

Original Article**Comparison of body fat mass changes during the third trimester and at one month postpartum between lactating and nonlactating Japanese women****Erika Ota^{1,*}, Megumi Haruna¹, Masayo Matsuzaki¹, Yuka Honda¹, Satoshi Sasaki², SeonAe Yeo³, Sachiyo Murashima⁴**¹ Department of Midwifery and Women's Health, Division of Health Sciences and Nursing, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan;² Department of Social and Preventive Epidemiology, School of Public Health, The University of Tokyo, Tokyo, Japan;³ School of Nursing, University of North Carolina at Chapel Hill, USA;⁴ Department of Community Health Nursing, Division of Health Sciences and Nursing, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan.**Summary**

The purpose of the present study was to compare which parts of the body fat mass tended to increase during the third trimester and at 1 month postpartum between lactating and nonlactating Japanese women. This prospective study examined 49 healthy pregnant women in the third trimester, and at 1 month postpartum. Demographic data, including lactation status, were obtained from a self-administered questionnaire. Newborn information was obtained from hospital charts. Anthropometric data, including body fat mass, were measured by the bioelectrical impedance analysis (BIA) method in the third trimester, and at 1 month postpartum. At 1 month postpartum, 16 mothers (32.7%) were lactating and 33 (67.3%) were mainly feeding formula. There were no significant differences between the lactating and nonlactating women regarding their demographic data, energy intakes and body fat mass changes during the third trimester of pregnancy. The trunk fat mass change showed a significant difference ($p = 0.008$) between the third trimester and 1 month postpartum, after adjustment by age and parity using repeated measurement ANCOVA, in the lactating and nonlactating women. In conclusion, the total body fat mass and body fat mass in the trunk at 1 month postpartum was significantly greater in lactating women than in nonlactating women.

Keywords: Bioelectrical impedance analysis, Fat mass, Lactating, Postpartum, Pregnancy

1. Introduction

Lactation has many beneficial health effects (1), and the World Health Organization recommends exclusive lactation for 6 months after birth. In Japan, however, only 44.8% of mothers are still lactating at 1 month

postpartum (2). The nutritional situation during reproduction is considered to be important for the health of the mother and their child.

Among previous reports regarding the relationships between postpartum weight or body fat retention and lactation, six studies found no relationship between postpartum weight or body fat retention and lactation (3-8) while another three studies showed very weak negative associations between lactation and weight retention (9-11). These findings were controversial. One of the reason for having no relation between postpartum weight retention and lactation may be higher energy intakes and expenditure in lactating women than in nonlactating women (12), because of a physiologic

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consequence of elevated concentrations of prolactin, an appetite stimulant in lactational period (13). Most previous studies have focused on obesity after delivery. Compared with Caucasian, White, Black or Brazilian women (4-11), Asian women have different energy intakes and metabolic energies that are reflected in body fat mass measurements.

In Japan, only one study examined waist/hip ratio during first trimester to 1 month postpartum in well nourished Japanese women (14) but there are no study examined the postpartum fat mass change in region with energy intakes information or lactating status among Japanese.

Body fat mass changes may different between populations or experimental design or methods. It remains unknown which parts of the body tend to store body fat mass after birth in lactating and nonlactating women especially in Japanese women.

In the present study, we carried out a longitudinal examination with the following objective to assess their energy intakes and which parts of the body fat mass tend to increase during the third trimester and at 1 month postpartum in healthy lactating and nonlactating Japanese women.

2. Methods

2.1. Study design and sample selection

This prospective study was conducted between July 2004 and November 2005 and involved women attending an antenatal clinic in Saitama. The clinic was located in a suburb of the Tokyo metropolitan area in Japan.

Criteria for inclusion were a singleton birth with no obstetric complications, age over 18 years, and intent to deliver at the clinic. Women with intrauterine growth retardation, polyhydramnios or oligohydramnios, spontaneous abortion or preterm delivery were excluded from the study.

