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Maternal Changes of Body Composition and Energy Balance in Korean Lactating Women*

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ABSTRACT

This study was conducted to examine how Korean women manage energy metabolism during lactation. Eighteen women recruited were healthy, had normal pregnancies and were required to breast-feed their babies exclusively for at least 12wks. During the study period, all subjects were visited and interviewed five times : 3d, 9d, 4wk, 8wk, and 12wk lactation. Body composition variables were analyzed by a bioelectrical impedance method, energy intakes were assessed by using the inventory-weighing method, energy expenditure were determined by recording daily activities, and milk energy output was investigated from the amount of milk production and the gross energy content of milk. The subjects consumed less energy than current recommended allowance all over the study period, but compatible with fairly adequate lactational performance. They responded the additional energy stress of lactation by enhancing metabolic efficiency, increasing energy intakes, reducing physical activities and mobilizing body reserves. Another finding in this study was that the reduction in body fat-free mass may be the one way that women meet the energy demands of lactation like the reduction in body fat mass. The results from this study suggest that current recommended additional energy need during lactation, 2.09MJ/d(500kcal/d), is too high for healthy Korean women. Our data also indicate that the changes of body composition and energy balance at earlier postpartum are extremely different from those at later periods. (*Korean J Nutrition* 29(8) : 899~907, 1996)

KEY WORDS : lactating women · body composition · energy balance.

Introduction

Our understanding of energy requirements during lactation remains incomplete. The energy requirement of lactating women has been a topic of considerable debate because of the large difference between the current recommended intake by FAO/WHO/UNU and the amounts typically reported in dietary-intake studies. Studies from the developed[1-4] and developing countries[5)6] have shown that women can produce milk fairly even when energy intakes are considerably below the recommendation. Furthermore, these reports show that body fat loss during lactation is small. Continuous pregnancy may develop obesity in adult women[7]. Such results indicate that current estimates 10.46MJ/d(2,500kcal/d) of energy needs during lactation may be too high. On the other hand, some investigators[8)9] suggested that the energy cost for proper lactation was 2.09MJ/d(500kcal/d), so the value of current energy recommendation was reasonable. This discrepancy could be due to inaccurate dietary-intake measurements, low expected levels of physical activity, high estimated amounts of body fat mobilization, or disregard of increased metabolic efficiency

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during lactation.

The Korean recommended dietary allowance(RDA)[10] for energy during lactation is 10.46MJ/d(2500 kcal/d), which includes an extra energy(2.09MJ/d) and the recommended energy(8.37MJ/d) for nonpregnant and nonlactating women. The additional daily allowance was based on an assumed production of milk 750mL/d, and energy need to produce milk in 0.35 - 0.38MJ(85 - 90kcal) per 100mL. However, reported energy intakes of lactating women in Korea[11-14] are between 7.53 and 8.37MJ/d(1800 - 2000kcal/d), which are generally much lower than the above recommendation. Reported milk production ranges from 650 to 720mL/d, the value is lower than the above assumed production[14-16]. Also, little is known about energy balance during postpartum in Korean women, therefore, this study was conducted to examine how Korean women manage energy metabolism during lactation.

Ssubjects and methods

1. Subjects

This study was approved by the Ethics Committee of Chonnam National University Hospital. All the women gave oral consents before participating in the study. Eighteen women were recruited from a local middle-income population of Korean citizens. A doctor in a public health center explained to each subject the objectives of the study and the various procedures to be followed. All the women were healthy, had normal pregnancies, and delivered normal babies vaginally. They were required to breast-feed their babies exclusively for at least 12weeks(wk). Anthropometric, obstetric, and general data about the subjects are given in Table 1.

During the study period, all subjects were visited and interviewed five times at their home by the research team : 3(2-5)d, 9(7-10)d, 4wk, 8wk, and 12wk lactation. Anthropometry, body composition, dietary intakes, physical activities, and milk production and composition were measured at each visit. All study procedures were conducted by the same number of the research team who took the initial measurements.

