Intake of milk and dairy products significantly contributes to maternal adequate weight gain in pregnant women after 28 weeks gestation

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In Japan, mean birth weight has decreased and prevalence of low birth weight babies is higher than other OECD countries. We examined the relationship of maternal weight gain with dietary intake and smoking during pregnancy.

Women with singleton pregnancies without any complications who had prenatal medical check-ups at a hospital in Tokyo from July 2012 to August 2013 were selected as potential participants. They were informed of appropriate weight gain according to their BMI before pregnancy and provided a leaflet regarding healthy diet at 15–20 weeks gestation. After that, midwives assessed weight gain status and gave brief dietary advice at each check-up. Seventy-six women with “insufficient” or “excess” weight gain around 28 weeks gestation were requested to record three-day food intakes and were given individualized dietary advice on their records by dieticians. Hierarchical logistic regression analysis was conducted using weight gain status from 28 weeks gestation to delivery (inadequate = 0, adequate = 1) as a dependent variable.

Regarding smoking, odds ratios could not be calculated because no couples in “adequate” group smoked. A significant promoting factor for maternal adequate weight gain was the number of days with milk and dairy products consumption (OR = 2.20 (95% CI = 1.10–4.37)) that was counted from the dietary records. In addition to their nutritional values, consumption of milk and dairy products has been pointed out as an indicator of good dietary behavior, and therefore, could be the reason for appropriate weight gain during pregnancy.

**Key words**: pregnancy, weight gain, dietary behavior, milk and dairy products

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I. Introduction

Mean birth weight of Japanese babies has decreased by about 200g in the last 40 years\(^1\). In 2015, the prevalence of low birth weight babies (< 2,500) among OECD countries was 6.5% whereas that in Japan was 9.5%\(^2\). Weight gain during pregnancy has been said to be an important indicator to assess fetal development\(^3\)–\(^4\). Inadequate weight gain may have adverse effects on mother and her fetus. Overweight or obesity in pregnant women might be related to complications such as gestational diabetes mellitus (GDM)\(^5\)–\(^6\) and pregnancy induced hypertension (PIH)\(^5\), and might be a risk factor for macrosomia\(^5\)–\(^7\), congenital anomaly\(^5\), fetal growth restriction (FGR)\(^5\) and maternal mortality\(^8\). On the other hand, insufficient weight gain in pregnancy might lead to delivery of low birth weight babies\(^5\)–\(^9\)–\(^10\), FGR\(^5\), and intrauterine growth retardation (IUGR)\(^11\). It might increase the risk for the future development of chronic diseases such as heart disease and diabetes mellitus\(^5\)–\(^12\).

Regarding maternal age group at her first delivery, 30–35 years makes up the largest proportion (36.5%) and 20–39 years accounts for 70.4% in 2017\(^13\). Women in these age groups have various health problems described below.

1. Underweight and desire for slenderness

The proportion of underweight women (BMI < 18.5) was the highest in their 20s (22.3%) and the second highest in their 30s (15.5%) in 2015\(^14\). Even if their current BMI is “normal (BMI=18.5– < 25.0)”, more than half of women in their 20s and 30s are trying to reduce their weight\(^15\). Moreover, even if the current BMI is “underweight”, more than 10% of them are trying to reduce their weight.

2. Smoking and passive smoking

Total percentage of people who smoke every day or sometimes (hereafter, smoking rate) is decreasing significantly year after year\(^16\). In 2015, smoking rates among Japanese women in their 20s and 30s were 6.7% and 11.0%, respectively. Among the female smokers in their 20s and 30s, however, the proportion of who do not want to quit smoking was 17.0% and 15.0%, respectively. Even nonsmokers are exposed to secondhand smoke in various places in everyday life such as homes, workplaces, restaurants, and the street. Although Health Japan 21 (the second term)\(^16\) set a target for passive smoking, it has not been achieved as of 2015.

3. Dietary behavior

The proportion of women who “hardly ate meals with Grain dishes (staples), Fish or meat dishes (main dish), and Vegetable dishes (side dish)” is the highest in their 30s (12.6%) and the second highest in their 20s (12.1%) among all age groups\(^14\). Daily vegetable intakes are 226.8g in their 20s and 246.3g in their 30s. Both amounts are far below the target set in Health Japan 21 (350g/day)\(^16\). Daily intakes of milk and dairy products are especially small in their 20s (102.4g) and 30s (104.8g), and they are about 30g less than the target set in Health Japan 21 (130g/day)\(^16\).

