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Prolonged breast-feeding protects mothers from later-life obesity and related cardio-metabolic disorders

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Abstract

Objective: To investigate the long-term effects of duration of postpartum lactation on maternal body composition and risk for cardio-metabolic disorders in later life.

Design: Retrospective study. Body composition was measured using dual-energy X-ray absorptiometry and serum glucose, insulin and lipids were analysed using enzymatic photometric methods 16–20 years after the last pregnancy. Medical history and lifestyle factors were collected via a self-administered questionnaire. Detailed information regarding weight change patterns during each pregnancy was obtained from personal maternity tracking records.

Setting: City of Jyväskylä and surroundings in Central Finland.

Subjects: Two hundred and twelve women (mean age 48, range 36–60 years).

Results: At 16–20 years after their last pregnancy, women who had breast-fed for less than 6 months had higher total body fat mass and fat mass percentage, particularly in the android region (46·5 (SD 8·2) %) than mothers who had breast-fed for longer than 6 months (39·0 (SD 10·2) %) or for longer than 10 months (38·4 (SD 10·9) %, $P < 0·01$). These differences were independent of pre-pregnancy weight and BMI, menopausal status, smoking status, level of education, participation in past and present leisure-time physical activity, and current dietary energy intake. Higher body fat mass was also associated with higher fasting serum glucose concentration and insulin resistance, TAG, LDL cholesterol and total cholesterol concentrations, as well as higher systolic and diastolic blood pressure ($P < 0·05$ for all).

Conclusions: Short duration of breast-feeding may induce weight retention and fat mass accumulation, resulting in increased risk of cardio-metabolic disorders in later life.

Keywords
Breast-feeding
Obesity
Cardio-metabolic disorders

Pregnancy is associated with excessive weight gain and central fat deposition[1], which are suggested to serve as an energy reservoir to ensure adequate nutrient supply for the infant[2]. Although the increase in maternal fat mass may be essential for the infant, it is evident that pregnancy poses a considerable risk to the mother's health, as manifested by increased blood pressure[3], atherogenic lipid profile and insulin resistance[4]. Fortunately, postpartum lactation enables women to reverse this detrimental trend; during lactation, fat is mobilized primarily from the trunk and thighs[5], reducing central fat accumulation, which is considered a major risk factor for metabolic disorders[6].

In spite of the recommendations to breast-feed[7] and the known beneficial effects of breast-feeding on both infant and maternal health, only 18% of mothers in Finland breast-feed until 12 months[8]. In the USA[9] and Europe[10] the trends are similar, indicating that more information about the effects of breast-feeding on maternal health is called for. Animal studies have already suggested that repeated pregnancies without lactation may predispose mothers to obesity[11,12]. In humans, however, the weight-reducing effects of postpartum lactation have remained controversial. Some studies have shown that breast-feeding significantly reduces weight[13–15], whereas others have reported no effect on maternal anthropometrics and body composition[16,17]. These discrepancies in research results may be due to inconsistency in descriptions of breast-feeding patterns, variation in follow-up durations and parity.

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However, given the increasing trend towards overweight and obesity in all developed countries[18,19], and the consequent detrimental health effects, the impact of lactation on maternal health and body composition during the reproductive years and beyond deserve attention.

If the anticipatory role for mothers is to deposit fat during pregnancy and lose it during lactation, we may ask: are mothers who do not lactate at risk for obesity? We hypothesized that repeated pregnancies in the absence of or followed by only a short period of postpartum lactation would have detrimental effects on body composition in women and increase risk for cardio-metabolic disorders in later life. To test our hypothesis, we investigated the long-term cumulative effects of repeated pregnancies and duration of postpartum breast-feeding on maternal anthropometrics, body composition and metabolic risk 16–20 years after the last parturition.