Table 1. Characteristics of the subjects

Age(y)	27.6± 0.7*
Height(cm)	160.1± 0.8
Prepregnancy weight(kg)	51.5± 1.2
Body mass index(kg/m^2), Prepregnancy	20.0± 0.5
Weight gain during pregnancy(kg)	14.0± 0.8
Length of gestation(d)	282.3± 1.5
Parity	1.7± 0.1
Birth weight of infant(g)	340.3±69.1

*Mean±SEM

2. Anthropometry

Body weight was measured with the woman wearing minimal clothing in the morning after breast-feeding by using a digital scale(Model M-Ⅱ, Kubota Co., Tokyo, Japan, accurate to 0.1kg). Weight gain due to pregnancy was estimated from the difference between the weight before pregnancy and the weight before delivery as obtained by recall.

3. Assessment of body composition

Total body fat(TBF), fat-free body weight(FFBW) and total body water(TBW) contents were obtained by BIA(bioelectric impedance analysis) method[17]. Whole body impedance was measured with a portable device Bioelectric Impedance Fatness Analyzer(GIF-891, Gil Woo Trading Co., Seoul, Korea). Energy derived from body reserves was estimated from TBF and FFBW changes. The energy equivalents(kJ/g) of TBF and FFBW were taken as 38.1kJ/g and 5.0kJ/g, respectively[18].

4. Determination of milk production and gross energy content

The amount of breast milk produced over a 48-hour (h) period was determined by the test-weighing procedure[19] using an electronic balance (Nova, Dalim-Ishida Co., Seoul, Korea, accurate to 2 g). One feeding milk samples from one breast before breakfast was taken for analysis of protein, fat, and lactose. Protein was analyzed by a modified Lowry method[20], fat was determined gravimetrically by Folch method[21], and lactose was determined spectrophotometrically using β-galactosidase and glucose oxidase(Lactose/D-Galactose kit, Boehringer Mannheim Diagnostics, Indianapolis, USA). Gross energy content of milk was calculated by using the values of heat of combustion[18] : the values of protein, fat, and lactose are 24.52(5.86), 38.49(9.2), and 16.53(3.95)kJ/g(kcal/g), respectively. Milk energy output(MEO) was determined from the amount of milk production and the gross energy content of milk.

5. Measurement of energy intakes

The subjects had their regular foods at home. Actual food intakes were assessed by using the weighed-inventory technique. The subjects weighed and recorded their intakes of food and drink by themselves for 2 consecutive days, with frequent supervision by the research team. Each subject was supplied with an electronic balance(Nova, Dalim-Ishida Co, Seoul, Korea, correct to 2 g). For determination of protein, fat and carbohydrate contents, an appropriate aliquot was proportionally(one tenth of meal) taken and pooled. Nitrogen contents were analyzed by the micro-Kjedahl method and were converted to protein contents by multiplying the factor 6.25. Fat contents were determined gravimetrically. Carbohydrate contents were determined by the phenol-H_2SO_4 method [22]. The energy intake was calculated from the ingested amounts of protein, fat, and carbohydrate, by multiplying the factor 16.74(4), 37.66(9), and 16.74(4) kJ/g(kcal/g), respectively.

6. Estimation of Energy expenditure

Basal metabolic rate(BMR) was estimated by the equations for predicting BMR from weight and height suggested by WHO[23]. Physical activity was assessed by recording minute-by-minute activities for 2 consecutive days. Each activity was calculated as a multiple of BMR according to WHO method[23]. The weighed average of these multiples was used as an indicator of the level of physical activity(PAL). Gross energy expenditure(GEE) was calculated by multiplying PAL and BMR.