During the recruitment period, 100 women attended pregnancy check-ups during their first trimester of pregnancy. Of these 100 women, 25 were excluded from the study for spontaneous abortion ($n = 1$), intention to deliver at a different clinic ($n = 13$) or changing the time of their check-up to the afternoon ($n = 11$). After receiving detailed information, 62 of the remaining 75 pregnant women (83%) agreed to participate in the study. One woman with intrauterine growth retardation during the third trimester and 7 women with incomplete data were excluded. Finally, a total of 54 pregnant women (72%) completed the measurements at the third trimester. Data at 1 month postpartum were available for 49 women. Five women dropped out of the study in the postpartum period, comprising 4 women who did not attend the 1-month check-up and one woman who refused to continue participating in the study because she did not have time.

2.2. Ethical considerations

Approval for the study was obtained from the Institutional Review Board of The University of Tokyo. Subjects were provided with information about the purpose and methods of the study and informed that participation was voluntary, that they were free to withdraw at any time and that full confidentiality was guaranteed. Written informed consent was obtained from all participants.

2.3. Data collection

The data were measured in each woman during pregnancy at 32 weeks of gestation and at 1 month postpartum when they attended the clinic for check-ups.

A self-administered questionnaire was used to obtain data regarding age, height, smoking and drinking habits, self-reported diseases, use of medications and lactation status. Lactation was defined as more than 8 lactation events/day and adding < 200 mL/day of formula. Women who gave > 200 mL/day of formula were classified as nonlactating. We selected the cutoff value of 200 mL because adding formula only once or twice per day can sustain 8 lactation events/day.

Dietary habits over the previous month were assessed with a brief self-administered diet history questionnaire (BDHQ) (15). The BDHQ used was a short version of a previously developed and validated comprehensive self-administered diet history questionnaire (DHQ) (16). It consisted of 74 questions for frequency and a part for portion sizes of 62 selected food items. Energy and nutrient intakes were calculated using an ad hoc computer algorithm based on the Standard Tables of Food Composition in Japan (5th edition) (17).

Data for self-reported prepregnancy weight, parity, past history, pregnancy complications, estimated fetal weight from ultrasonic echography, estimated amniotic fluid during pregnancy and at delivery, birth weight, infant sex and delivery time in weeks were taken from the hospital chart.

Weight and body fat mass were measured by the 8-electrode bioelectrical impedance analysis (BIA) method using a multi-frequency body composition analyzer (MC-190EM; Tanita Corp., Tokyo, Japan) after micturition. Ueda (18) developed a new system for measuring maternal total fat mass using the BIA method by compensating for the intrauterine component weight, as estimated by direct measurement or ultrasound examination, and assessed its validity for pregnant women. In the present study, BIA measurements were performed using a body fat analyzer (Model TBF-410; Tanita Corp.), which estimates body composition on the basis of maternal body density, and calculated by prediction equations from the impedances (50 kHz, single frequency) obtained at four electrodes placed

in contact with the soles of the subjects' bare feet in a standing position. To compensate for intrauterine weight, fetal weight was estimated by ultrasound examination, placental weight was calculated as described previously (19) and amniotic fluid weight was estimated by the Brace method (20). Body fat mass was measured in a total of five body parts, namely each arm, each leg and the trunk plus head (Figure 1). This BIA method provided high correlations with mean regional lean soft tissue and whole-body skeletal muscle mass



Figure 1. Parts of the body measured for body fat mass. (Modified from Lunar Rad. Co., USA). (a) Arms; (b) legs; (c) trunk.

estimates using the reference method of dual-energy x-ray absorptiometry (DXA) (21) for non pregnant women. Overall, the total body fat mass measurements showed high validity with DXA analysis during pregnancy, and the regional fat mass measurements showed high validity with DXA analysis after delivery.

2.4. Statistical analysis

The student's *t*-test was used to compare the mean characteristics of the participants and group differences for changes in body fat mass between lactating and nonlactating women. Repeated measurement analysis of covariance (ANCOVA) was used to test each independent variable which was total body fat mass, trunk fat mass, arms fat mass and legs fat mass among the third trimester and 1 month postpartum, dependent variables were lactating status adjusted by age and parity. All statistical analyses were carried out using SPSS for Windows version 16 for Japan.

