutrica® computerized program (version 2.5, research Centre of the Social Insurance Institution, Turku, Finland). The database of this program has been validated and is continuously updated with data on new, commercially available foods.

To describe the quality of the diet, a healthy eating index was calculated based on guidelines given by the European Health Monitoring Program (Steingrimsdottir et al.

2002). Selected nutrition indicators for health were intakes of vegetables, fruits and berries, fish and bread and intakes of saturated fatty acids and salt. The intakes of these foods were calculated from the food diaries and were scored between 1 and 5 for each food, a maximum index being 25.

At each study visit, women receiving dietary counselling received oral feedback from their food diary. After each study visit, all women received, by post, their numeric sum, from their food diary, of their intake of nutrients, as calculated by Micro-Nutrica® computerized program. Women, who received dietary counselling, also received verbal feedback that contained proposals for dietary improvements.

4.4.4. Anthropometric measurements (II-IV)

Weight was measured at each study visit using a calibrated scale. Weights and height, measured at the first study visit, were used to calculate BMI as body weight (kg) divided by the square of height as meter (m). The women were classified according to BMI prior to pregnancy as normal-weight (BMI < 25.0 kg/m^2), overweight (25.0 kg/m^2 BMI < 30.0 kg/m^2), or obese (BMI ≥ 30 kg/m^2). Total gestational body weight gain was calculated by subtracting body weight prior to pregnancy from the body weight recorded at prenatal visit and at the hospital within one week before delivery. Assessment of body weight gain in comparison to that recommended for pregnancy was made according to mothers' BMI prior to pregnancy categories. Gestational body weight gain was classified as normal, excessive or low, the recommended gain being 12.5-18.0 kg for women with a BMI prior to pregnancy below 19.8, 11.5-16.0 kg for those with a BMI from 19.8 to 26.0, and 7-11.5 kg for those with a BMI above 26.0 prior to pregnancy.

Waist circumference was measured at six months, one, two and four years after pregnancy by the nutritional scientist. Subjects were divided into two groups with a waist circumference < 80 cm and ≥ 80 cm according to the measurement after pregnancy. Waist circumference, exceeding the cut-off of 80 cm, may be taken to reflect central obesity and has been found to be related to an increased risk of metabolic and cardiovascular diseases (Siren et al. 2012).

4.4.5. Three-Factor Eating Questionnaire (IV)

Validated TFEQ-18 questionnaire was used here to evaluate women's eating behaviour at six months, one, two and four years after pregnancy (**Table 8**). The questionnaire covers three aspects of behaviour related to eating; cognitive restraint (CR) (six claims in the questionnaire), uncontrolled eating (UE) (nine claims) and emotional eating (EE)

(three claims). CR represents constant restriction of eating, regardless physiologic signs of hunger and satiety, UE comprises overeating relative to physiologic need and a feeling of lack of control when considering eating and EE refers to overeating during depressed and melancholic states. All questions are principally answered on a scale: totally agree, agree, disagree and totally disagree, and coded, the final score ranging from 1 to 100, higher values indicating higher behaviour in each type: CR, UE or EE (Karlsson et al. 2000).

4.5. Statistical analyses

Results were presented as percentage of the number of subjects (Study I). As there were no differences in frequencies of responses between nurses in maternity and child health clinics, results were analysed for all clinics together.

Analyses considering the dietary intake, the dietary counselling groups were combined as no differences were noted in dietary intake between the women receiving dietary counselling with or without probiotics (study II-IV). Thus, energy standardised intakes was not presented. T-tests, analysis of variance (ANOVA) and the Chi-squared test were used for baseline clinical characteristic and dietary intake, body weight and waist circumference, which had normal distribution (studies II-IV). Being dissatisfied with body weight was tested by the Chi-squared test. When evaluating the implementation of recommendations the Generalized Estimating Equations (GEE) analysis, which takes into account all study visits during six months and four years after pregnancy, was used. Despite random allocation of the subjects to the study groups there was a difference in body weight at baseline, 1st trimester of pregnancy, the women receiving dietary counselling with probiotics having the lowest BMI and women receiving dietary counselling with placebo having the highest BMI at baseline (ANOVA, $p = 0.004$). Thus, results for body weight and waist circumference after pregnancy are presented as adjusted for baseline BMI.

Analysis of covariance (ANCOVA) was used as a secondary analysis, where the continuous BMI and waist circumference were compared between three study groups and the baseline BMI was included as a continuous covariate. The results are given as adjusted means with 95% confidence intervals. BMI prior to pregnancy was included as a dichotomous or as a continuous covariate, when appropriate. The results are given as adjusted odds ratios with 95% confidence intervals. Eating behaviour scores are given as mean scores with 95 % confidence intervals (IV). Associations between nutrient intake (as tertiles), BMI (< 25 kg/m^2 or ≥ 25 kg/m^2) and waist circumference (< 80 cm or ≥ 80 cm) *vs*. eating behaviour scores were analysed using the GEE analysis with ANOVA.

No interaction effect between dietary intervention and eating behaviour was detected ($p > 0.05$) by GEE analysis interaction which suggests that eating behaviour had no influence on the effectiveness of the intervention. Thus, all study groups are presented together.

Women who were re-pregnant were excluded from the analyses in study II-IV. Statistical analyses were performed by Statistical Package for the Social Sciences version 13.0 in study amongst nurses (study I) and versions 15.0 (study II) or 20 (study III-IV) amongst women (SPSS Inc. Chicago, IL, USA).

4.6. Ethics

Studies I-IV was all approved by the Ethics Committee of the Hospital District of South-West Finland. The studies complied with the Declaration of Helsinki as revised in 2000. Written informed consent was obtained from the participants in studies II-IV.

5. RESULTS

5.1. The clinical characteristics of participants

In the study amongst nurses (I) (n = 327), who were representative of all Finnish hospital districts, a validated questionnaire was used for these nurses to evaluate dietary counselling practices in their clinics. These questionnaires had a final response rate being 50%. The majority of the nurses were public health nurses (87%) and the rest of midwifes or nurses. Of the public health nurses 19% worked at maternity health clinics, 39% at child health clinics and 41% worked at both of these. Mean age of nurses was 48 years (between 23 and 61) without significant difference between different clinics.

Of the recruited women (n = 256) at the baseline, in the first trimester of pregnancy, the mean age of total population was 30.0 years (18.5 – 41.8) with the majority (76%) having college or university education (II – IV). Smoking rate prior to pregnancy was 18% and of the women, 57% were primigravida. Duration of exclusive breastfeeding was on average 3.4 (± 2.0). BMI prior to pregnancy was on average 23.5 (17.4 – 34.8). There was difference in BMI at baseline between three study groups (23.6 in women receiving dietary counselling with probiotics, 25.4 in women receiving dietary counselling with placebo and 24.6 in control women; $p < 0.05$), thus the results for BMI and waist circumference are presented as adjusted for baseline. There were no differences in other baseline characteristic amongst the three study groups.

5.2. Dietary counselling in clinics (I)

5.2.1. Practices in health clinics from the nurses' view point

Nurses provided dietary counselling to families and most nurses (84%) thought that nutrition was a very important subject. Seventy-seven – 100% of the nurses counselled their clients for several nutrient related diseases, including obesity, hypertension, type 2 diabetes and gestational diabetes as well as also difficult experienced diets such as eating disorders and chronic inflammatory bowel diseases. Of the nurses, 92% inquired into their clients' current diet almost always or moderately often. Of these nurses, 99% inquired through informal discussions. Nurses (72% of respondents) reported that they had not consulted dieticians mainly due to lack of services. Overall, nurses thought that individual counselling, supporting the well-being of families, promoting health and reducing the risk of metabolic or cardiovascular diseases was challenging. Increased amount of nutritional education, collaboration with families and other healthcare professionals and resources to improve counselling in clinics are necessary.