The Japanese Ministry of Health, Labour and Welfare issued the “Dietary Guidelines for Pregnant and Lactating Women”\(^17\) in 2006. It consists of the following nine guidelines: 1) Maintain a proper weight before pregnancy, 2) Take sufficient energy mainly from Grain dishes (staples), 3) Take vitamins and minerals from Vegetable dishes (side dish), 4) Take proper amount of Fish or meat dishes (main dish), 5) Take sufficient amount of calcium from milk and dairy products, 6) Control weight gain properly, 7) Nourish a baby with breast milk, 8) Do not smoke and do not drink alcohol and ask other people for assistance, and 9) Have room for mind and body. This study examined the relationship of maternal weight gain with dietary intake and smoking during pregnancy based on the recommendation by the guidelines (No. 2, 3, 4, 5, and 8).
II. Methods

1. Participants

Participants of this study were recruited in almost the same way as the study by Tajirika et al\textsuperscript{18}. Four hundred and forty-seven women with singleton pregnancies, who had prenatal medical check-ups at a research facility in Tokyo from July 2012 to August 2013 were selected as potential participants (Figure 1). They did not have any complications such as GDM, PIH, or lymphangioleiomyomatosis. Women got a detailed explanation about the study protocol and provided informed consent. They were informed of their appropriate weight gain according to their BMI before pregnancy, which was calculated from the self-reported height and weight at 15–20 weeks gestation. At that time, they were provided with leaflets regarding healthy diet during pregnancy. After that, at each medical check-up, weight gain status was checked using

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{participants_selection_process.png}
\caption{Participants selection process}
\end{figure}

GDM, gestational diabetes mellitus; PIH, pregnancy induced hypertension
weight gain chart and pregnant women were given brief dietary advice by midwives.

A total of 31 women stated below were excluded from the study. One refused further participation, another had a stillbirth, 20 moved to other obstetric facilities before 30 weeks gestation, one gave birth to an infant with major birth defects, seven gave premature delivery (before 36 weeks gestation) or post mature delivery (after 42 weeks gestation), and one did not have a record of birth weight. The following 312 people were also excluded; 310 women whose weight gain status around 28 weeks gestation was “adequate”, one with GDM, and one with PIH. Participants with “insufficient” or “excess” weight gain around 28 weeks gestation were requested to record the foods they ate with non-weighed method for non-continuous three-day period and to estimate the intake amount. After recording dietary intake, they were given individualized dietary advice on their records by dieticians. For one day in the three-day records, dieticians interviewed detailed amounts and kinds of foods consumed using Tabenavi-kun to estimate weight of dishes and ingredients. They also calculated energy and nutrient intakes, and counted servings according to the Japanese Food Guide Spinning Top for Pregnant and Lactating Women. Detailed nutrient intake for one day was calculated by using a computer program (Shokuji-shirabe 2017, National Institute of Health and Nutrition).

We analyzed dietary records of 104 women and the following 27 women were excluded; 15 women who did not complete the three-day food records and 13 women who took unusual meals. Finally, 76 women were included in the analyses.

2. Variables

The Japanese Food Guide Spinning Top for Pregnant and Lactating Women shows recommended servings for five groups (Grain dishes (staples), Fish or meat dishes (main dish), Vegetable dishes (side dish), Milk and dairy, and Fruits) as additional amounts to those for before pregnancy. In this study, however, we selected food and dish groups which are also mentioned in the Dietary Guidelines for Pregnant and Lactating Women.

In the Japanese Food Guide Spinning Top for Pregnant and Lactating Women, 5 to 7 servings, 3 to 5 servings, and 5 to 6 servings were recommended for Grain dishes (staples), Fish or meat dishes (main dish), and Vegetable dishes (side dish), respectively per day. However, we defined the phrase “taking Grain dishes (staples), Fish or meat dishes (main dish), and Vegetable dishes (side dish)” as that women had each dish at least 1 serving per meal, since estimated amount of food intake only from 21 out of 76 participants were detailed enough for further quantitative analysis. In addition, it recommends 2 servings of milk and dairy products per day. Due to the same limitation of our dietary records, we simply counted the number of days with milk and dairy products consumption regardless of serving amount.