7. Statistical analysis

The data reported are the mean values with SEM. Data for 5 time intervials were analyzed by one-way ANOVA with repeated measures design ; $p<0.05$ was considered to be significant. Where ANOVA showed significant effects, differences among 5 time intervials were evaluated for significance by Duncan's procedure. Changes in tendency througout the study period were examined by using linear regression.

Results

1. Changes in anthropometry and body composition

Maternal body weight(BW) and body composition during study period are shown in Table 2, and daily changes in body composition are presented in Fig. 1. BW displayed a gradual decline over the 12wk lactation($p<0.01$). Therefore, when BW was expressed as the ratio of prepregnancy BW, there was also a gradual decline from 1.29 to 1.13 during the study period. Of the gestational weight gain(14.0kg), 5.9kg remained at 12wk lactation. Assuming that the trend in BW loss was linear, the overall rate of BW loss as 80.4±21.7g/d. However, the rate of BW loss was the greatest during the period from 3d to 9d, and thereafter lessened gradually. A wide range of gestational weight gain(10.1~23.5kg) was represented in this study, and also there was a considerable inter-subject variation in the overall rate of BW loss(-349.2~35.7g/d) during the study period. Body mass index (BMI) also displayed a gradual decline from 24.5 to 22.5 during the study period.

Table 2. Anthropometry and body composition over the first 12 weeks of lactation

	3d	9d	4wk	8wk	12wk
Body weight(kg)	63.1 ±1.1^{a}*	61.1 ±1.1^{ab}	58.4 ±1.4^{b}	57.6 ±1.4^{b}	57.4 ±1.5^{b}
BW/prepregnancy BW	1.20±0.01^{a}	1.18±0.02^{ab}	1.15±0.02^{b}	1.13±0.02^{b}	1.13±0.02^{b}
Body mass index(kg/m^2)	24.5 ±0.4^{ab}	23.7 ±0.5^{ab}	22.8 ±0.5^{b}	22.6 ±0.6^{b}	22.5 ±0.6^{b}
Total body fat(kg)	17.3 ±1.0	16.7 ±0.9	16.3 ±0.9	15.9 ±0.8	16.1 ±0.9
% Wt	27.4 ±1.4	27.3 ±1.4	27.9 ±1.5	27.6 ±1.0	28.1 ±1.2
Fat-free body weight(kg)	45.8 ±1.1^{a}	44.4 ±1.2^{ab}	42.1 ±0.9^{b}	41.6 ±0.9^{b}	41.3 ±0.9^{b}
% Wt	72.6 ±1.4	72.7 ±1.9	72.0 ±1.9	72.4 ±1.0	72.0 ±1.2
Total body water(kg)	33.6 ±0.9^{a}	32.7 ±0.6^{ab}	30.9 ±0.7^{b}	30.4 ±0.7^{b}	30.5 ±1.0^{b}
% Wt	53.2 ±1.0	53.5 ±0.8	52.9 ±0.8	53.0 ±0.7	53.4 ±1.6

*Mean±SEM

Values with the different superscripts within a row are significantly different($p<0.05$).