Materials and methods

Study design

The present retrospective study was part of the Calex-family study, which has been described elsewhere[20,21]. Briefly, the study was conducted in the city of Jyväskylä and its surroundings in Central Finland in 2007 to 2008. Medical history and lifestyle factors, such as level of education, previous (stages of life: 20–29, 30–39, 40–49, >50 years of age) and current participation in leisure-time physical activity, and information on breast-feeding, number of pregnancies and biological children, and pre-pregnancy weight and height, were collected via a self-administered questionnaire. Participants were also asked to provide detailed information on weight change patterns during each pregnancy from their personal maternity tracking records, which have been issued to mothers since the socialization of maternal health care in Finland. Intakes of total energy and energy-yielding nutrients were assessed from food records[22]. Breast-feeding was expressed in total exclusive (giving the infant no food or liquid other than breast milk) and partial (giving the infant some breast milk in addition to other liquid or solid foods) breast-feeding months.

The recruitment of the study population is presented schematically in Fig. 1. Briefly, 212 mothers (mean age 48, range 36–60 years) participated in the body composition and other laboratory assessments. Of this number, 206 women provided valid information on the number of biological children they had. Thirteen (6·3 %) women reported having one child, seventy-one (34·5 %) had two, seventy-two (35·0 %) had three, thirty-five (17·0 %) had four and fifteen (7·3 %) had more than four biological children. Participants were excluded if they had gestational diabetes or hypertension, were currently pregnant or reported being pregnant within 5 years before the present measurements. In addition, we excluded those who reported twin pregnancies (*n* 5) or did not have body composition data (*n* 3). Thus, the final sample consisted of 198 mothers.

The 198 participants were divided into three groups according to the average duration of breast-feeding they reported (total months of breast-feeding divided by the number of biological children). WHO recommends 6 months for a minimum duration to breast-feed[7]. The lowest cut-off point was selected on the basis of this recommendation. Sixty-seven (34 %) mothers reported a short duration of breast-feeding (SDB, defined as breast-feeding their infants for less than 6 months), sixty-eight (34 %) reported a medium duration of breast-feeding (MDB, defined as breast-feeding their infants for more than 6 months but less than 10 months) and sixty-three (32 %) reported a long duration of breast-feeding (LDB, defined as breast-feeding for longer than 10 months). Five (7 %) of the SDB and two (3 %) of the LDB mothers

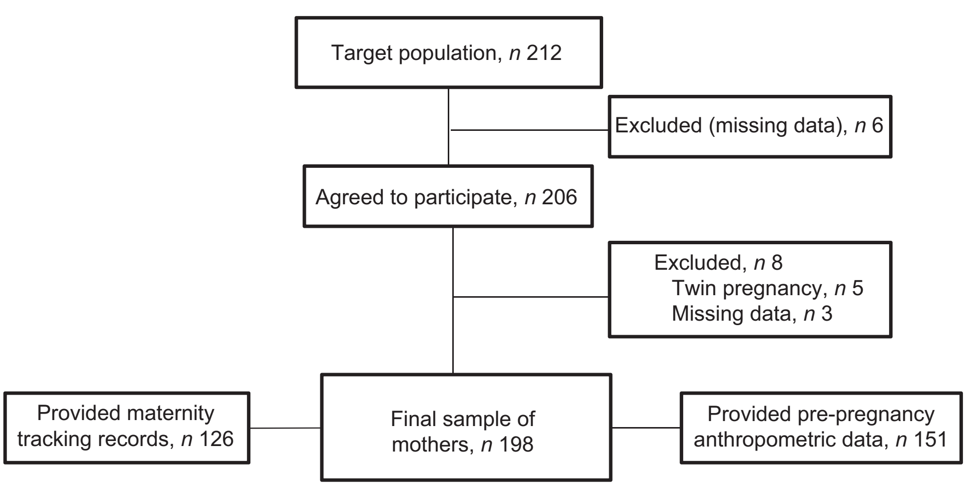

Fig. 1 The mothers (age 36–60 years) were recruited from the city of Jyväskylä and its surroundings in Central Finland, 2007–2008. After applying the inclusion criteria, the final sample consisted of 198 women

reported that they had never exclusively breast-fed their infants. One hundred and fifty-one mothers provided pre-pregnancy anthropometric data and 126 mothers provided maternity tracking records. The study protocol was approved by the ethical committee of the Central Health Care District, Central Finland. Written informed consent was given by all participants prior to the assessments.