5.2.2. Nutritional knowledge of nurses

Most nurses had received nutrition courses in their nursing education (97% of respondents) or further education (73% of the respondents). However, nutrition courses was minimal in nursing education (98% of nurses' responses) and advanced training were insufficient (88% of nurses' responses). They have actively searched for information on nutrition, in addition to further training, especially *via* conversations with colleagues (95%), professional literature (95%) and through the internet (92%).

Insufficient nutrition education among nurses is indicated by the nurses' varying knowledge of present nutrition recommendations (**Figure 2**). The effect of maternal nutrition during lactation on the composition of breast milk was known (96% of respondents agreed entirely or slightly) as well as the treatment of food allergies by avoiding the foods which cause the symptoms (92% of respondents agreed entirely or slightly). Instead, not avoiding foods to prevent allergies was known by 78% of the nurses, differences in composition between breast milk and formulas by 82% of the nurses, treatment of hyperglycaemia by balanced diet by 56% of the nurses, differences in energy requirements between pregnant and lactating women by 58% of the nurses and the recommended duration of exclusive breastfeeding until six months by 62% of the nurses.

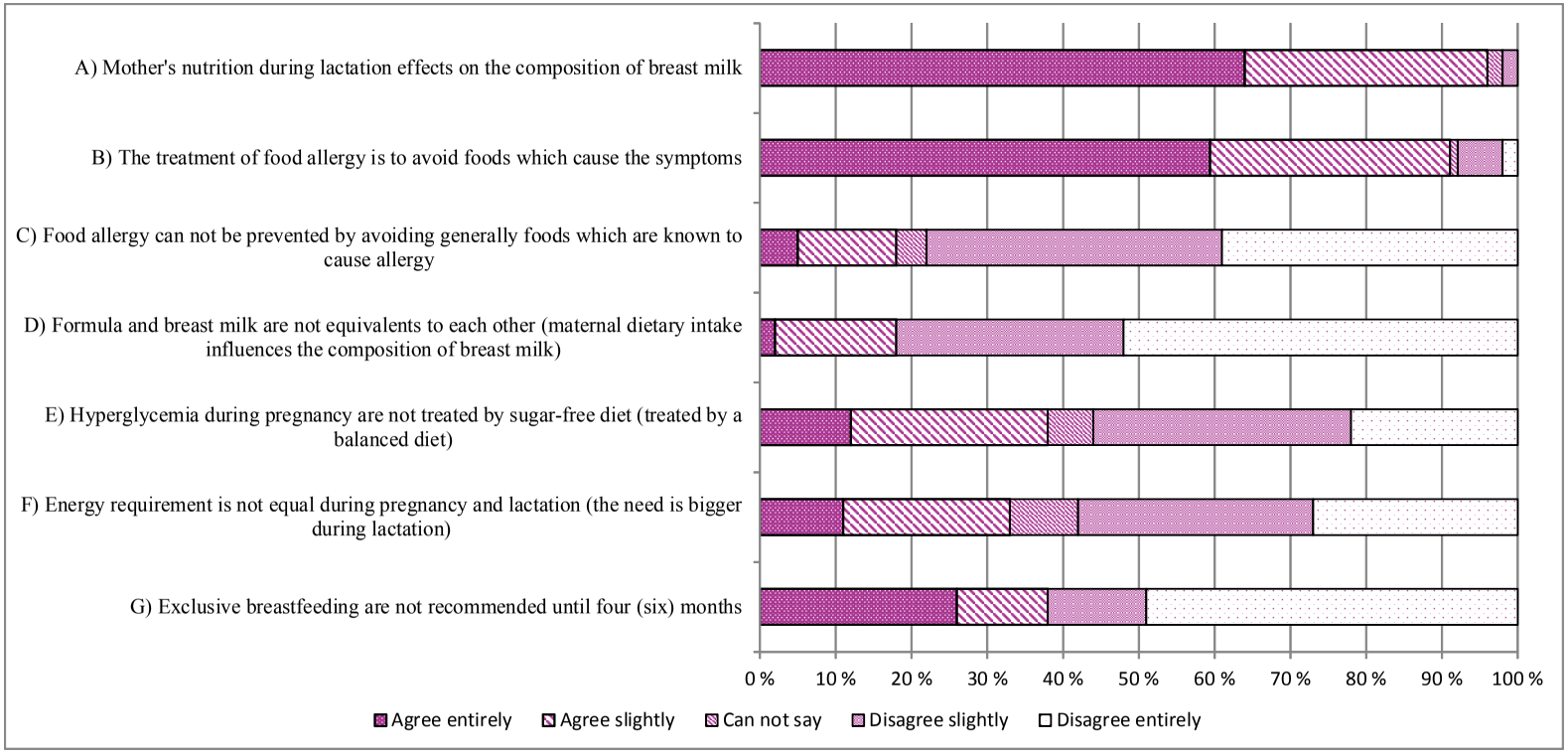


Figure 2. Claims are presented according to the dietary or treatment recommendations. The proportion of nurses who answered right are presented agree entirely and slightly. Claims A and B were presented according to the recommendations and other claims C – G were presented against the recommendations in the questionnaire.

5.3. Dietary counselling effects on dietary intake and adiposity (II, III)

5.3.1. Dietary intake during and after pregnancy

The impact of dietary counselling executed by a nutritionist on dietary intake was evident in consumptions of dietary fats and dietary fibre during and after pregnancy (**Table 9**). Dietary counselling groups were combined due to no differences in dietary intake between women receiving dietary counselling with probiotics or women receiving dietary counselling with placebo were seen. Women in intervention groups received significantly less saturated fatty acids and significantly more mono- and polyunsaturated fatty acids (as E %) as well as more dietary fibre and vitamin C than control group during pregnancy and six months after pregnancy. Similar trends were perceived one and two years after pregnancy with the intake of saturated fatty acid being significantly lower in women receiving dietary counselling. Further, the intervention group had reduced intake of saturated fatty acid and increased intake of dietary fibre and vitamin C until four years after pregnancy but not significantly.

When evaluating the implementation of dietary recommendations over the period of four years after pregnancy, an effect of dietary counselling on the quality of fat intake was observed. The recommendations were met more frequently in the dietary counselling groups compared to control group with respect to intake of dietary fibre (OR 2.37, 95% CI 1.15 – 4.90, p = 0.019), saturated fatty acids (OR 2.06, 95% CI 1.15 – 3.69, p = 0.015) and vitamin C (OR 1.52, 95% CI 1.02 – 2.26, p = 0.041) taking into account all study visits after pregnancy together.

Table 9. The mean dietary intake during pregnancy (9a), six months, one (9b), two and four (9c) years after pregnancy in the intervention and control group.

Table 9a

Dietary factor	(unit)	During pregnancy[1]				
		Dietary intervention (n = 155)		Control (n = 77)		
		Mean	SD	Mean	SD	p[2]
Energy	(MJ)	8.5	1.5	8.3	1.7	0.41
Protein	(g)	82	17	82	18	1.0
	(E%)	16	2.1	17	2.0	0.20
Carbohydrate	(g)	257	48	248	51	0.24
	(E%)	51	4.3	51	4.9	0.46
Dietary fibre	(g)	**22**	**5.89**	**20**	**5.6**	**0.03**
Fat	(g)	71	17	70	19	0.70
	(E%)	31	4.3	31	4.6	0.87
SFA	(g)	27	7.1	29	8.7	0.12
	(E%)	**12**	**2.2**	**13**	**2.3**	**0.01**
MUFA	(g)	**25**	**6.9**	**23**	**6.7**	**0.05**
	(E%)	**11**	**2.0**	**10**	**1.9**	**0.045**
PUFA	(g)	**13**	**3.6**	**11**	**3.7**	**0.01**
	(E%)	**5.5**	**1.1**	**5.0**	**1.0**	**< 0.001**
Vitamin D	(µg)	5.5	3.11	5.2	2.4	0.42
Vitamin E	(mg)	**11**	**2.71**	**9.0**	**2.4**	**< 0.001**
Vitamin C	(mg)	**160**	**61.2**	**130**	**47**	**0.002**
Folic acid	(µg)	**310**	**69.5**	**280**	**65**	**0.02**
Calcium	(mg)	1250	335	1250	390	0.95
Iron	(mg)	12	2.68	12	2.8	0.45

[1] Mean intake over the period 1st and 3rd trimester of pregnancy.