3. Results

3.1. Demographic data

The demographic data are shown in Table 1. Forty-nine women continued to participate until 1 month postpartum. All participants delivered between 37 and 42 weeks of gestation. At 1 month postpartum, 16 of 49 mothers (32.7%) were lactating and 33 mothers (67.3%) were mainly feeding formula (nonlactating). The lactating and nonlactating women showed no significant differences in their demographic data and energy intakes at the third trimester and at 1 month postpartum.

The mean (SD) weight gain from prepregnancy until the last perinatal check-up was 9.5 (3.5) kg. The mean (SD) weight reduction from delivery to 1 month postpartum was 7.6 (2.0) kg.

Table 1. Characteristics of the participants

		Lactating (n = 16)	Non lactating (n = 33)	p-value ^{a)}
Maternal	Age (years)	31.4 ± 2.9	30.9 ± 3.8	n.s.
	Height (cm)	158.1 ± 4.6	157.2 ± 5.7	n.s.
	Prepregnancy body mass index (BMI:kg/m ²)	21.2 ± 2.5	21.7 ± 4.3	n.s.
	Gestational weight gain (kg)	10.4 ± 4.1	9.1 ± 3.4	n.s.
	Parity: primipara	5 (31)	13 (39)	n.s.
	Total energy intake (kcal/day)			
	Third trimester	1,428 ± 298	1,423 ± 398	n.s.
	One month postpartum	1,676 ± 374	1,608 ± 541	n.s.
	Weight (kg)			
	Prepregnancy	53.3 ± 8.2	53.2 ± 8.5	n.s.
	Third trimester	61.2 ± 7.6	60.3 ± 7.9	n.s.
	One month postpartum	56.2 ± 7.6	54.6 ± 7.6	n.s.
	Third trimester to one month postpartum	-5.1 ± 1.8	-5.7 ± 2.2	n.s.
	Week of delivery (week)	38.9 ± 0.9	39.1 ± 1.1	n.s.
Placenta weight (g)	560 ± 108	589 ± 107	n.s.	
Neonatal	Birth weight (g)	2,978 ± 399	3,214 ± 429	n.s.
	Birth height (cm)	48.4 ± 2.0	49.3 ± 2.0	n.s.
	Infant sex: boy	9 (56)	22 (67)	n.s.

Mean ± SD or n (%); n.s.: nonsignificant; ^{a)} Student's *t*-test.

The mean (SD) fat mass reductions from the third trimester to 1 month postpartum were: total body, 0.9 (2.5) kg; arms, 0.1 (0.9) kg; legs, 0.6 (0.8) kg; and trunk, 0.1 (1.9) kg. The trunk fat mass showed the largest increase among the different parts of the body examined.

As shown in Figure 2, at 1 month postpartum, nonlactating women exhibited a decrease in their total body fat mass and there was a significant difference ($p = 0.026$) between the lactating and nonlactating women. As shown in Figure 3, the lactating women showed an increase in their trunk fat mass while the nonlactating women exhibited a decrease, and there was a significant difference ($p = 0.008$) from the third trimester to 1 month postpartum between the lactating and nonlactating women.

The fat masses in the arms (Figure 4) and legs (Figure 5) exhibited similar changes at the third

trimester and at 1 month postpartum in the lactating and nonlactating women.

4. Discussion

We measured the amounts of body fat mass using the BIA method in pregnant women followed up longitudinally during the third trimester and at 1 month postpartum and analyzed the differences between lactating and nonlactating women.

A main finding of our study is the trunk fat mass change showed a significant difference between the third trimester and 1 month postpartum in the lactating and nonlactating women.