Anthropometric and body composition assessments

Body height (cm) and weight (kg) were measured using standardized protocols, and BMI (kg/m^2) was calculated. Bone mass (BM in kg), lean tissue mass (LM in kg) and fat mass (FM in kg) of the whole body and in different areas of the body (arm, leg, trunk, android and gynoid, femoral and gluteal regions) were assessed using dual-energy X-ray absorptiometry (Prodigy; GE Lunar Corp., Madison, WI, USA). The CV of two repeated measurements on the same day was on average 0·7 % for BM, 1·0 % for LM and 2·2 % for FM in the present study. Blood pressure was measured twice in the morning, by the oscillometric method, after the participants had arrived at the laboratory and sat at rest for 10 min.

Blood samples and analysis

Blood samples were drawn from the antecubical vein in the morning (07.00–09.00 hours) after overnight fasting (12 h). If the mothers were in the premenopausal state, the blood sample was drawn on the fifth day from the start of menstruation. Serum was separated within 30 min, and stored at −80°C until analysis. Serum glucose, total cholesterol (TC), HDL cholesterol (HDL-C) and TAG concentrations were measured by enzymatic photometry on a Kone Pro Clinical Chemistry Analyser (Thermo Clinical Labsystems Oy, Espoo, Finland) with commercial kits. LDL cholesterol (LDL-C) was calculated using the Friedewald equation[23]. An IMMULITE Analyser (Diagnostic Products Corporation, Los Angeles, CA, USA) and an IMMULITE Insulin Kit were used for quantitative determination of insulin. The CV of two repeated measurements on the same day was on average 3·4 % for insulin.

Statistical analyses

All data were checked for normality using the Shapiro–Wilk *W* test in the SPSS for Windows statistical software package version 15·0 (SPSS Inc., Chicago, IL, USA). If data were not normally distributed, natural logarithms were used. ANOVA with the Least Significant Difference *post hoc* test was used to compare differences among the breast-feeding groups in pre-pregnancy anthropometrics, age at baseline and at each pregnancy, and weight change during each pregnancy. To validate the self-estimated weight before the first pregnancy, we compared the self-estimated weight with the measured weight at the beginning of the first pregnancy using Bland–Altman analysis[24].

A general linear model was employed to compare the differences in anthropometric, body composition, serum glucose and insulin and lipid profiles among the groups 16–20 years after the last parturition. All the analyses were adjusted for relevant factors. Statistical significance was set at $P < 0·05$.

To determine which factors were associated with weight gain, total body fat mass and android fat mass, a generalized estimating equations (GEE) model was used. The following predictors were included in the model: pre-pregnancy weight and BMI, age at first pregnancy, smoking, menopause status, level of education, previous and current participation in leisure-time physical activity, current dietary energy intake, number of biological children, and duration of exclusive and total breast-feeding months. The R^2 of the GEE model was computed according to Hardin[25], and can be interpreted as a similar measure of the proportion of the outcome variance explained by the model as that in common linear regression.

Results

The characteristics of the participants in the year before the first pregnancy are given in Table 1. No significant differences were found in age, BMI or systolic and diastolic blood pressure between the groups before the first pregnancy. Gestational durations and inter-pregnancy intervals were similar among all groups ($P > 0·05$ for all,

Table 1 Participants' characteristics before the first pregnancy according to study group: women (mean age 48, range 36–60 years) from the city of Jyväskylä and surroundings in Central Finland, 2007–2008