[2] Comparison of nutrients intake between dietary intervention groups and control group were tested by T-test.

Table 9b

Dietary factor	(unit)	Six months after pregnancy: Dietary intervention (n = 141) Mean	SD	Control (n = 68) Mean	SD	p[1]	One year after pregnancy: Dietary intervention (n = 132) Mean	SD	Control (n = 64) Mean	SD	p[1]
Energy	(MJ)	7.8	1.9	7.8	1.5	0.76	7.4	1.8	7.6	1.7	0.61
Protein	(E%)	82	21	83	20	0.80	18	3.3	18	3.1	0.55
	(g)	18	3.3	18	3.1	0.64	77	22	80	16	0.41
Carbohydrate	(E%)	220	60	218	53	0.78	49	5.9	48	5.7	0.30
	(g)	47	5.9	46	6.0	0.24	215	55	214	49	0.91
Dietary fibre	(g)	**20**	**7.8**	**18**	**5.8**	**0.02**	19	6.7	17	5.3	0.16
Fat	(E%)	68	22	71	17	0.31	32	5.9	32	5.1	0.66
	(g)	**33**	**5.4**	**34**	**5.2**	**0.07**	63	21	65	21	0.44
SFA	(E%)	**24**	**8.8**	**29**	**8.7**	**< 0.001**	**12**	**3.0**	**13**	**3.1**	**0.04**
	(g)	**12**	**2.7**	**14**	**2.8**	**< 0.001**	**23**	**8.1**	**26**	**10**	**0.03**
MUFA	(E%)	25	8.2	23	6.5	0.13	**11**	**2.8**	**11**	**2.2**	**0.03**
	(g)	**12**	**2.5**	**11**	**2.5**	**0.03**	**22**	**8.4**	**22**	**7.5**	**0.03**
PUFA	(E%)	**13**	**4.8**	**11**	**3.6**	**0.01**	5.8	1.6	5.4	1.7	0.10
	(g)	**6.3**	**1.6**	**5.6**	**1.7**	**0.001**	12	5.0	11	4.3	0.30
Vitamin D	(µg)	6.1	4.7	5.6	4.1	0.14	5.9	4.5	5.3	3.7	0.34
Vitamin E	(mg)	**10**	**3.7**	**8.9**	**2.4**	**0.002**	**9.8**	**3.7**	**8.6**	**3.0**	**0.02**
Vitamin C	(mg)	120	67	98	63	0.09	96	55	95	57	0.87
Folic acid	(µg)	270	92	270	83	0.88	260	82	250	73	0.73
Calcium	(mg)	1080	450	1160	470	0.24	1080	400	1090	380	0.93
Iron	(mg)	12	3.7	12	3.1	0.10	12	3.5	11	3.5	0.53

[1] Comparison of nutrients intake between dietary intervention groups and control group were tested by T-test.

Table 9c

		Two years after pregnancy					Four years after pregnancy				
		Dietary intervention (n = 117)		Control (n = 56)			Dietary intervention (n = 84)		Control (n = 39)		
Dietary factor	(unit)	Mean	SD	Mean	SD	p[1]	Mean	SD	Mean	SD	p
Energy	(MJ)	7.5	1.9	7.7	1.8	0.43	7.6	1.7	7.4	2.4	0.63
Protein	(E%)	18	3.6	18	3.1	0.72	17	3.3	17	3.0	0.72
	(g)	77	22	80	19	0.34	77	19	76	21	0.77
Carbohydrate	(E%)	48	6	47	6.4	0.27	47	5.6	47	6.8	0.54
	(g)	213	57	215	56	0.81	216	55	206	65	0.42
Dietary fibre	(g)	18	6.4	17	5.0	0.77	19	7.0	17	5.7	0.16
Fat	(E%)	32	6.1	33	5.8	0.33	33	5.4	34	6.9	0.34
	(g)	65	23	69	23	0.32	67	21	68	29	0.85
SFA	(E%)	13	3.3	14	3.1	0.05	13	3.1	13	3.5	0.17
	(g)	25	11	28	11	0.10	25	9.2	27	14	0.48
MUFA	(E%)	11	2.8	11	2.4	0.92	12	2.5	12	3.2	0.68
	(g)	22	8.7	23	8.0	0.74	24	8.6	24	12	0.92
PUFA	(E%)	5.6	1.7	5.6	1.5	0.91	5.7	1.6	5.9	1.9	0.63
	(g)	11	4.4	11	3.8	0.87	12	4.6	11	4.6	0.72
Vitamin D	(µg)	5.9	3.5	5.5	2.7	0.37	6.3	3.9	5.5	2.8	0.24
Vitamin E	(mg)	9.5	3.9	9.0	2.8	0.40	9.7	3.6	8.8	3.5	0.21
Vitamin C	(mg)	110	67	92	64	0.15	110	54	93	57	0.11
Folic acid	(µg)	260	84	250	70	0.61	260	71	260	82	0.96
Calcium	(mg)	1070	400	1130	400	0.30	1070	380	1050	510	0.75
Iron	(mg)	11	3.5	11	2.9	0.95	11	3.3	11	3.4	0.68

[1] Comparison of nutrients intake between dietary intervention groups and control group were tested by T-test.

5.3.2. Weight and waist circumference

Weight from pregnancy to four years after pregnancy

Gestational body weight gain was on average 14.8 kg without significant differences between three study groups (p = 0.981). Of the women 49% received dietary counselling with probiotics, 40% receiving dietary counselling with placebo and 31% in controls gained body weight as recommended (p = 0.100).

BMI was on average 24.9 (SD 4.3) at six months, 24.4 (SD 4.3) at one, 24.4 (SD 3.9) at two years and 24.5 (SD 4.0) at four years after pregnancy being higher compared to situation prior to pregnancy (BMI 23.5, SD 3.8). The BMI's (adjusted for baseline BMI) in different study groups at six months, one, two and four years after pregnancy have been presented in **Figure 3**.