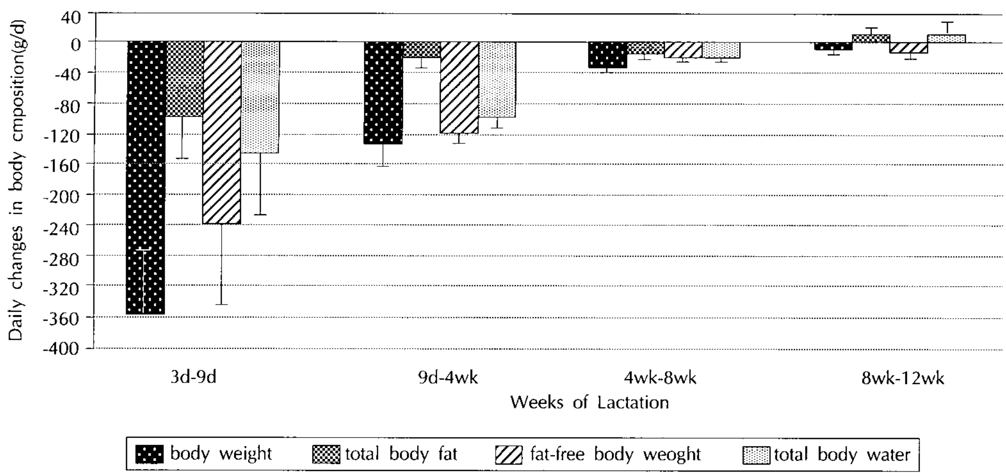

Fig. 1. Daily changes in body composition. Values are means(±SEM) during the first 12 week of lactation. All values are not significantly different at $p < 0.05$.

Table 3. Milk production and composition over the first 12 weeks of lactation

	3d	9d	4wk	8wk	12wk
Milk output(g/d)	446 ± 30^{b}*	471 ± 24^{b}	612 ± 33^{a}	708 ± 34^{a}	685 ± 27^{a}
Protein(mg/g)	1.26 ± 0.02^{a}	1.19 ± 0.03^{ab}	1.15 ± 0.04^{b}	0.98 ± 0.02^{c}	0.92 ± 0.02^{c}
Fat(mg/g)	2.62 ± 0.22^{b}	2.99 ± 0.15^{ab}	3.38 ± 0.14^{a}	2.96 ± 0.22^{ab}	2.98 ± 0.21^{ab}
Lactose(mg/g)	6.03±0.15	6.29±0.15	6.06±0.14	6.25±0.17	6.42±0.14
Gross energy(kJ/g)	2.32±0.06(0.56)	2.33±0.10(0.56)	2.70±0.07(0.65)	2.34±0.08(0.56)	2.28±0.08(0.55)

*Mean±SEM
Values with the different superscripts within a row are significantly different ($p < 0.05$).
Values with calorie unit(kcal/g) in parentheses.

In contrast to the values for BW, TBF slightly decreased until 8wk lactation. The overall rate of TBF loss was 16.7±13.8g/d. As the above results, the percentage of TBF maintained relatively constant in the range of 28.1 to 27.3 throughout the study period. However, the pattern of FFBW change was similar to the BW change. The overall rate of FFBW loss was 64.3±26.3g/d. The percentage of FFBW also remained unchanged in the range of 72.0 to 72.7 throughout the experimental period. TBW displayed a gradual decline until 8 wk lactation($p < 0.01$). The overall rate of TBW loss was 25.3±10.2g/d. However, the percentage of TBW had not changed over the whole experimental period.

2. Lactational performance

The amounts and composition of milk produced during the study period are shown in Table 3. Milk production averaged 651g/d over the 12wk lactation. The amount of milk production linearly increased over time($p < 0.0001$). However, milk production reached a peak at 8 wk lactation, therefore the amount of milk produced at 12wk tended to be lower than that at 8wk. The protein concentration significantly decreased over the study period($p < 0.0001$). The fat concentration did not linearly increased, but that at 4 wk lactation was significantly higher than that at 3d lactation. The contents of lactose and energy were not significantly different over the experimental period. Energy content averaged 2.28±0.08kJ/g(0.57±0.01kcal/g) over the study period.

3. Dietary intakes of energy-yielding nutrients

Maternal dietary intakes are given in Table 4. Energy intake increased gradually over the 12wk postpartum($p < 0.05$). The overall mean energy intake was 9.26±0.27MJ/d(2212±65kcal/d), and that expressed as the amount per body weight averaged 159±5kJ/d(38±1kcal/kg/d). The energy intake ranged from 16% to 23% below the RDA for energy in Korean lactating women throughout the ex-