	SDB (*n* 51)		MDB (*n* 51)		LDB (*n* 49)		*P* value		
	Mean	SD	Mean	SD	Mean	SD	SDB *v.* MDB	SDB *v.* LDB	MBD *v.* LDB
Age (years)	26·4	4·8	26·0	3·5	25·9	3·5	0·601	0·485	0·851
Height (cm)	164·0	6·7	165·7	5·4	166·8	5·6	0·164	0·024*	0·351
Weight (kg)	57·1	8·1	56·2	6·2	59·1	7·0	0·501	0·193	0·042*
BMI (kg/m^2)	21·2	2·3	20·4	2·0	21·2	2·1	0·101	0·874	0·125
Systolic BP (mmHg)†	118·8	9·2	117·0	10·6	119·5	10·5	0·509	0·794	0·335
Diastolic BP (mmHg)†	70·7	7·6	69·7	8·5	72·3	6·9	0·586	0·414	0·153

SDB, short duration of breast-feeding; MDB, medium duration of breast-feeding; LDB, long duration of breast-feeding; BP, blood pressure.
*Significant at $P < 0·05$.
†Blood pressure obtained at the beginning of the first pregnancy.

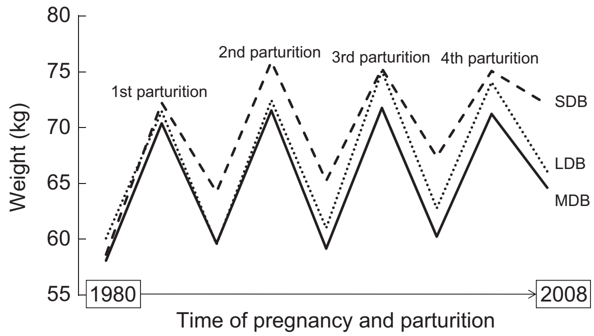

Fig. 2 ANOVA was used to compare weight change among the breast-feeding groups during the reproductive years. Body weight was similar among the groups at the beginning of the first pregnancy. After the first and each consecutive parturition, the SDB mothers retained significantly more body weight compared with MDB and LDB mothers (all $P < 0.001$). Number of women in each group: at first pregnancy, SDB (*n* 38), MDB (*n* 44) and LDB (*n* 44); at second pregnancy, SDB (*n* 33), MDB (*n* 41) and LDB (*n* 42); at third pregnancy, SDB (*n* 14), MDB (*n* 26) and LDB (*n* 30); at fourth preganancy, SDB (*n* 5), MDB (*n* 8) and LDB (*n* 15); and in year 2008, SDB (*n* 38), MDB (*n* 44) and LDB (*n* 39). SDB, short duration of breast-feeding; MDB, medium duration of breast-feeding; LDB, long duration of breast-feeding. Women (mean age 48, range 36–60 years) from the city of Jyväskylä and surroundings in Central Finland, 2007–2008

data not shown). Consequently, there were no significant differences in average age at the subsequent pregnancies (second pregnancy, SDB 28·6 (sd 3·8) years, LDB 28·2 (sd 3·1) years and MDB 29·0 (sd 3·8) years; third pregnancy, SDB 31·3 (sd 4·2) years, LDB 29·9 (sd 3·3) years and MDB 31·1 (sd 3·4) years; fourth pregnancy, SDB 34·0 (sd 4·3) years, MDB 33·5 (sd 4·3) years and LDB 33·0 (sd 2·1) years) among the groups (all $P > 0·05$).

Between the years 1980 and 2008, the SDB mothers gained significantly more body weight (14·0 (sd 9·1) kg) than either the MDB mothers (8·3 (sd 6·5) kg; $P = 0·001$) or the LDB mothers (7·6 (sd 6·6) kg; $P < 0·001$; Fig. 2). Gestational weight gains were similar among groups in all pregnancies. However, between the first parturition and the beginning of the second pregnancy, weight reduction was more significant in the MDB (−10·5 (sd 4·5) kg) and LDB (−11·4 (sd 3·4) kg) mothers than in the SDB mothers (−8·0 (sd 4·4) kg; $P < 0·01$ for all). In fact, only the LDB mothers had returned to their pre-pregnancy weight (59·5 (sd 6·7) kg; $P = 0·084$), whereas the MDB mothers were 1·8 (sd 2·6) kg and SDB mothers 5·0 (sd 4·2) kg heavier by the beginning of the second pregnancy ($P < 0·001$ for both). Although gradual weight gain was observed in all groups, this phenomenon followed a similar pattern in the mothers' subsequent pregnancies (Fig. 2). The self-estimated weight before the first pregnancy correlated significantly with the weight measured at the first time point (8 weeks) of the first pregnancy ($R^2 = 0·898$, $P < 0·001$). Furthermore, a Bland–Altman analysis showed a good agreement (mean difference 2·6 %) and the disagreement was 7·7 % between the self-estimated and first measured weight (data not shown), regardless of the fact some weight gain is experienced during early pregnancy.