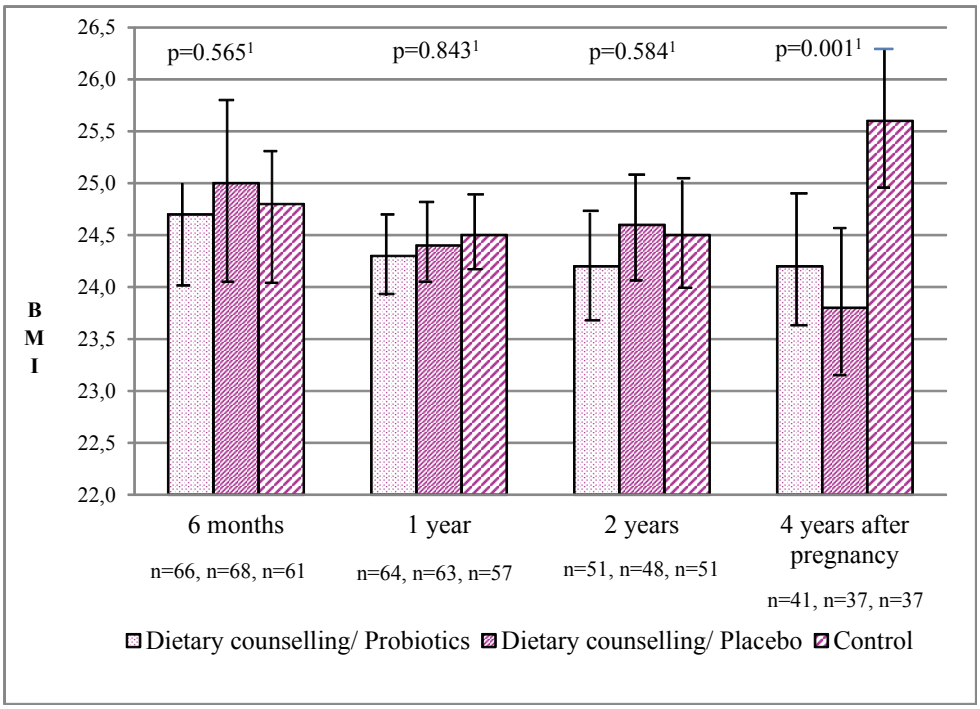


Figure 3. Mean BMIs (95 % CI) in different study groups over the four years period after pregnancy.

[1]Three groups were compared using analysis of covariance, where the baseline BMI was included as a covariate.

Mean BMI's were 24.7 (SD 3.4) in women with dietary counselling and probiotics, 25.0 (SD 5.0) in women with dietary counselling and placebo and 24.8 (SD 3.9) in controls (p = 0.565), at six months after pregnancy; 24.3 (SD 3.3) *vs* 24.4 (SD 5.3) *vs* 24.5 (SD

3.9) at one year after pregnancy, respectively; p = 0.843; 24.2 (CI 23.6 – 24.7) *vs* 24.6 (CI 24.0 – 25.1) *vs* 24.5 (CI 23.9 – 25.0); p = 0.584) at two years after pregnancy without significant difference amongst the three study groups. At four years after pregnancy, the mean BMI was the lowest in women receiving dietary counselling with probiotics (24.2, CI 23.6 – 24.9) and placebo (23.8, CI 23.1 – 24.5) and the highest at control women (25.6, CI 24.9 – 26.3) when comparing three study groups (p = 0.001). Duration of breastfeeding did not associate with the body weight after pregnancy.

In women, 64% reported that they were dissatisfied with their body weight at two years after pregnancy. Dissatisfied rankings did not differ in women receiving dietary counselling and controls (63% in women with counselling, 67% in controls; p = 0.609). Dissatisfied rankings decreased at four years after pregnancy being 55% at this point. Control women were more dissatisfied with their body weight than women receiving dietary counselling (68% *vs* 49%, p = 0.045). Twenty-eight percent (47 / 166) reported attempts to lose body weight at two years after pregnancy whereas 40% (46 / 115) at four years after pregnancy.

Waist circumference after pregnancy

Use of probiotics until six months after pregnancy affected waist circumference at six months and one year after pregnancy when comparing the three groups (**Figure 4**). At six months after pregnancy, the waist circumferences were 75.4 (SD 7.9) in women with dietary counselling and probiotics; 80.8 (SD 10.9) in women with dietary counselling and placebo; 79.6 (SD 9.2) in control women; p = 0.005; adjusted for baseline BMI. At one year after pregnancy, values were: 77.4 (SD 6.9); 79.4 (SD 11.2); 78.9 (SD 10.2), respectively; p = 0.030.

There was no significant difference in waist circumference amongst the three study groups at two years after pregnancy (77.8; 95 % CI 75.9 – 79.7 in women with dietary counselling and probiotics, 80.2; 95 % CI 78.2 – 82.2 in women with dietary counselling and placebo, 78.7; 95 % CI 76.8 – 80.6) in controls; p = 0.226) when adjusted baseline BMI. Instead, waist circumference was the lowest in women receiving dietary counselling compared to women in the control group at four years after pregnancy when comparing three groups (77.3, CI 75.2 – 79.4 in women with dietary counselling and probiotics; 78.9, 95% CI 76.8 – 81.0 in women with dietary counselling and placebo; 83.0, 95% CI 80.8 – 85.2 in controls; p = 0.001). The use of probiotics until six months after pregnancy has no additional effects on waist circumference at two or four years after pregnancy.

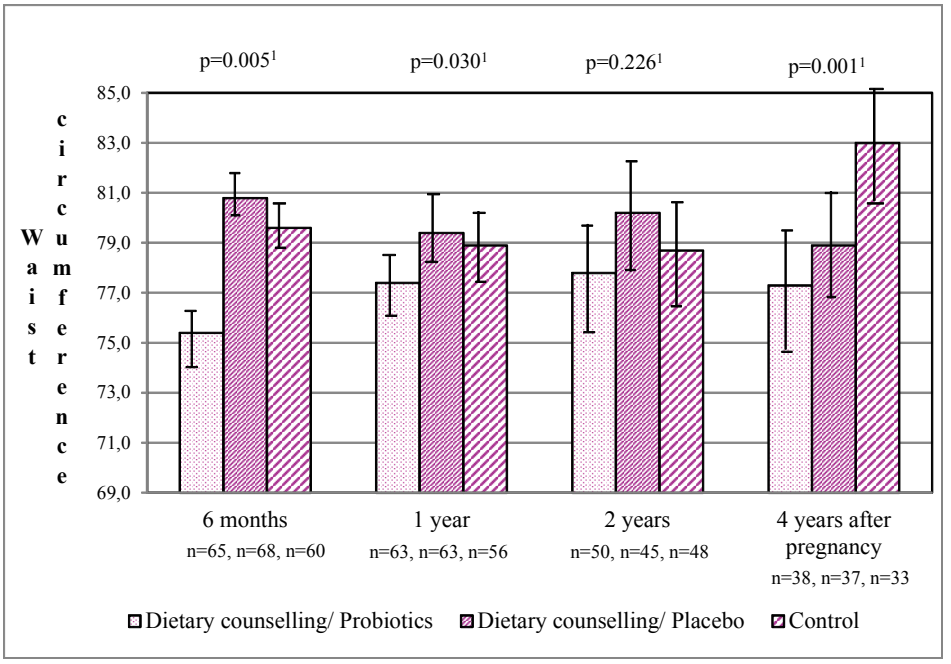


Figure 4. Waist circumferences (adjusted for baseline BMI) of women are presented in different study groups over the four years period after pregnancy.

[1]Three groups were compared using analysis of covariance, where the baseline BMI was included as a covariate.

5.4. Eating behaviour after pregnancy effect on dietary intake and body weight (IV)

Mean eating behaviour scores were: 41.9 (95% CI; 39.4 – 44.3) for cognitive restraint (CR); 30.2 (95% CI; 27.0 – 33.4) for uncontrolled eating (UE) and 37.9 (95 %CI; 33.3 – 40.7) for emotional eating (EE) during the period six and 48 months after pregnancy. TFEQ-18 scores were found not to differ amongst the three intervention groups (p = 0.981 for CR; p = 0.917 for UE; p = 0.782 for EE).

5.4.1. Dietary intake

Eating behaviour, especially cognitive restraint and uncontrolled eating associated with dietary intake during the period six months and four years after pregnancy. High scores in cognitive restraint associated with the lowest intake (as tertiles) of fat (E %) and lowest intake of protein (g) and tended to associate with the highest intake of

carbohydrate (E %). Instead, high UE scores associated with greater intakes of energy (kcal, $p < 0.001$), fat (g, $p = 0.002$), saturated fatty acids (g, $p = 0.030$), carbohydrate (g, $p = 0.004$), dietary fibre (g, $p < 0.001$) and sucrose (g, $p = 0.017$; E %, $p < 0.001$) (**Table 10**).