Table 4. Dietary intakes over the first 12 weeks of lactation

	3d	9d	4wk	8wk	12wk
Energy(kJ/d)	8488±205*(2037)	8674±201(2082)	9347±420(2243)	9158±188(2198)	9550±284(2292)
(kJ/kg/d)	134.1±3.7(32.2)	141.9± 4.2(34.1)	159.6± 5.6(38.3)	157.5± 4.8(37.8)	167.9± 5.7(40.3)
%RDA	81.2±2.0	82.9± 1.9	89.4± 4.0	87.5± 1.8	91.3± 2.7
Protein(g/d)	80.5±3.8	83.2± 4.7	76.6± 3.9	83.1± 3.3	82.9± 3.0
%RDA	100.6±4.7	104.0± 5.8	95.8± 4.8	103.9± 4.1	103.6± 3.8
%Energy	15.9±0.7	16.1± 0.9	13.7± 0.7	15.2± 0.6	14.5± 0.5
Fat(g/d)	46.7±4.2	42.0± 1.6	52.1± 5.2	59.6± 4.1	57.3± 3.4
%Energy	20.7±1.9	18.2± 0.7	21.0± 2.2	24.4± 1.7	22.6± 1.3
Carbohydrate(g/d)	332.1±7.4	357.7±11.0	362.6±18.8	330.6±10.9	359.0±14.2
%Energy	65.4±1.4	69.0± 2.1	64.9± 3.4	60.4± 2.0	62.9± 2.5

*Mean±SEM
All values are not significantly different at $p < 0.05$.
RDA : recommended dietary allowances for Korean lactating women

Table 5. Gross energy expenditure, basal metabolic rate and physical activity level over the first 12 weeks of lactation

	3d	9d	4wk	8wk	12wk
Basal metabolic rate					
(kJ/d)	5897±63*(1415)	5775±59(1386)	5617±80(1348)	5579±80(1339)	5564±83.3(1335)
(kJ/kg/d)	94±0.7(22.6)	96±0.9(23.0)	97±0.9(23.3)	98±0.9(23.5)	98±0.9(23.5)
Physical activity	1.35±0.03^{b}	1.44±0.03^{ab}	1.56±0.03^{a}	1.62±0.02^{a}	1.54±0.03^{a}
Gross energy expenditure					
(kJ/d)	8010±204^{b}(1922)	8321±177^{ab}(1997)	8766±244^{ab}(2104)	9053±213^{a}(2173)	8579±250^{ab}(2059)
(kJ/kg/d)	126±2.6^{b}(30.2)	137±3.1^{ab}(32.9)	151±3.1^{ab}(36.2)	158±1.7^{a}(37.9)	150±3.1^{ab}(36.0)

*Mean±SEM
Values with different superscripts within a row are significantly different ($p < 0.05$).
Values with calorie unit(kcal/d, kcal/kg/d) in parentheses.

Table 6. Energy balance(kJ/d) over the first 12 weeks of lactation

	3d – 9d	9d – 4wk	4wk – 8wk	8wk – 12wk
E intake	8581± 203*(2059)	9011± 310(2162)	9253±304(2221)	9354±236(2245)
E equivalent TBF change①	–3404±2329(–817)	–305± 590(–73)	–408±302(–98)	263±332(63)
E equivalent FFBW change②	–997± 572(–239)	–446± 98(–107)	–74±584(–18)	–67± 53(–16)
E equivalent Milk produced③	1317± 77^{b}(316)	1673± 121^{ab}(402)	2022±117^{a}(485)	2050± 87^{a}(492)
Residual E④	8899±2532(2136)	6956±1165(1669)	7562±531(1815)	7195±454(1727)
GEE	8166± 191^{b}(1960)	8544± 211^{ab}(2051)	8910±229^{a}(2138)	8816±232^{ab}(2116)
GEE/Residual E	0.94±0.13	1.26±0.13	1.20±0.10	1.19±0.11