At 16–20 years after the last parturition, no significant differences between the groups in age, height, total body lean mass, total bone mass, number of biological children, smoking status, menopause, current total energy and macronutrient intake, or participation in current leisure-time physical activity were found (all $P > 0·05$; Table 2). In addition, no significant differences between the groups in previous participation in leisure-time physical activity were observed (data not shown). However, the SDB mothers weighed more and had higher BMI and total fat mass than either the MDB or LDB mothers ($P < 0·001$ for both; Table 2). In addition, a notably higher proportion of the SDB mothers had only a basic level of education compared with the MDB and LDB mothers ($P < 0·05$ for both). Furthermore, the SDB mothers had significantly more fat in the android region (46·5 (sd 8·2) %) than either the MDB (39·0 (sd 10·8) %) or the LDB mothers (38·4 (sd 10·9) %; $P < 0·01$ for both). After adjusting for level of education, the level of significance remained the same (all $P < 0·05$; Fig. 3).

In accordance with their higher fat mass, the SDB mothers had significantly higher fasting serum glucose concentration than the LDB mothers ($P = 0·033$), and higher insulin concentrations and insulin resistance index (HOMA-IR) than either the LDB or MDB mothers (all $P < 0·05$; Table 3). Similarly, the SDB mothers had higher serum TC, LDL-C and TAG levels than either the LDB or MDB mothers (all $P < 0·05$), and lower HDL-C than the MDB mothers ($P = 0·016$; Table 3). Furthermore, the SDB mothers had higher systolic and diastolic blood pressure than either the MDB or LDB mothers. After adjusting for level of education, the level of significance remained unchanged ($P < 0·05$ for both).

A GEE model was used to evaluate the risk factors associated with body composition. We found that a common predictor for low gain in body weight, total fat mass and android fat mass was long duration of breast-feeding (explaining 20 %, 24 % and 14 % of the variance, respectively; Table 4). Specific predictors for high total weight gain were high age at first pregnancy (11 %), menopause (7 %) and short duration of exclusive breast-feeding (6 %). Significant predictors for high total fat mass were high pre-pregnancy weight, menopause, short duration of exclusive breast-feeding and low current leisure-time physical activity (explaining 16 %, 5 %, 11 % and 7 % of the variance, respectively). Specific predictors for high android fat mass were high pre-pregnancy BMI (11 %), menopause (9 %), high age at first pregnancy (7 %) and short duration of exclusive breast-feeding (5 %).

Discussion

In the current retrospective study, we found that body weight and body composition during the reproductive

Table 2 Participants' characteristics at 16–20 years after the last parturition according to study group: women (mean age 48, range 36–60 years) from the city of Jyväskylä and surroundings in Central Finland, 2007–2008