The Dietary Guidelines also recommend that pregnant women should not smoke or be exposed to secondhand smoke. Thus, the following dietary and smoking behaviors were used for analyses.

1) Maternal dietary behaviors: (1) Consumption frequency of the meals consisted of at least 1 serving from each of Grain dish (staples), Fish or meat dish (main dish), and Vegetable dish (side dish) per day (0–9 times in three days), (2) The number of days with milk and dairy products consumption out of three days (0–3 days).

2) Parents’ smoking at 20 weeks

Parents’ smoking data was collected by a questionnaire and a medical interview to mothers.

3. Statistical analyses

For descriptive statistics, median, the first and third quartiles were calculated for the variables
about maternal dietary behaviors that were not normally distributed, and mean and standard deviation (SD) were calculated for other variables. For comparison among three groups of maternal weight gain status from 28 weeks gestation to delivery, one-way analysis of variance (ANOVA) was used for normally distributed continuous variables and Kruskal–Wallis test was used for those without normal distribution which were confirmed by Shapiro–Wilk test. Fisher’s exact test was used to examine the relations between categorical variables. Multiple comparison test with Bonferroni correction was conducted. Hierarchical logistic regression analysis was carried out using weight gain status from 28 weeks gestation to delivery as a dependent variable and it was incorporated into the model as a dummy variable; women who had “insufficient” or “excess” weight gain were grouped into “inadequate = 0” and others were “adequate = 1”. As independent variables, maternal dietary intake was put into Step 1, in addition, parents’ smoking behavior was put into Step 2. Maternal age at delivery, gestational age, BMI before pregnancy, parity, and sex of the infant were put into the model as control variables. The model calibration was assessed using Hosmer–Lemeshow goodness-of-fit test (p > 0.05 indicates good fitness).

The Spearman’s rank correlation coefficients for intakes of energy, protein, and vitamins and consumption frequency of the meals consisted of at least 1 serving from each of Grain dish (staple), Fish or meat dish (main dish), and Vegetable dish (side dish), and for intake of calcium and the number of days with milk and dairy products consumption out of three days were also calculated to examine the relation between detailed nutrient intake for one day and habitual intake assessed by food consumption frequency for three days.

All statistical analyses were performed by SPSS version 25 (Japan IBM). Statistical significance was set at p < 0.05.

4. Ethical consideration

This study protocol was approved by the Institutional Review Board of Nissan Tamagawa Hospital (No. 11–13) and the National Institute of Health and Nutrition (No. 20120723–02).

III. Results

Characteristics of mothers and their children by maternal weight gain status from 28 weeks gestation to delivery are shown in Table 1. All of the eight women who used to smoke had quit smoking after detecting pregnancy. It means that no one smoked during pregnancy. In addition, no one took alcohol during pregnancy. Although there was no macrosomia (4,000g≤birth weight), four babies had low birth weight (<2,500g). Regarding BMI before pregnancy, mothers’ and fathers’ smoking behaviors, and infant sex, there were significant differences among the three groups of maternal weight gain status during pregnancy (p = 0.028, p = 0.013, p = 0.037, and p = 0.043, respectively). As a result of multiple comparison test after Kruskal–Wallis test, the number of days with milk and dairy products consumption was significantly larger in women whose weight gain during pregnancy was adequate than those with excess weight gain (p = 0.037).

Hierarchical logistic regression analysis found that the number of days with milk and dairy products consumption was a significant promoting factors for maternal adequate weight gain from 28 weeks gestation to delivery (OR=2.20 (95% CI=1.10–4.37)) and delivery of male baby was a significant restricting factors for that (OR=0.19 (95% CI =0.05–0.66)) (Table 2). The results of Hosmer–Lemeshow goodness-of-fit test showed that the model fit well to logistic function in both Step 1 and Step 2 (p = 0.348 and p = 0.286, respectively). Regarding parents’ smoking behaviors, odds ratios were not calculated because all the couples in “ade-
Table 1 Characteristics of mothers and their infants by maternal weight gain status from 28 weeks gestation to delivery during pregnancy