Our study further found that there were no differences between energy intakes during the third trimester to one month postpartum between lactating and nonlactating women. We used the BDHQ to assess

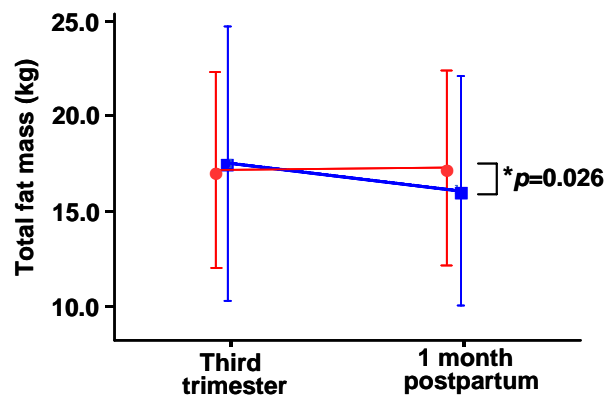


Figure 2. Changes in total fat mass in lactating (—●—; red) and nonlactating (—■—; blue) women. Data represent the crude mean \pm SD (kg). * $p = 0.026$, by ANCOVA¹⁾ ($n = 49$). ¹⁾ Adjusted by age and parity.

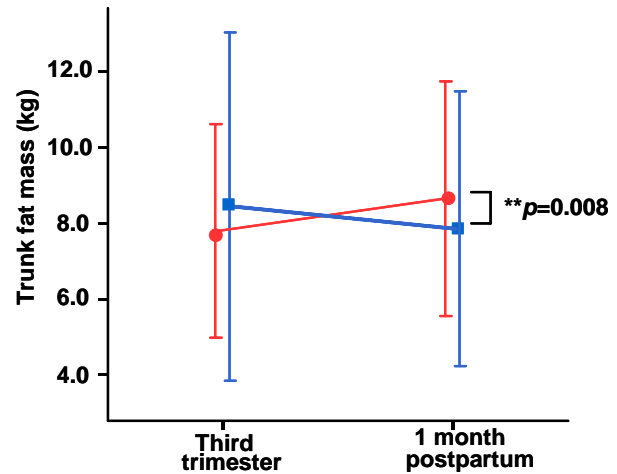


Figure 3. Changes in trunk fat mass in lactating (—●—; red) and nonlactating (—■—; blue) women. Data represent the crude mean \pm SD (kg). ** $p = 0.008$, by ANCOVA¹⁾ ($n = 49$). ¹⁾ Adjusted by age and parity.

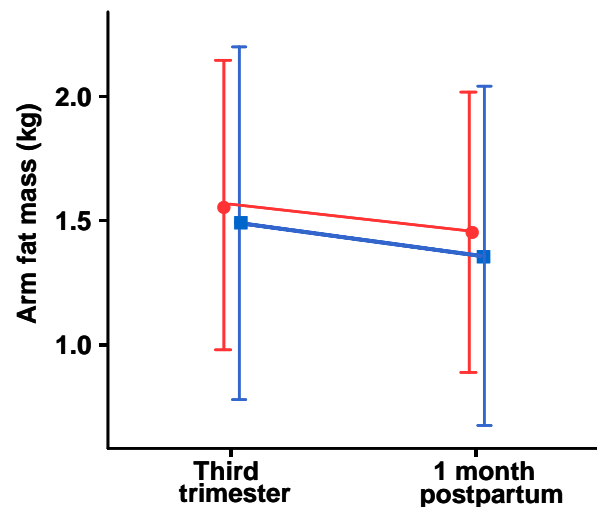


Figure 4. Changes in arm fat mass in lactating (—●—; red) and nonlactating (—■—; blue) women. Data represent the crude mean \pm SD (kg). No significant differences were detected by ANCOVA¹⁾ ($n = 49$). ¹⁾ Adjusted by age and parity.