*Mean±SEM
Values with the same superscripts within a column are significantly different ($p < 0.05$).
①②③ Assumption : energy equivalents of TBF and FFBW change are 38.1(9.1) and 5.0(1.2) kJ/g(kcal/g), respectively, and energetic efficiency for converting dietary energy to milk energy is 80%
④ Residual energy=energy intake-energy equivalent TBF change-energy eqivalent FFBW change-energy equivalent of milk produced. E = energy, TBF = total body fat, FFBW = fat-free body weight, GEE=gross energy expenditure
Values with calorie unit(kcal/d) in parentheses.

perimental period. The overall mean ingested amount of protein was 77.9±2.9g/d, which was 95% of the RDA for protein for Korean lactating women[10]. Fat intake also slightly increased over the study period($p < 0.05$). However, no tendency was observed in protein and carbohydrate intakes. The composition of energy was as follows : 14.8% from protein, 21.3% from fat, and 64.0% from carbohydrate.

4. Energy expenditure, basal metabolic rate and physical activity level

The values of BMR, PAL and GEE are presented in Table 5. The BMR averaged 5.60±0.78MJ/d (1344±187kcal/d) and 97±1kJ/kg/d(23±0kcal/kg/d) during the study period. The values for BMR showed a tendency to decrease over time. However, when expressed as per kg BW, the values tended to slightly increase. The values for PAL increased gradually over the study period($p < 0.01$). However, the values was at maximum at 8wk postpartum. There was a significant difference in PAL between the value at 3d and that at 8wk lactation. The overall mean PAL was 1.56. The overall mean GEE was estimated to be 8.74±0.20MJ/d(2097±47kcal/d). Expressed in relation to body weight, the overall mean GEE was 148±2kJ/kg/d(36±0kcal/kg/d). There was no trend in GEE over time, expressed either in absolute terms or when normalized for body weight. However, GEE reached a peak at 8wk lactation, therefore, there was a significant difference in GEE between the value at 3d and that at 8 wk lactation.

5. Energy balance

The data of energy balance were shown in Table 6. The energy derived from TBF change averaged -637±540kJ/d(-152±129kcal/d), and that derived from FFBW change averaged -323±132kJ/d(-77±32kcal/d). However, the energy derived from TBF as well as FFBW was the greatest at 9 d and thereafter both decreased sharply over time, but not significant. However, TBF tended to increase at 12wk postpartum. The overall mean residual energy was 7.48±0.51MJ/d (1789±121kcal/d). The energy needed for milk production was 1.29MJ/d at 3d and thereafter significantly increased to 2.08MJ/d at 8wk. The residual energies at 3d and 9d were extraordinarily great, which could be due to the energy derived from TBF. The residual energy gradually decreased thereafter, but not significant. The lack of statistical significance was due to the considerable individual variation among the subjects.

Discussion

This study intended to examine how Korean women manage the energy metabolism and to access changes in the pattern of body composition during the first 12wk of lactation. The values of gestational weight gain, 14.0kg, and birth weight of infants, 3.4kg, are indirect indicators of fairly good nutritional status of the subjects during pregnancy.

The body weight loss in our study was in good agreement with other studies[2)3)5)]. However, the rate of weight loss was extremely different at each measurement time. This result indicates that the mean value during a long period such as 2mo or 6mo is less meaningful to represent the fact of weight change. There are few studies that have measured body composition within 1 mo postpartum.

Although the BIA method used in this study has not been evaluated in lactating women, weight loss in this study accompanied with the decline of TBF, FFBW, and TBW. Therefore, each percentage of TBF, FFBW and TBW did not change at all measurements. However, weight loss was primarily due to by the decrease in FFBW; the overall mean weight loss, 80.4g/d, was composed of 16.7g of TBF and 64.3g of FFBW. Recently, Sadurskis et al.[2)] reported that TBF was not mobilized until the first 2mo postpartum and the mobilization from 2mo to 6mo was modest. However, FFBW was significantly decreased. They suggested that the fat store may serve another biological purpose in addition to its role as an energy depot, and more stress is required to mobilize the fat store, ie, a serious shortage of food or physically heavy work. Many studies[1)6)7)] showed that TBF loss occurred after 3mo or 6mo of lactation. It is possible to assume that the period after 3mo or 6mo is the time when physical activity of lactating women starts to increase[5)].