|                     | Adequate (n=24) | Insufficient (n=21) | Excess (n=31) | p value |
|---------------------|----------------|---------------------|---------------|---------|
| **Maternal weight gain status from 28 weeks gestation to delivery** |               |                     |               |         |
| Maternal weight gain status from 28 weeks gestation to delivery |               |                     |               |         |
| Adequate (n=24)     | 2 (8.3)        | 2 (9.5)             | 9 (29.0)      | 0.214 a |
| Insufficient (n=21) | 20 (83.3)      | 18 (85.7)           | 21 (67.7)     |         |
| Excess (n=31)       | 2 (8.3)        | 1 (4.8)             | 1 (3.2)       |         |
| Mean ± SD           | 33.3 ± 3.7     | 33.1 ± 2.9          | 32.5 ± 4.0    | 0.707 c |
| **BMI before pregnancy (kg/m²)** |               |                     |               |         |
| Low (< 18.5)        | 1 (4.2)        | 7 (33.3)            | 7 (22.6)      | 0.028 a *|
| Normal (18.5 − <25.0) | 22 (91.7)     | 14 (66.7)           | 20 (64.5)     |         |
| Obese (25.0≥)       | 1 (4.2)        | 0 (0.0)             | 4 (12.9)      |         |
| Mean ± SD           | 20.5 ± 2.1     | 20.0 ± 2.3          | 21.0 ± 2.9    | 0.378 c |
| **Parity**          |               |                     |               |         |
| Multipara           | 8 (33.3)       | 11 (52.4)           | 16 (51.6)     | 0.335 a |
| Primipara           | 16 (66.7)      | 10 (47.6)           | 15 (48.4)     |         |
| **Smoking**         |               |                     |               |         |
| No                  | 24 (100)       | 20 (95.2)           | 24 (77.4)     | 0.013 a *|
| Yes, but quit smoking after detecting a pregnancy | 0 (0) | 1 (4.8) | 7 (22.6) |         |
| **Husbands’ smoking** |             |                     |               |         |
| No smoking in front of wives | 24 (100) | 21 (100) | 27 (87.5) | 0.037 a *|
| Smoking in front of wives | 0 (0)  | 0 (0) | 4 (12.5) |         |
| **Infants**         |               |                     |               |         |
| **Sex**             |               |                     |               |         |
| Female              | 18 (75.0)      | 9 (42.9)            | 14 (45.2)     |         |
| Male                | 6 (25.0)       | 12 (57.1)           | 17 (54.8)     | 0.043 a *|
| **Birthweight (g)** |               |                     |               |         |
| <2,500              | 1 (4.2)        | 3 (14.3)            | 0 (0.0)       | 0.062 a |
| 2,500 − <4,000      | 23 (95.8)      | 18 (85.7)           | 31 (100.0)    |         |
| Mean ± SD           | 3018.4 ± 377.1 | 2967.6 ± 349.7     | 3180.7 ± 325.9| 0.119 b |
| **Length at birth (cm)** |           |                     |               |         |
| Mean ± SD           | 48.5 ± 1.6     | 48.6 ± 1.5          | 49.0 ± 1.6    | 0.455 b |
| **Gestational age (days)** |         |                     |               |         |
| <259 (37 weeks)     | 23 (95.8)      | 20 (95.2)           | 31 (100.0)    | 0.511 a |
| 259 (37 weeks) – <293 (41 weeks) | 1 (4.2) | 1 (4.8) | 0 (0.0) |         |
| Mean ± SD           | 275.8 ± 8.8    | 274.7 ± 6.9         | 276.0 ± 7.1   | 0.824 b |
| **Maternal dietary behavior** |       |                     |               |         |
| Consumption frequency of the meals consisted of at least 1 serving from each of Grain dish (staple), Fish or meat dish (main dish), and Vegetable dish (side dish) | 4.3 ± 1.6 | 4.0 ± 1.9 | 4.0 ± 1.9 |         |
| Median [the first quartile – the third quartile] | 4.0 [3.0–5.0] | 5.0 [3.0–5.0] | 4.0 [2.0–5.0] | 0.701 c |
| The number of days with milk and dairy products consumption out of three days | 2.6 ± 0.8 ¹ | 2.2 ± 1.0 | 2.0 ± 1.0 ¹ |         |
| Median [the first quartile – the third quartile] | 3.0 [2.25–3.0] | 3.0 [1.5–3.0] | 2.0 [1.0–3.0] | 0.037 c *|