	SDB (*n* 67)		MDB (*n* 68)		LDB (*n* 62)		*P* value		
	Mean	SD	Mean	SD	Mean	SD	SDB *v.* MDB	SDB *v.* LDB	MBD *v.* LDB
Age (years)	47·7	5·6	48·5	4·7	48·2	4·4	0·385	0·629	0·714
Height (cm)	164·1	6·1	165·3	5·5	166·0	6·2	0·235	0·072	0·520
Weight (kg)†	73·5	15·6	66·8	10·2	67·6	9·5	0·002*	0·007*	0·704
BMI (kg/m^2)†	27·3	5·5	24·4	3·7	24·6	3·3	<0·001*	0·001*	0·847
Total fat mass (kg)†	29·4	11·1	23·3	7·8	24·6	9·6	<0·001*	0·006*	0·425
Total bone mass (kg)	2·6	0·4	2·6	0·4	2·6	0·4	0·268	0·617	0·113
Total lean mass (kg)	41·3	5·0	40·4	4·0	41·6	4·3	0·216	0·731	0·118
Diastolic BP (mmHg)	86	10	78	10	80	12	0·002*	0·012*	0·578
Systolic BP (mmHg)	142	19	129	14	131	18	0·003*	0·032*	0·427
Smoking (no/yes; %)	62/38		68/32		78/22		0·495	0·180	0·223
Menopause (no/yes; %)	80/20		84/16		88/12		0·568	0·239	0·523
HRT (yes/no; %)	82/18		84/16		84/16		0·760	0·741	0·971
Education (B/H; %)	56/44		35/65		39/61		0·015	0·031	0·746
PA (h/week)	2·4	1·8	2·7	1·9	2·1	1·7	0·345	0·428	0·088
Biological children	2·7	1·0	2·9	1·3	3·0	1·5	0·249	0·110	0·633
TBF per child (months)	4·1	1·7	8·4	1·1	13·7	3·2	<0·001*	<0·001*	<0·001*
Protein (%E)	18·5	3·0	18·5	3·5	18·2	2·8	0·874	0·493	0·596
Carbohydrates (%E)	45·5	6·3	45·6	6·8	46·7	5·4	0·902	0·297	0·360
Fats (%E)	33·7	5·2	33·4	6·3	33·5	4·3	0·707	0·808	0·907
Dietary energy (kJ)	7385	1481	7217	1661	7075	1594	0·551	0·291	0·636
Dietary energy (kcal)	1765	354	1725	397	1691	381	0·551	0·291	0·636

SDB, short duration of breast-feeding; MDB, medium duration of breast-feeding; LDB, long duration of breast-feeding; BP, blood pressure; HRT, hormone replacement therapy; B, basic education (high-school or upper secondary level); H, higher education (polytechnic/academic level); PA, physical activity; TBF, total breast-feeding months; %E, percentage of daily energy intake.
Results are adjusted for level of education.
*Significant at $P<0·05$.
†Significance from natural log values comparison.

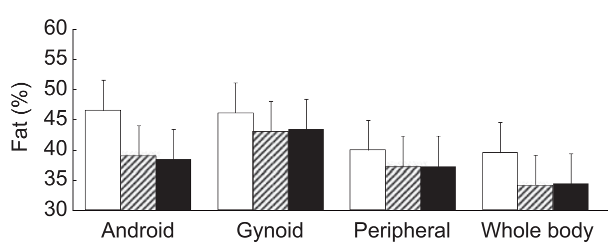

Fig. 3 A general linear model was performed to assess the difference in segmental body fat distribution 16–20 years after the last parturition among women with different durations of breast-feeding. Mothers in the SDB group (□, *n* 67) had a significantly higher percentage of fat in the total body and in the android ($P<0.01$ for both), gynoid and peripheral regions ($P<0.05$ for both) than mothers in either the MDB group (▨, *n* 68) or the LDB group (■, *n* 62). Results are adjusted for level of education. Values are means with their standard deviations represented by vertical bars. SDB, short duration of breast-feeding; MDB, medium duration of breast-feeding; LDB, long duration of breast-feeding; peripheral, arms plus legs. Women (mean age 48, range 36–60 years) from the city of Jyväskylä and surroundings in Central Finland, 2007–2008

years were associated with the duration of postpartum lactation. Mothers who had breast-fed their infants for less than 6 months had higher total and relative body fat mass, particularly in the android region, compared with mothers who had breast-fed for longer than 6 months. This difference was observed 16–20 years after the last parturition and was independent of pre-pregnancy weight and BMI, menopausal status, smoking status, level of education, participation in previous and present leisure-time physical activity, and current dietary energy intake. Short duration of breast-feeding was also associated with increased risk of metabolic disorders manifested by higher fasting serum glucose concentration and insulin resistance, serum TAG, LDL-C and TC concentrations, as well as higher systolic and diastolic blood pressures.