Our results that weight loss was extremely great at an earlier time of postpartum and that weight loss was primarily due to the decrease in FFBW are interesting. Changes in the content of body fat during lactation have been the subject of many studies, because the knowledge of these changes is important in understanding the energy requirements during lactation. On the other hand, changes in fat-free mass have not been focused. Our findings showing that the extent of FFBW loss was considerable indicate that the energy derived from FFBW may play an important role during lactation. However, Taggart et al.[24)] found that all skinfold sites decreased by a surprisingly large amount within the end of the first postpartum week.

They suggested that there was an additional factor causing a sharp decrease in skinfold at the time of postpartum. Energy required within 1wk postpartum is mainly for both parturition and colostrum production. The data of body composition at 3 day postpartum obtained in this study may reflect the effects of colostrum production. And yet, we have no data of energy needed for parturition and initiation of milk production.

The overall mean value(652g/d) of milk production obtained in this study is consistent with the results of other investigators[3)14)16)25)]. However, the value was slightly less when compared to those from affluent countries[2)3)26)] and Gambian[8)]. The overall mean milk composition was within expected norms, too. The concentrations of protein, lactose and fat were similar to the data by other Korean investigators [14)16)]. However, the values for fat concentration were slightly lower than those from affluent conturies. Therefore, the overall mean energy content of milk, 2. 3kJ/d, was also slightly lower than the generally accepted value of 2.8kJ/d[27)]. It may be concluded that the lactational performance of the subjects was fairly adequate by most standards, but rather inadequate with respect to energy density and fat concentration.

The overall mean dietary energy intakes of the subjects, 9.26MJ/d and 159kJ/kg/d, was lower than the recommended dietary standards of FAO/WHO/UNU[23)] as well as those for Korean[10)]. The degree of shortage was great at earlier period postpartum. On the other hand, protein intakes were fairly good. From the data of protein intakes, it can be concluded that the subjects in this study were not in a condition of food shortage.

Both basal metabolic rates expressed as per day and per kg body weight did not change significantly over the 12wk postpartum. Although the equations based on weight and height used in this study have not been evaluated in lactating women, this results agree with the study of Guillermo-Tuazon et al.[5)] who reported that BMR did not change significantly during the 6mo of lactation. Thomson et al.[9)] and Illingworth et al.[28)] reported also that resting metabolic rate is unaffected by lactation. The fact that BMR was not changed despite decreases in both BW and FFBW, could be explained due to the effects of compensation by increases in BMR resulting from milk production. Frigerio et al.[8)] who found that BMR was not different between lactating and non-lactating women by measuring it in the respiratory chamber raised the same question of the energetic efficiency of milk synthesis. Comparision of the overall mean BMR, 5. 60MJ/d and 97kJ/kg/d with FAO/WHO/UNU standards[23)] represented around 106%. However, the BMR was lower than those of some studies from affluent countries[2)26)], but higher than the values from less-affluent countries[5)6)8)]. The discrepancy may be due to the difference in BW of subjects and methods used. The data of PAL represent that the subjects in this study reduced their physical activities, especially during the early postpartum period, thus decreased below lowered their energy requirement. These results are consistent with the reports of Coward et al.[29)]. Also, the phenomenon that PAL increased significantly over time agreed with the recent report by Raaij et al.[30)]. They found that physical activity gradually increased during the first year postpartum. The overall mean value of PAL, 1.56, indicates that the subjects in this study had a light to moderate activity pattern during the study period. According to the above results of BMR and PAL, there was no trend in GEE over the whole study period. However, the value of GEE at 8 wk reached at peak when the value of PAL was at maximum.