* Fisher’s exact test
¹ One-way analysis of variance (ANOVA)
² Kruskal-Wallis test
³ p <0.05.
4 According to official recommendations in Japan, weight gains of 9 to 12kg and 7 to 12kg among women whose BMI before pregnancy were normal (18.5 − <25.0) and low (<18.5), respectively, were considered “adequate” and those outside of these ranges were considered “insufficient” or “excess”. For women whose BMI before pregnancy slightly exceeds 25.0 are recommended to gain about 5kg and those extremely exceeding 25.0 need individual advice from their obstetricians, considering other pre-existing risks. The same symbol, ¹, refers to the case of significant difference by multiple comparison test with Bonferroni correction at p <0.05.
Table 2 Hierarchical logistic regression analysis with maternal weight gain status during pregnancy\(^a\) as the dependent variable

|                          | Step 1 |                   | p value | Step 2 |                   | p value |
|--------------------------|--------|-------------------|---------|--------|-------------------|---------|
| **Control variables**    |        |                   |         |        |                   |         |
| Maternal age at delivery | 1.03   | 0.87–1.21         | 0.75    | 1.01   | 0.85–1.21         | 0.89    |
| Gestational age          | 1.02   | 0.94–1.10         | 0.64    | 1.00   | 0.93–1.09         | 0.94    |
| BMI before pregnancy     | 1.04   | 0.83–1.32         | 0.72    | 1.03   | 0.80–1.31         | 0.85    |
| Parity \(^b\)            |        |                   |         |        |                   |         |
| Primipara Reference      |        |                   |         |        |                   |         |
| Multipara                | 0.37   | 0.11–1.25         | 0.11    | 0.35   | 0.09–1.35         | 0.13    |
| Sex of the infant \(^c\) |        |                   |         |        |                   |         |
| Female Reference         |        |                   |         |        |                   |         |
| Male                     | 0.20   | 0.06–0.66         | **0.01**| 0.19   | 0.05–0.66         | **0.01**|
| **Independent variables**|        |                   |         |        |                   |         |
| Consumption frequency of the meals consisted of Grain dishes (staple), Fish or meat dishes (main dish), and Vegetable dishes (side dish) \(^d\) | 1.02 | 0.75–1.39 | **0.02** | 1.00 | 0.73–1.36 | 0.99 |
| Consumption frequency of milk and dairy products \(^e\) | 2.26 | 1.12–4.55 | **0.02** | 2.20 | 1.10–4.37 | **0.02** |
| Mother’s smoking \(^f\) | No smoking from pregnancy Reference | | | | | |
| Quit smoking after detecting a pregnancy | | | | | | |
| Father’s smoking \(^g\) | No smoking in front of their wives Reference | | | | | |
| No smoking in front of their wives | | | | | | |

OR, odds ratio; CI, confidence interval
\(^a\) Inadequate = 0, Adequate = 1
\(^b\) Primipara = 0, Multipara = 1
\(^c\) Female = 0, Male = 1
\(^d\) Consumption frequency of the meals consisted of at least 1 serving from each of Grain dish (staple), Fish or meat dish (main dish), and Vegetable dish (side dish) per day (0–9 times)
\(^e\) The number of days with milk and dairy products consumption out of three days (0–3 days)
\(^f\) Quit smoking after detecting a pregnancy=1, No smoking=0
\(^g\) Smoking in front of their wives=1, No smoking in front of their wives=0
\(\ast p < 0.05\)
\(\ast\ast p < 0.01\)

Odds ratio was not estimated because there was a cell that frequency was 0.
Hosmer–Lemeshow goodness-of-fit test: \(p = 0.348\) in Step 1, \(p = 0.286\) in Step 2

Table 3 Spearman’s rank correlation coefficients between detailed nutrient intake for one day and habitual intake (for three days)