However, no interaction effect between dietary intervention and eating behaviour was detected ($p > 0.05$) by GEE analysis interaction which suggests that eating behaviour does not influence the effectiveness of the intervention.

Table 10. Mean eating behavioural scores for CR, UE and EE (with 95 % CI) are presented in different tertiles (T1 = the lowest intake, T3 = the highest intake) of pooled intakes of energy and energy yielding nutrients (fatty acids, carbohydrates and protein) taking into account study visits after pregnancy (6 months, 1, 2 and 4 years) together. Differences in mean scores in different tertiles were tested by ANOVA.

			CR[1]			UE[2]		
Dietary factor	(unit)		Mean	95% CI	ANOVA (p)	Mean	95% CI	ANOVA (p)
Energy	(kcal)	T1	44	40 – 47	0.28	**26**	**23 – 30**	**< 0.001**
		T2	41	38 – 45		**27**	**24 – 30**	
		T3	40	37 – 44		**42**	**37 – 47**	
Protein	(g)	**T1**	**45**	**42 – 48**	**0.007**	27	22 – 32	0.10
		T2	**40**	**37 – 43**		35	30 – 41	
		T3	**40**	**37 – 44**		31	25 – 36	
	(E %)	T1	42	38 – 46	1.0	33	29 – 37	0.09
		T2	42	39 – 45		33	28 – 38	
		T3	42	39 – 45		28	24 – 31	
Carbohydrates	(g)	T1	42	38 – 45	0.98	**25**	**21 – 29**	**< 0.05**
		T2	42	39 – 45		**36**	**30 – 43**	
		T3	42	39 – 46		**33**	**28 – 38**	
	(E %)	T1	**40**	**36 – 43**	**0.06**	32	24 – 39	0.57
		T2	**41**	**38 – 44**		32	26 – 39	
		T3	**45**	**41 – 48**		29	24 – 33	
Sucrose	(g)	T1	44	40 – 47	0.09	**28**	**22 – 33**	**0.02**
		T2	40	36 – 43		**31**	**24 – 37**	
		T3	42	38 – 45		**36**	**32 – 40**	
	(E %)	T1	44	40 – 47	0.36	**23**	**19 – 27**	**< 0.001**
		T2	41	37 – 44		**35**	**31 – 39**	
		T3	41	38 – 44		**37**	**32 – 41**	
Dietary fibre	(g)	T1	41	38 – 44	0.41	**26**	**23 – 29**	**< 0.001**
		T2	41	38 – 44		**29**	**25 – 33**	
		T3	43	40 – 47		**40**	**35 – 44**	
Fat	(g)	T1	44	41 – 47	0.08	**29**	**25 – 33**	**< 0.05**
		T2	42	39 – 45		**26**	**21 – 30**	
		T3	40	36 – 43		**38**	**33 – 43**	
	(E %)	T1	**45**	**41 – 48**	**< 0.05**	28	24 – 32	0.29
		T2	**41**	**38 – 45**		30	26 – 34	
		T3	**40**	**36 – 43**		34	28 – 40	
SFA	(g)	T1	44	41 – 48	0.15	**28**	**23 – 33**	**0.03**
		T2	41	38 – 44		**28**	**23 – 34**	
		T3	40	36 – 43		**37**	**31 – 43**	
	(E %)	T1	44	41 – 48	0.15	29	25 – 34	0.61
		T2	41	37 – 44		30	25 – 35	
		T3	41	37 – 44		33	27 – 39	

[1] Cognitive restraint

[2] Uncontrolled eating

[3] Emotional eating

Dietary factor	(unit)		Mean	EE[3] 95% CI	ANOVA (p)
Energy	(kcal)	T1	34	30 – 39	0.24
		T2	38	33 – 43	
		T3	39	34 – 44	
Protein	(g)	T1	35	30 – 40	0.08
		T2	40	35 – 45	
		T3	36	31 – 41	
	(E %)	T1	40	35 – 44	0.14
		T2	34	29 – 39	
		T3	37	32 – 42	
Carbohydrates	(g)	T1	36	31 – 41	0.68
		T2	39	33 – 44	
		T3	37	31 – 42	
	(E %)	T1	37	32 – 42	0.21
		T2	39	34 – 44	
		T3	35	30 – 40	
Sucrose	(g)	T1	37	32 – 42	0.74
		T2	39	34 – 44	
		T3	35	30 – 40	
	(E %)	T1	37	32 – 42	0.39
		T2	38	33 – 43	
		T3	35	30 – 40	
Dietary fibre	(g)	T1	37	32 – 42	0.60
		T2	36	31 – 40	
		T3	39	33 – 44	
Fat	(g)	T1	34	30 – 39	0.20
		T2	39	33 – 44	
		T3	39	33 – 45	
	(E %)	T1	36	32 – 41	0.93
		T2	37	32 – 42	
		T3	38	32 – 43	
SFA	(g)	T1	36	31 – 41	0.90
		T2	38	32 – 43	
		T3	37	32 – 43	
	(E %)	T1	36	31 – 41	0.53
		T2	39	34 – 44	
		T3	36	31 – 42	

5.4.2. Body weight control

Eating behaviour was linked with both overweight (BMI ≥ 25) and central adiposity (waist circumference ≥ 80 centimeter) during the period six months and four years after pregnancy. EE (44, 95 % CI 38 – 50 *vs*. 33, 95 % CI 29 – 37; p = 0.003) scores were significant and CR (45, 41 – 48 *vs*. 40, 37 – 43; p = 0.051) and UE scores (35, 30 – 41 *vs*. 28, 24 – 32; p = 0.069) tended to be higher in women with BMI ≥ 25 than in those with BMI < 25 (**Figure 5**). UE scores were significantly higher (35, 31 – 39 *vs*. 27, 23 – 31; p < 0.001) and EE scores tended to be higher (40, 34 – 45 *vs*. 34, 30 – 38; p = 0.051) instead in women with waist circumference ≥ 80 cm than in those with waist circumference UE < 80 cm (**Figure 6**).

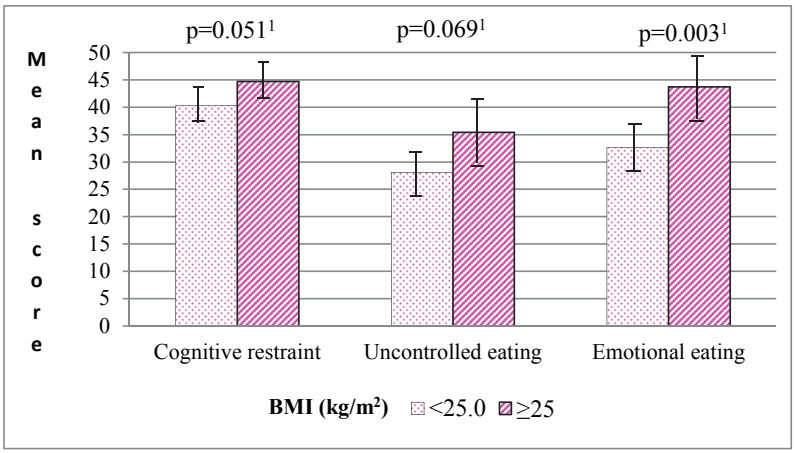


Figure 5. Mean (95% CI) eating behaviour scores during the period six months and four years after pregnancy in women with normal-weight (BMI < 25 kg/m^2) and overweight (BMI ≥ 25 kg/m^2) women.

[1]The p-values are based on the GEE analysis with ANOVA.