The energy came from TBF loss was the greatest at 9d and thereafter decreased sharply over time, but at 12wk, some energy was used for body fat store. That came from FFBW loss was the greatest at 9d and thereafter decreased over time, too. However, the magnitude of decrease in the latter was not sharper than the former. Energy needed for milk production increased significantly over time. It could be explained due to increasing milk output over time. As the results, residual energy at 9d was more than GEE, on the other hand, these at 4wk, 8wk and 12wk were less than GEE. Thus, the ratio of GEE/residual energy at 9d was below 1.0, but above 1.0 after 4wk postpartum. Although GEE were measured indirectly in this study, it is clear that the results indicate metabolic efficiency might be enhanced during the study period except at 9d postpartum. This is supported by the facts that although GEE was more than residual energy after 4wk postpartum, the subjects did compensate the discrepancy by either mobilizing endogenous energy or increasing exogenous energy. The energy came from TBF as well as FFBW rather decreased throughout the period of study. Roberts and Coward[31] published data indicating that lactation may be associated with an increased metabolic efficiency in rats, the point was confirmed by Illingworth et al.[28] who pointed out that metabolic efficiency is enhanced in lactating women and non-lactational component of maternal energy expenditure is diminished and it was supported again by Sadurskis et al.[2]. Furthermore, the efficiency for converting dietary energy to milk energy may be higher than 80%, which is generally accepted[8][32].

In conclusion, these lactating Korean women consumed less energy than current recommended allowance during 12wk lactation, but compatible with fairly adequate lactational performance. They responded to the additional energy stress of lactation by enhancing metabolic efficiency, increasing energy intakes, reducing physical activities and mobilizing body reserves. Another finding in this study was that the reduction in FFBW may be the one way that women meet the energy demands of lactation like the reduction in TBF. The results from this study suggest that current recommmended energy need during lactation, 2.09MJ/d, is too high for healthy Korean women. Our data also indicate that the changes of body composition and energy balance at earlier postpartum are extremely different from those at later periods.

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=국 문 초 록=

한국인 수유부의 체조성 변화 및 에너지 평형

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본 연구는 한국인 수유부의 에너지 대사가 수유기간에 따라 어떻게 변화되는지를 알아보고자 수행되었다. 대상자는 건강하고 임신상태가 정상이었던 산모중 적어도 12주간 모유영양을 실시하는 수유부 18명으로 하였다. 연구기간중 각 항목의 조사는 대상자를 수유기간 3일, 9일, 4주, 8주 및 12주 등 5차례의 가정방문하여 실시하였으며 체조성의 변화, 에너지 섭취량 및 에너지 소비량은 각각 BIA (bioelectrical impedance analysis) 법, 평량법 및 활동기록법으로 조사하였다. 또한 유즙에너지 생성량은 유즙생성량과 유즙내 에너지 함량을 이용하여 산출하였다. 연구기간동안 대상자의 에너지 섭취량은 수유부 권장량에 미달되었으나 수유 이행에는 별 무리가 없는 수준이었다. 따라서 수유부는 대사적 효율성의 향상, 에너지 섭취량의 증가, 신체 활동량의 감소 및 체내 저장에너지의 동원 등으로 수유를 통한 부가적인 에너지 요구량을 충당하는 것으로 보인다. 이 연구에서는 또한 체내 비지방조직의 감소가 체지방조직의 감소처럼 수유기에 부가적으로 요구되는 에너지량을 충족시키는 한 방법이 될 수 있음을 시사하였다. 본 실험 결과 수유기에 부가적으로 요구되는 현 에너지 권장량(2.09 MJ/d)이 건강한 여성에게는 너무 높은 수준일 수 있음을 나타내었으며 또한 수유초기의 체조성의 변화 및 에너지 평형은 수유후기와는 크게 다름을 보여주었다.