| Energy or nutrients | Consumption frequency of the meals consisted of Grain dishes (staple), Fish or meat dishes (main dish), and Vegetable dishes (side dish) \(^a\) | Consumption frequency of milk and dairy products \(^b\) | \(r_s\) | \(p\) value | \(r_s\) | \(p\) value |
|--------------------|-------------------------------------------------------------------------------------------------|---------------------------------|--------|-------------|--------|-------------|
| Energy (kcal)      | 0.325                                                                                           | 0.004                           | **\(*) | --          | --     | --          |
| Protein (g)        | 0.392                                                                                           | 0.001                           | **\(*) | --          | --     | --          |
| Vitamin A (µgRAE)  | 0.261                                                                                           | 0.023                           | *      | --          | --     | --          |
| Vitamin D (µg)     | 0.088                                                                                           | 0.452                           | --     | --          | --     | --          |
| Vitamin E (µg)     | 0.267                                                                                           | 0.021                           | *      | --          | --     | --          |
| Vitamin K (µg)     | 0.221                                                                                           | 0.056                           | --     | --          | --     | --          |
| Vitamin B\(_1\) (µg) | 0.164                                             | 0.158                           | --     | --          | --     | --          |
| Vitamin B\(_2\) (µg) | 0.283                                             | 0.014                           | *      | --          | --     | --          |
| Niacin (mgNE)      | 0.198                                                                                           | 0.089                           | --     | --          | --     | --          |
| Vitamin B\(_12\) (µg) | 0.330                                             | 0.004                           | **\(*) | --          | --     | --          |
| Vitamin B\(_3\) (µg) | 0.213                                             | 0.067                           | --     | --          | --     | --          |
| Folic acid (µg)    | 0.252                                                                                           | 0.045                           | *      | --          | --     | --          |
| Pantothenic acid (mg) | 0.287                                             | 0.013                           | *      | --          | --     | --          |
| Vitamin C (mg)     | 0.246                                                                                           | 0.034                           | *      | --          | --     | --          |
| Calcium (mg)       | --                                                                                              | 0.399                           | <0.001 \(**) | -- | -- | -- |

\(r_s\), Spearman’s rank correlation coefficients
\(^a\) Consumption frequency of the meals consisted of at least 1 serving from each of Grain dish (staple), Fish or meat dish (main dish), and Vegetable dish (side dish) per day (0–9 times)
\(^b\) The number of days with milk and dairy products consumption out of three days (0–3 days)
\(\ast p < 0.05\)
\(\ast\ast p < 0.01\)
\(\ast\ast\ast p < 0.001\)
quate” group did not smoke (Table 2).

The relations between detailed nutrient intake for one day and habitual intake (consumption frequency for three days) were examined using Spearman’s rank correlation coefficients (Table 3). There were significant positive correlations between each of intake of energy, protein, and vitamins and consumption frequency of the meals consisted of at least 1 serving from each of Grain dish (staple), Fish or meat dish (main dish), and Vegetable dish (side dish), and between intake of calcium and the number of days with milk and dairy products consumption out of three days.

**IV. Discussion**

We collected dietary records from women with 28 weeks gestation, the beginning of the late pregnancy. Especially at this time, well-balanced diet is needed because of rapid growth of the fetus and increased risk of maternal complications. Fifty to eighty percent of women in early pregnancy have emesis gravidarum with anorexia, vomiting, or nausea. For these reasons, we conducted the dietary assessment at 28 weeks gestation.

According to the hierarchical logistic regression analysis, probability of having adequate weight gain was more than doubled when the number of days with milk and dairy products consumption increased one day. There are two possible reasons for this.

The first one is nutritional effects of milk and dairy products itself. Previous studies observed positive correlations between intake of dairy products and fetal femur length, and negative correlation between intake of milk and risk of IUGR. Besides, Heppe et al and Olsen et al reported that maternal intake of protein from milk was positively related to birth weight, while carbohydrate and fat from milk and nondairy protein were not. This association could not be explained by general protein effects, but the details are not yet known. On the other hand, a report that women who consumed six glasses of milk per day had a 59% higher odds ratio of large for gestational age (LGA) birth compared to women with no milk consumption implies that over consumption of milk is not good for appropriate fetal growth.

Another influence of milk itself is the effects of insulin–like growth factor–1 (IGF–1) which is known to give stimulating effect on fetal growth. Holmes et al and Giovannucci et al reported that high intake of milk, not red meat, increased serum IGF–1. Norat et al reported that high intake of milk and cheese increased serum IGF–1. However, there is no strong evidence that bovine IGF–1 from milk is absorbed by human and it is not clearly known how IGF–1 from milk and dairy products stimulates fetal growth.