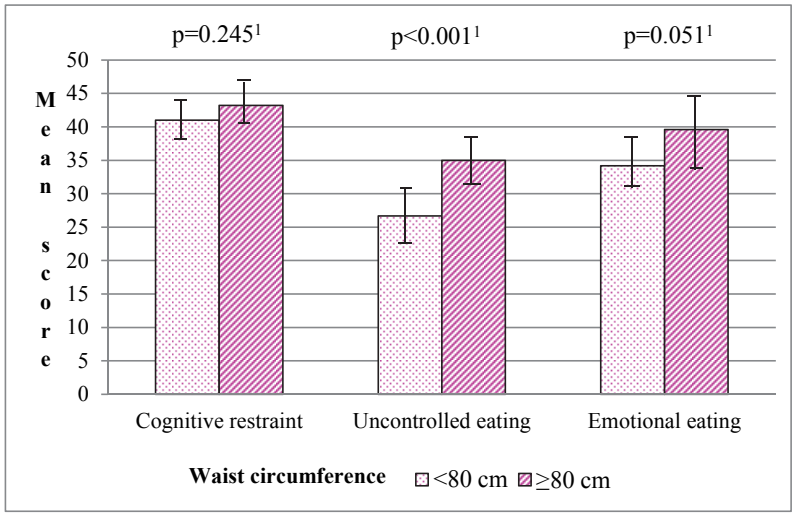


Figure 6. Mean (95% CI) eating behaviour scores during the period six months and four years after pregnancy in women with normal waist circumference (waist circumference < 80 cm) and central adiposity (waist circumference ≥ 25 cm) women.

[1]The p-values are based on the GEE analysis with ANOVA.

5.5. Other factors effects of on body weight after pregnancy

Being overweight prior to pregnancy was a major predictor for a high BMI at four years after pregnancy (OR 27.1 (8.4-87.2), $p < 0.001$). Furthermore, women gaining body weight during pregnancy according to or less than to the recommendations had lower mean BMI (23.0) compared to women gaining body weight higher than the recommendations (BMI 26.1) at four years after pregnancy ($p < 0.001$).

6. DISCUSSION

6.1. The achievements of individual dietary counselling during and after pregnancy

This study showed that counselling from the early pregnancy up to four years after pregnancy achieved improved dietary intake and body weight. Therefore, dietary counselling for pregnant women but also in women who have given birth should be provided. The present study is concordant with a previous finding that a women's body weight increases after pregnancy compared to pre-pregnancy body weight (Olson et al. 2003) and pregnancy may indeed trigger the overweight and obesity in later (Linne et al. 2004). Thus, prevention becoming of overweight and maintaining body weight loss after pregnancy is needed.

6.1.1. Dietary intake

In the present study, dietary counselling resulted in changes in dietary intake according to the dietary recommendations during pregnancy and until one year after pregnancy but no effects in dietary changes existed four years after pregnancy. There are few studies which demonstrate the useful effects of dietary counselling which last from two to six months in dietary intake amongst women during and after pregnancy (Garg et al. 2006, Korpi-Hyovalti et al. 2012, Liu et al. 2009) and there exists no evidence to the effect of dietary counselling on long-term dietary intake. Dietary changes by dietary counselling begun during pregnancy may be more efficient than started after pregnancy because dietary counselling after pregnancy resulted in no dietary changes amongst women (Ostbye et al. 2009). This may be due to the fact that after delivery, the mother's attention is fixed for their child's nutrition instead of their own diet.

6.1.2. Body weight gain during pregnancy

Contrary to previous findings in which counselling reduced mean gestational body weight gain (Huang et al. 2011), the total mean body weight gain was similar in women in the present study, whether women received dietary counselling or not. The majority of women had normal weight prior to pregnancy and gained weight as recommended and thus the differences in weight gain during pregnancy was obviously not seen in this study population. In addition, the majority of the women were well-educated in this present study unlike in the previous study by Huang et al. (Huang et al. 2011). Well-educated individuals may have balace their dietary intake compared to lower educated

women, including lower intake of saturated fatty acids (Deshmukh-Taskar et al. 2009, Miura et al. 2011). Gestational body weight gain, in women with highly-education, is closer to the recommendations than low-educated individuals, since unhealthy dietary patterns, including high-fat diet, typical for low-educated individuals, are positively associated with weight gain during pregnancy (Uusitalo et al. 2009, Lagiou et al. 2004).

6.1.3. Body weight control after pregnancy

This present study provides novel evidence and showed that in the long-term, four years after pregnancy, body weight control can be achieved by dietary counselling. This is possible when the recommended dietary intake (Hasunen et al. 2004;11) is started at the beginning of the pregnancy. Previous studies showed the effect of dietary counselling on weight control until maximum 18 months after pregnancy (Ostbye et al. 2009, Olson et al. 2004, Huang et al. 2011, Bechtel-Blackwell 2002, Kinnunen et al. 2007). The present study proved the finding that long-term dietary counselling, once or three times a year can be as influential as compared to short-term counselling, occurring several times in the year (Huang et al. 2011, Jeffery et al. 2000).

This study demonstrated the advantageous effects of probiotics on maternal central adiposity at six months and one year after pregnancy. After two and four years after pregnancy, this effect was lost. One explanation for this may be the duration of the use of probiotics supplements which ended when exclusive breastfeeding finished or at six months after pregnancy. Clarifying the effect of long-term use of these supplements on waist circumference would be of interest. A mechanism for difference in waist circumference between women receiving probiotics and placebo is not clear and further studies are needed. Gut microbiota differs in normal and overweight women prior to pregnancy and during pregnancy (Collado et al. 2008). Further, gut microbiota alters in composition between normal and overweight children during infancy with bifidobacterial numbers being higher in normal than overweight children (Kalliomaki et al. 2008).

In addition to the dietary counselling, women were encouraged to undertake regular physical activity and exercise according to their capabilities during the present study. Similarly, previous studies tended to combine dietary changes with increased levels of physical activity (McCrory et al. 1999, Amorim et al. 2007a, Bertz et al. 2012). The constant finding was that, in the absence of dietary changes, physical activity failed to reduce body weight in the short-term (Bertz et al. 2012, Dewey et al. 1994) but not during long-term body weight control (Rooney et al. 2002). Controversy remains to whether increased physical exercise combined with dietary changes decreases body weight more than dietary changes alone.

The evidence for beneficial effect of dietary counselling on gestational body weight gain or body weight after pregnancy is not completely understood since there are studies which show that dietary interventions have no effect on gestational body weight gain or short-term body weight loss after pregnancy (Ostbye et al. 2009, Althuizen et al. 2013). It is challenging to provide objective and reproducible data on body weight loss amongst women who have given birth. One reason for the inconsistent findings may lie in breast-feeding. Firstly, breastfeeding demands adequate dietary intake without aiming to control body weight. Secondly, the duration of breastfeeding varies greatly amongst women and thus the starting time of the body weight control after pregnancy is very individual. Breastfeeding is linked with greater maternal body weight loss after pregnancy (Linne et al. 2004, Ostbye et al. 2012) although the present study showed on the contrary that breastfeeding did not associate with the body weight after pregnancy. Nevertheless, the present study focused on long-term body weight control and breastfeeding related to body weight loss only between 2.5 and 6 months after pregnancy (Brewer et al. 1989, Crowell 1995, Lederman 2004, Hatsu et al. 2008, Ota et al. 2008). On the contrary, breastfeeding, lasting over one year, which rare in this study, associates with increased body weight (Adair et al. 1992).