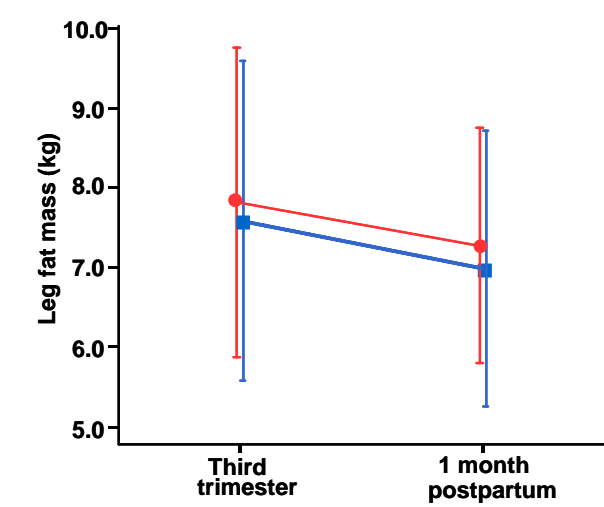


Figure 5. Changes in leg fat mass in lactating (—●—; red) and nonlactating (—■—; blue) women. Data represent the crude mean \pm SD (kg). No significant differences were detected by ANCOVA¹⁾ ($n = 49$). ¹⁾ Adjusted by age and parity.

total energy intake because of its feasibility and validity. However, because the BDHQ cannot directly observe the participants' dietary intake, the results should be interpreted cautiously. The total energy intake assessed with the BDHQ was seriously underreported compared with the estimated energy requirements (22), consistent with another study (23). However, it was unlikely to introduce a serious bias for comparisons of the intakes between the lactating and nonlactating women.

It is very difficult to measure body fat mass during pregnancy according to body parts or regions by DXA because of the perceived ionizing radiation hazard during pregnancy. The BIA method has high validity compared with DXA ($r = 0.87$, $p < 0.001$) for the total body fat mass and different parts of the body (24). However, it has a limitation in being unable to identify the specific body parts involved in the trunk fat mass gain, such as breast fat mass or abdominal fat mass. This is the first study to compare body fat mass in different regions between lactating and nonlactating women during pregnancy using the BIA method.

There is evidence of differences in fat mass storage in regions with high lipoprotein lipase (LPL) activation (25). Specifically, it was reported that both nonpregnant and pregnant women favored lipid assimilation in the femoral depot (25). However, the metabolic pattern changes during lactation because LPL activity decreases and lipid mobilization increases in the femoral depot. These changes are much less pronounced in the abdominal region. The fat cells from these different regions show different responses during pregnancy and lactation (25). In addition, abdominal adipose tissue has a higher adenosine content than femoral adipose tissue in lactating women (26). High estrogen levels during pregnancy promote a gynoid type of fat distribution (gluteofemoral), and low levels of estrogen during lactation may favor partitioning of the body fat to the upper body (27).

The present data are consistent with those in a previous longitudinal study using magnetic resonance imaging before pregnancy and at 5-10 days ($n = 15$), 2 months ($n = 15$), 6 months ($n = 13$) and 12 months ($n = 10$) postpartum, which showed that body fat mass exhibited greater decreases in the legs than in the trunk (34). Another previous study compared the waist/hip ratios in well-nourished Japanese women ($n = 41$) between the first trimester and 1 month postpartum and found significant retention of fat in the upper body (14).

Previous studies have compared nonpregnant women or lactating women longitudinally. It is therefore unclear whether the trunk fat mass gain after delivery is stimulated by lactation or in all women after birth regardless of lactation. Most of the previous studies comparing lactating and nonlactating women were longitudinal and aimed to solve obesity by identifying which groups had returned to their prepregnancy weights at 6 months or 1 year after birth (6-8). From

our findings, trunk fat mass changes only occur in lactating women, and the lack of differences in the energy intakes during the third trimester and at 1 month postpartum and other factors between the lactating and nonlactating women suggests that lactation itself may stimulate these metabolic pattern changes.

In addition, limitation of this study is that we focused on only healthy pregnant women and one setting and small sample size, it is difficult to extrapolate the results of our study. Further studies are required to measure fat retention for a longer time and more sample size including underweight women who gain insufficient fat mass during pregnancy.

In conclusion, the total body fat mass and body fat mass in the trunk at 1 month postpartum was significantly greater in lactating women than in nonlactating women.

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