Another nutritional effect of milk is increase in bone density. In previous studies of pregnant women in Japan, the bone density of the ribs (calcaneus stiffness) was significantly increased in those who had been drinking milk in the past and those who had increased intake of milk and dairy products during pregnancy. It is presumed that measurement of calcaneus stiffness is effective in capturing changes in bone in short term such as during pregnancy. Furthermore, high calcaneus stiffness increases calcium supply to the fetus and promote fetal growth. Milk and dairy products contain calcium that have higher intestinal absorption than green and yellow vegetables and small fish and are the major source of calcium. Therefore, we assume that sufficient calcium intake affected bone density and led to proper fetal growth.

The second possible reason is a good behavioral profile of women who frequently consume milk and dairy products. They might be health conscious and have healthy dietary behavior since researches show that it is hard to consume milk and dairy
products on a daily basis\textsuperscript{30, 34}. Milk and dairy products are often extracted as a component of “healthy diet” or “well-balanced diet” in Japan\textsuperscript{35-38}. Therefore, their overall good nutritional intake could contribute to their adequate weight gain during pregnancy.

Daily consumption of milk and dairy products may be more difficult than to eat the meals consisted of Grain dishes (staples), Fish or meat dishes (main dish), and Vegetable dishes (side dish) since traditional Japanese meals do not include them. When we incorporate milk and dairy products into our daily meals, it is necessary to make some extra efforts such as purchasing a cup of yogurt or a glass of milk in addition to a set menu at cafeteria, for example. In fact, the percentage of Japanese women who eat the meals consisted of Grain dishes (staples), Fish or meat dishes (main dish), and Vegetable dishes (side dish) twice a day and almost every day was 57.7\%\textsuperscript{14} while the percentages of Japanese women who consume milk and dairy products every day ranged 3.3\%\textsuperscript{30} to 42.2\%\textsuperscript{32}. This is why only the consumption frequency of milk and dairy products was a significant independent variable. It has a large between-person difference resulted from their awareness and dietary behavior\textsuperscript{39}.

A previous study showed that adequate maternal intakes of dairy products during the first half of pregnancy is related to reduce risk of small for age (SGA) infant\textsuperscript{40}. In our study, however, accurate dietary intakes in the early pregnancy was unknown because we requested to keep dietary records only in the late pregnancy.

The result of hierarchical logistic regression analysis shows that delivery of male baby was a significant restricting factors for maternal adequate weight gain from 28 weeks gestation to delivery. It may be because there are gender differences in the size of the placenta and the efficiency of nutrient utilization in the womb. Even if they are born with about the same birth weight, placenta of pregnant women expecting a boy is smaller than a girl\textsuperscript{41}. Previous studies report that boys are more susceptible to maternal diet and metabolism than girls\textsuperscript{41, 42}. If pregnant women have good dietary habit, boys are more likely to be born heavier than girls. Otherwise, the nutritional supply to the fetus may be reduced and may lead to give birth with low weight. For these reasons, boys tend to have greater birth weight swings than girls and may have led to this result. In this study, however, women who had “insufficient” or “excess” weight gain were grouped into “inadequate”. We could not clarify which delivery for male was associated with “inadequate” or “excessive” weight gain in pregnant women through hierarchical logistic regression analysis. Although this result was significant, we do not consider that because odds ratio was small (0.19).