In theory, weight loss is supported by negative energy balance due to either increased energy expenditure or reduced energy intake, or both. However, we did not find differences in current dietary energy or energy-yielding nutrient intake, or in previous or current participation in leisure-time physical activity, among the different breast-feeding duration groups. Although postpartum lactation significantly increases energy expenditure due to the production of milk in the mammary glands[1], it is also accompanied by increased energy intake[15]. Unfortunately, we were unable to obtain postpartum dietary data from our participants. However, we speculate that given their long duration of breast-feeding and short-spaced pregnancies, it is unlikely that the participants had tried to lose weight postpartum by restricting their dietary energy intake. This indicates that postpartum weight loss cannot be explained merely by changes in energy expenditure or energy intake alone. Thus, we speculate that postpartum weight loss may relate mainly to hormonal/metabolic changes induced by lactation.

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Table 3 Laboratory test results of the participants at 16–20 years after the last parturition according to study group: women (mean age 48, range 36–60 years) from the city of Jyväskylä and surroundings in Central Finland, 2007–2008

	SDB (*n* 67)		MDB (*n* 68)		LDB (*n* 62)		*P* value		
	Mean	SD	Mean	SD	Mean	SD	SDB *v.* MDB	SDB *v.* LDB	MBD *v.* LDB
TC (mmol/l)	5·5	0·9	5·5	0·9	5·2	0·6	0·811	0·015*	0·027*
HDL-C (mmol/l)	1·6	0·5	1·8	0·5	1·7	0·4	0·018*	0·119	0·442
LDL-C (mmol/l)	3·4	0·7	3·2	0·8	3·0	0·7	0·410	0·047*	0·225
TAG (mmol/l)*	1·3	0·6	1·0	0·4	1·0	0·5	0·015*	0·005*	0·648
GLUC (mmol/l)	5·4	0·6	5·4	0·8	5·2	0·4	0·753	0·029*	0·059
INS (μU/l)†	8·6	5·0	6·3	4·3	6·1	4·0	0·002*	0·002*	0·898
HOMA-IR†	2·1	1·3	1·5	1·1	1·5	1·1	0·002*	0·002*	0·972

TC, total serum cholesterol; HDL-C, HCL cholesterol; LDL-C, LDL cholesterol; GLUC, serum fasting glucose; INS, serum fasting insulin; HOMA-IR, homeostasis model assessment – insulin resistance index.
Results were adjusted for level of education.
*Significant at $P < 0·05$.
†Significance from natural log values comparison.

Table 4 Generalized estimating equations model accounting for variance in total weight gain, total fat mass and android fat mass among women (mean age 48, range 36–60 years) from the city of Jyväskylä and surroundings in Central Finland, 2007–2008

Dependent variable	Predictors	R^2	*P* value
Total weight gain	TBF	−0·20	<0·001
	Age at first pregnancy	−0·11	0·002
	Menopause	−0·07	0·013
	EBF	−0·06	0·024
Total fat mass	TBF	−0·24	<0·001
	Pre-pregnancy weight	−0·16	<0·001
	Exclusive BF	−0·11	0·002
	LTPA	−0·07	0·014
	Age at first pregnancy	−0·06	0·031
	Pre-pregnancy BMI	−0·05	0·049
	Menopause	−0·05	0·035
Android fat mass	TBF	−0·14	<0·001
	Pre-pregnancy BMI	−0·11	0·002
	Menopause	−0·09	0·006
	Age at first pregnancy	−0·07	0·012
	Pre-pregnancy weight	−0·05	0·043
	EBF	−0·05	0·035

TBF, total duration of breast-feeding; EBF, exclusive breast-feeding; LTPA, leisure-time physical activity.
Only statistically significant ($P < 0·05$) predictors are presented in the table.