Women's dissatisfaction with their own body weight at two and still at four years after pregnancy was seen with the majority of the women experiencing their body weight as unsatisfactory. Dissatisfactions were higher at two years compared to four years after pregnancy. Women who received dietary counselling were more satisfied with their body weight compared to women who did not receive counselling at four years after pregnancy. This is reasonable, since women receiving dietary counselling had lower BMI than women not receiving counselling. Nevertheless, being dissatisfied with their own body weight does always mean the overweight or obesity (Wong et al. 1999). In addition, being dissatisfied with a normal body weight may indicate an eating disorder, which occurs in 2 to 4% of Finnish, Australian and Norwegian women (Keski-Rahkonen 2010, Watson et al. 2012, Knoph et al. 2013).

6.2. How to achieve the lifestyle changes

The duration of dietary counselling affects the achievement of dietary and weight changes in individuals. Dietary changes until one year after pregnancy can be achieved by repeated dietary counselling, as demonstrated in short-term studies (Kinnunen et al. 2007). Long-lasting interventions are needed to achieve long-term changes due to the following factors. There are several factors including cultural and environmental factors that affect dietary intake of individual and thus may complicate the success of influential counselling. Psychological factors (Hurley et al. 2005), beliefs, socioeconomic status (Irala-Estevez et al. 2000, Darmon et al. 2008), physical activity (Melzer et al. 2005) and social factors have been highlighted to link with dietary intake

in previous studies in adults and thus may disturb on the success of counselling. In addition, lifestyle changes are demanding to achieve, since they are strictly related to behaviour. Behavioural changes may be the most difficult thing to change because long term behaviour results into formed habits (Brownell et al. 1995) and changing existing habits are often laborious and demand time to achieve. Thus, delivering nutrition information alone, without consultation, rarely produces the long-lasting changes in diet (Polley et al. 2002). There is strong evidence that behaviour therapy is useful when aimed to control body weight and change dietary intake as well as increase physical activity regiments (Brownell 1998, Avenell et al. 2004, Levy et al. 2010). Importantly, long-lasting dietary changes are impossible to maintain without individual desire. Thus, the motivation of the individual to change their lifestyle is important.

6.2.1. Health education vs. individual counselling

One example of the successful dietary counselling is the North Carelia study which aimed to assess behavioural changes (Puska et al. 2009). The study amongst adults in Finland achieved dietary changes and health benefits including the improvement of serum cholesterol levels (Pietinen et al. 1988). Dietary changes and useful health outcomes amongst the Finnish North Carelian population were achieved by overall health education (Puska et al. 2009) in the 1970's. Specifically, the study was based on large multi-sectorial partnerships including the cooperation with health care professionals, business leaders, voluntary health organisations and local political decision-makers (Puska et al. 2009). Thus, individuals' lifestyle changes were made possible to achieve from the point of view of environment. Contemporary culture and environment is different compared to decades ago. A "fast food" culture predominates, unhealthy foods are continuously available and intensive food advertising *via* the media is common. These factors may cause increased dietary intake and thus the success of overall health education may be inhibited.

The present study focused on individual dietary counselling which resulted in dietary changes as previously observed (O'Toole et al. 2003). Face-to-face, personal counselling enabled close interactive discussions and the possibility to use visual aids. Lifestyle changes can be achieved by reflective listening in which counsellor asks their client open questions about their client's self-efficacy and supportive counselling (Groeneveld et al. 2011) which is the basis of the method of counselling called "motivational interviewing" (Smith et al. 1997, Mhurchu et al. 1998, Harland et al. 1999). The food diary is an illustrative aid in counselling. Especially, regularly given individual feedback from food diaries with proposals for improvement of diet as completed in the present study may be important in dietary changes contrary to the monetary incentives given in a previous study which did not lead to dietary changes (Ostbye et al. 2009). Recording of the diet increases the self-monitoring which is

effective in body weight control (Ryan et al. 2000, Lally et al. 2008, Jacobs et al. 2011, Leong et al. 2012). Nevertheless, motivational interviewing (Pirlott et al. 2012) combined with the use of food diary are demanding in primary clinics because they are time-consuming.

To achieve effective counselling, sufficient professional skills of the counsellor are needed (Thompson et al. 2003). Indeed, on the basis of the present study, individual counselling, which is carried out by the health professionals familiar with counselling can be influential. Additional advantages to influential counselling for body weight control may be overall family therapy (Avenell et al. 2004). In the present study, only women were subjects of the counselling. To counsel the whole family, including partners, may be more efficient.

Technological methods are used successfully in individual counselling. Telephone counselling was used in previous studies among adults but its effectiveness on dietary changes was inconclusive (Ostbye et al. 2009, Newman et al. 2008, Fappa et al. 2012). Especially, video counselling improved lifestyles of pregnant women (Jackson et al. 2011). Application of the technology as a counselling tool may also be useful. Importantly, current interest in body weight control *via* modern technologies, especially the internet, is pronounced amongst mothers (Walker et al. 2012). Utilising social media may also be advantageous at the present time. This enables individual counselling, including following-up of diet regularly and long-term advice without the need fo in-person visitation to the clinics. Indeed, of the nurses, 92% actively searched for nutritional information *via* internet during the present study. Thus, the use of internet may be useful in communication between nurses and mothers. For health professionals, technology and research offer new tool for counselling advice (Thomas et al. 2012).

6.2.2. The optimal target and time for counselling

Dietary counselling is effective for those who have lower education (Oldroyd et al. 2008) or increased risk for diseases (Puska et al. 2009, Ammerman et al. 2002). On the contrary, this study emphasises that healthy and well-educated fertile women who attended dietary counselling achieved dietary changes and this was effective to control body weight.

Our study population of pregnant women is an important target group for counselling because early dietary interventions by counselling may be effective to the promotion of health in the mother's new family. Pregnant women may be more receptive for counselling than other populations, especially those who are at risk for life-style diseases such as type 2 diabetes. These women, who have recently given birth, appreciate individual counselling in clinics (Huurre et al. 2006). Especially, pregnant

women may be receptive for counselling since they may be dutiful and protective because of their foetus.

Results of the present study showed that women who were overweight prior to pregnancy and gained weight excessively during pregnancy are at risk for becoming overweight four years after pregnancy. Similarly, gaining weight excessively during pregnancy predisposes them to become overweight (Kac et al. 2004, Linne et al. 2004, Butte et al. 2006, Gore et al. 2003). Thus, those women may benefit from the counselling the most. After pregnancy, dietary counselling is demanding compared to the time during pregnancy. Mothers with small infants encounter new demands concerning infant needs and family (Walker 2007) and thus may interfere maintaining lifestyle changes (Leermakers et al. 1998, O'Toole et al. 2003) shortly after pregnancy and this may disturb the compliance with the counselling advice.

6.3. Strengths and limitations of this study

This study explores nationwide nurses' clinical practices representing all hospital districts in Finland (I). Questionnaires were tested to identify unclear questions. Thus, the questionnaire was valid for enquiry. A limitation of this study may be e-mail sent questionnaire which may have selected only nurses who use e-mail frequently. The internet was one of the nurses' most used information sources. The source of the internet content was not specified in the questionnaire which was a clear limitation, since there are huge amount of unreliable nutrition information in the internet.

This is a pioneer study which explores the long-term effects of dietary counselling during and after pregnancy on weight and dietary intake (II – III). Follow-up visits were standardized so that study measurements, enquires and analysis of dietary intake of food diaries were executed by the same personnel or personnel were introduced thoroughly during all visits. Clarifying dietary intake by food diaries when used consecutive days including one weekend day is informative and the most exact compared to other methods. Nevertheless, the mothers were allowed to choose the reporting days themselves which partly may weaken the reliability of the results. Although food diaries are the most accurately method to evaluate an individual's dietary intake on group level, there are some limitiations. Firstly, it is time-consuming and laborious. Secondly, underreporting is a limitation when individual's diet is clarified (Scagliusi et al. 2003, Olafsdottir et al. 2006). Underreporting exists especially amongst the obese (Pietilainen et al. 2010) and also amongst pregnant women (McGowan et al. 2012). Thirdly, nutrient intake measured from food intake is an estimation which is based on the reported information from food producers. Dietary intake is also influenced by several factors, thus, taking all of these would take into account the reliability of this study although it is very challenging. Breastfeeding may be one limitation which we did not considered in

this study. Breastfeeding is linked with greater maternal weight loss after delivery as discussed in section 6.1.3. Due to difficulties to assess absolutely dietary intake, body weight may be a better indicator when evaluating the effect of dietary counselling.