Indeed, after parturition, withdrawal of progesterone and the suckling of the breast by the infant facilitate the release of prolactin, thereby decreasing the level of oestrogen(1), which in turn enhances the mobilization of adipose tissue stores(26). Furthermore, since prolactin also inhibits lipogenesis(27) and suppresses glucose uptake in adipose tissue(28), it is conceivable that the pregnancy-induced pattern of fat deposition may be reversed during lactation by the fluctuating web of hormones. Unfortunately, due to the retrospective design of our study, we were unable to obtain data on changes in the hormonal milieu during and after pregnancy that would have allowed us to explore the underlying metabolism and confirm that the hormonal changes were induced by lactation. Nevertheless, we found that short duration of breast-feeding was the strongest independent predictor for high weight gain as well as total and central fat mass accumulation 16–20 years after the last parturition, explaining 14–24 % of the variance. Therefore, the long-lasting effect of hormonal changes induced by lactation on fat accumulation cannot be ruled out.

Accumulation of fat mass, especially in the android region, is associated with high risk of chronic diseases such as type 2 diabetes and CVD(6). The present study shows the long-term effects of breast-feeding duration not only on body weight and body composition but also on blood glucose and the lipid profile. Short duration of breast-feeding was associated with long-term accumulation of cardio-metabolic risks, suggesting that proper duration of lactation may not only reverse gestational hyperlipidaemia and impaired glucose metabolism, but also stabilize it thereafter, possibly even providing protection against type 2 diabetes in later life(29). Furthermore, most previous studies have only investigated the effect of breast-feeding in single pregnancies(13–16,30–32), and therefore the plausible cumulative effect of weight gain and duration of breast-feeding in repeated pregnancies over time has been overlooked or neglected. In our study we found that body weight accumulated with each consecutive full-term pregnancy and that after each pregnancy women with short duration of breast-feeding gained more weight than women in the other groups. This indicates that prolonged breast-feeding may be essential for prevention of weight gain during reproductive age in women, thereby reducing the high risk for chronic diseases in later life.

Apart from duration of breast-feeding, several other factors have also been found to predict fat mass accumulation and weight retention postpartum. In our study cohort we found no differences in BMI, blood pressure or age at pre-pregnancy. However, we found that weight gain was associated with age at first pregnancy and menopausal status. Accumulation of fat mass was also moderately associated with current participation in leisure-time physical activity in addition to age at first pregnancy and menopausal status. Furthermore, mothers with the shortest duration of breast-feeding had the lowest level of education, suggesting that to meet the current breast-feeding recommendations enhanced counselling is needed in particular for women with a low level of education.

The strength of our study is that we were able to obtain detailed and accurate data on weight change during each pregnancy from the maternal tracking records. In addition, we were able to use data with multiple factors to assess whole body composition, including bone, muscle and fat distribution in different body compartments. However, the study has some limitations. First, breast-feeding data collected retrospectively, particularly after a considerable period of time, may be subject to recall bias. However, the limited evidence available suggests that maternal recall does provide accurate estimates of initiation and duration of breast-feeding with high validity[33] even after 20 years[34]. Second, it is difficult to establish the exact physiological mechanisms that drive changes of maternal body composition during the reproductive period on account of the array of potentially confounding factors. Furthermore, we did not obtain maternal tracking records and pre-pregnancy data from all of our participants. However, there were no differences in body weight between those who provided the pre-pregnancy anthropometrics and those who did not at 16–20 years after the first pregnancy. Given that weight gain pattern is heavily dependent on accurate estimation of the pre-pregnancy weight, we validated the self-estimated pre-pregnancy weight with the documented maternity tracking records. Our results showed a good agreement between the self-estimated weight and measured weight. Considering the consistency and the power of our results, the missing data did not change the paradigm of the study, which partially justifies the authenticity of the results.

In conclusion, our results provide an important public health message that short duration of breast-feeding may induce weight retention and fat mass accumulation, resulting in increased risk of cardio-metabolic disorders in later life. Encouraging women to prolong breast-feeding beyond 6 months may provide an important strategy for reducing the growing obesity epidemic and obesity-related cardio-metabolic disorders in women.

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