Education levels in the women in the present studies (II – IV) were homogenous. Almost all the women had a high-level of education and this may distort the representativeness of gestional body weight gain in women from the general population. Huang et al. (Huang et al. 2011) used a random sampling from the population and found that counselling reduced the mean gestational body weight gain. Dietary habits tend to be healthier in highly-educated woman than low-educated women (Deshmukh-Taskar et al. 2009). In addition, low-educated individuals' physical activity level is lower than well-educated individuals (Vahasarja et al. 2012). Therefore, in our study, the difference in body weight gain between different education levels in women whom receive dietary counselling and women not receiving counselling may be less significant because our study population consisted of highly educated women. Because of this, all expected effects, from dietary counselling after pregnancy, on overall dietary intake and behaviours associated with diet were not observed.

Long-term, follow up studies (II – IV) are challenging because subjects need to attend several study visits. In these studies, women dropped out the study the longer the follow-up study lasted. In addition, the situations in life of young families are changing. Lack of time and moving to the other locality during the period after pregnancy may be limitations at the present study and may explain the amount of drop-out women. Of the women, 50% dropped-out which may complicate the interpretation of statistical analysis. For example, a large confidence interval in analysis (see section 5.5), which measures the effect of overweight prior to pregnancy on risk for overweight at four years after pregnancy, may be a consequence of a small study population.

Eating behaviour associated with dietary intake and body weight during the present study (IV). High scores in cognitive restraint associated with low fat intake whereas high scores in uncontrolled eating associated with high energy and fibre intake in line with what is previously shown (de Lauzon et al. 2004). High fibre intake in women with high uncontrolled eating scores may be consequence of high dietary intake. Instead, high scores in emotional eating related to overweight and high scores in uncontrolled eating related to central adiposity similar to what was previous showed (Konttinen et al. 2009). During the present study, high scores of all eating behaviours associated with high weight and waist circumference (Keskitalo et al. 2008). Indeed, there may be associations between emotional and restrained eating behaviours which we did not consider and may cause the inaccuracy in the findings. In addition, the present study population comprised of mothers with a history of allergic diseases, which may cause the increased restrained dietary intake. Therefore, all the effective factors which explain weight after pregnancy would need to be obtained. A statistical model using all the

biasing factors, such as dietary intervention, use of probiotics, style of eating behaviour, weight prior to pregnancy and weight gain during pregnancy, simultaneously, should be generated.

6.4. From this study to the practice – health clinics as a counselling place

6.4.1. Opportunities

The present study notes that dietary counselling for pregnant women and women whom have given birth can be influential. Dietary counselling to enhance the quality of diet promoted dietary intake according to the recommendations and was useful in body weight control. This study observed that energy intake did not differ between women receiving dietary counselling or not whereas, for example, the quality of fat differed. This shows that the amount of dietary intake is more difficult to influence compared to quality of diet, which is also a focus in preventing diseases. These findings support the notion that preventing overweight is easier than losing excessive weight, since weight loss demands decreasing energy intake whereas the prevention of overweight focuses on the quality of the diet. These present studies are in line with previous findings that dietary counselling resulted in dietary intake closer to the recommendations during (Garg et al. 2006, Korpi-Hyovalti et al. 2012) and lower weight after (Ostbye et al. 2009) pregnancy.

Importantly, early prevention of overweight is important in preventing obesity (Baidal et al. 2012) as well as obesity-related diseases such as type 2 Diabetes (Sanada et al. 2012). These findings highlight the importance of dietary counselling in clinics, which offer the optimal place for counselling for several reasons. Firstly, pregnant women are encountered in Finnish health clinics widely, several times from pregnancy until child is school-aged. Secondly, this study showed that nurses experience nutrition important in clinics and are motivated to educate themselves. Thirdly, the families appreciate the counselling received by nurses (Huurre et al. 2006).

6.4.2. Challenges

Challenges related to counselling in clinics exist although clinics evolved substantially during these decades. The prevalence of being overweight and obesity has increased in all aged population (WHO 2011) which causes additional challenges to the clinics. These conditions demand more consulting time, improved clinical guidelines, better training of primary staff, at-risk patient registers and closer collaboration with health professionals in primary care (Maryon-Davis 2005).

Consulting time, nutritional education of nurses and collaboration with other health care professionals are insufficient at the present and in previous studies (Hakulinen-Viitanen et al. 2005, Casey 2007, Breimaier et al. 2011). In the present study, nurses counselled their clients by informal dicussions without using methods which measure dietary intake. Indeed, inadequate consulting time may cause barriers to execute thorough counselling. Nevertheless, more time for counselling is a challenge to provide.

Insufficient nutritional knowledge by the nurses was evident. Avoidance of foods in preventing food allergy is still recommended by 20% of the nurses and treatment of hyperglycaemia by sugar-free diet by the 42% of the nurses against the current recommendations. In addition, the majority of the nurses used the internet as a source of nutritional information. Indeed, the internet as a source of information requires good skills to evaluate the reliability of the sources.

Special nutrition related diseases belong to a sphere of special health care and to the dieticians' sphere of responsibilities. According to this study of the nurses, 90% did not consult a dietician due to lack of services, which is striking and shows the increased need for dietician services. The report of Ministry of Social Affairs and Health revealed that the dietician's services had not been arranged at all in a third of health centres in Finland (Hakulinen-Viitanen et al. 2005). In the present study, the lack of dieticians' services was observed, since nurses counselled their clients in several nutrition-related situations such as obesity, gestational diabetes and type 2 Diabetes, and revealed these conditions to young families in Finland. Insufficient resources occured in previous studies among pregnant or women who have given birth since women experienced inadequate or no counselling, for example, about body weight control (Thompson et al. 2011, Ohlendorf et al. 2012) in primary care.

7. SUMMARY AND CONCLUSION

To prevent the onset of obesity, new intervational techniques are needed. Pregnancy is a window of opportunity, since it may induce an increased risk for development of overweight in both women and offspring. This study showed that individual dietary counselling started at the beginning of the pregnancy and lasted up to four years after pregnancy to cause useful dietary changes during and after pregnancy and long-term body weight control. Especially women who are at increased risk for development of becoming overweight, including overweight women prior to pregnancy, women who gain weight excessively during pregnancy and women with uncontrolled or emotional eating behaviour may benefit dietary counselling.

Health clinics in Finland can act as a practical channel to disseminate information to promote the health for families, since in clinics, young families are encountered extensively several times from early pregnancy up to child is school-aged. The results of this study suggest the need for developing dietary counselling practices in Finnish health clinics aimed to achieve efficient counselling in clinics within the limited consulting-time. Specifically, the enhancement of nurses' nutrition knowledge and counselling skills by education is needed. Electronic tools, such as internet may be future means to increase education amongst nurses and also social media may be utilised in dietary counselling between nurses and clients.

To conclude, the present results suggest that relatively seldom executed individual dietary counselling during and after pregnancy has long-lasting consequences for the health of mother later. Indeed, by developing dietary counselling practices in clinics may be pivotal to prevent the development of obesity and related diseases in women and also in their offspring. In long run, dietary counselling as a preventive tool can achieve economic and health savings for primary care later.

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