There are several limitations in our study. First, we selected participants from only one hospital in Tokyo. Moreover, data of only 76 women with dietary records on three weekdays were used for the analyses. Thus, small sample of this study may not represent entire pregnant women in Japan. In fact, all the 76 participants in this study had never smoked before pregnancy or quit smoking after conception while smoking rate of Japanese pregnant women was 5.0\%\textsuperscript{43}. Second, only pregnant women whose weight gain status around 28 weeks gestation was “inadequate” were included in this study, and dietary records before individualized dietary education used for analyses. It is possible for us to underestimate their dietary intake if their dietary behavior was improved after the nutritional advice. Third, we could not clarify detailed amounts and kinds of foods consumed and could not calculate energy and nutrient intakes. Even between the women who had the same number of days with
dairy products consumption, nutritional intake might be different due to variation in amounts and kinds of dairy products they consumed. Regarding well-balanced diet, we only examined whether the participants consumed more than 1 serving from all of Grain dishes (staple), Fish or meat dishes (main dish), and Vegetable dishes (side dish). A validation study showed that two–day or more weighed dietary records were positively correlated with continuous seven–day records\(^4\). Although we collected three–day food records, we did not request them to weigh the foods. In order to grasp more accurate habitual nutrient intake of individuals, at least two–day records with weight measurement should have been conducted, although similar studies for Japanese pregnant women also used the same dietary assessment method as this study\(^45, 46\). We showed significant positive relations between detailed nutrient intake for one day and habitual intake by the Spearman’s rank correlation coefficients. Since the diet during pregnancy particularly affects the growth of the fetus, it is more important to assess habitual nutrient intake than detailed intake for one day. Although they are effective to grasp accurate and specific nutrient intake, weighed food record or duplicate method take a great deal of time and costs. Since our dietary assessment by food consumption frequency was correlated to quantitative assessment and reflected consumption of longer period, we considered it was a decent method from the viewpoint of time and cost as well. Fourth, BMI before pregnancy was calculated based on self–reported height and weight. However, according to a previous study, self–reported height and weight were more highly correlated with their measured ones in the middle–aged Japanese than in other countries\(^47\). Therefore, self–reported height and weight by the current participants could be also reliable. Fifth, parents’ smoking data was self–reported by mothers and we could not measure secondhand smoke by others. According to the National Health and Nutrition Survey in Japan\(^44\), it is possible that participants were exposed to secondhand smoke out of the house such as workplaces, restaurants, and the street. Even if husbands did not smoke, participants may have had the influence of passive smoking outside. Finally, we investigated three patterns of delivery: vaginal birth, vacuum extraction delivery, and cesarean delivery. We included cesarean cases which tend to be carried out when maternal obesity\(^48\), macrosomia\(^5\) and premature\(^49\) delivery could happen. In this study, however, we did not exclude cesarean cases because we did not know the reason of cesarean delivery.

V. Conclusions

Hierarchical logistic regression analysis showed that the probability of having adequate weight gain was doubled when the number of days with milk and dairy products consumption increases one day. Women who frequently consumed milk and dairy products might have health consciousness and good dietary behavior, and might have increase her calcaneus stiffness and that could be the reason for adequate weight gain during pregnancy. Further research is needed to understand how proteins and IGF–1 from milk and dairy products affect the growth of the fetus.

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Intake of milk and dairy products significantly contributes to maternal adequate weight gain in pregnant women after 28 weeks gestation

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和文抄録

近年の日本における平均出生体重は減少傾向にあり，低出生体重児の出産割合も OECD 諸国と比較して高い。出生年齢にあたる 20～30 歳代の女性は，やせの者割合，喫煙率，主食・主菜・副菜を組み合わせた食事を摂ることがほとんどない者の割合が多く，牛乳・乳製品の摂取量が少ない。そこで，妊娠中の食行動及び夫婦の喫煙状況と体重増加との関連を調べた。

2012 年 7 月～2013 年 8 月に都内 1 病院にて健診を受けた，合併症のない単胎妊娠の妊婦を対象とした。妊娠 15～20 週時点で適切な体重増加量を指導し，妊娠中の健康的な食事についてのリーフレットを 1 回配布した。その後，健診時に助産師が妊娠前の BMI に応じて設定された基準を使用して体重を評価し，簡単な食生活についての指導を行った。妊娠 28 週付近の体重増加が不十分または過剰であった 76 名を本研究の対象とし，3 日間の食事内容を記録するよう指示し，「主食・主菜・副菜の揃った食事を摂った回数 (0～9)」，「牛乳・乳製品を含む食事を摂った日数 (0～3)」を調べた。また，自記式アンケートと病院での問診で夫婦の喫煙状況を把握した。妊娠 28 週～出産までの体重増加量が不十分または過剰であった者を適切 (=0)，適切であった者を適切 (=1) としたダミー変数を従属変数にした階層的ロジスティック回帰分析によって，食事内容と喫煙の影響を調査した。

喫煙については「適切」の群は夫婦とも全員が禁煙していたためオッズ比を算出することができなかったが，牛乳・乳製品の摂取日数が多いと妊娠中の体重増加が適切であった（オッズ比=2.20（95%信頼区間=1.10–4.37））。牛乳・乳製品は胎児の成長を促進するたんぱく質や IGF-1 を含むほか，健康的な食事の要素とされている食品である。よって，牛乳・乳製品をよく摂取する者は食事に対する意識が高く，良い食習慣が身に付いていたと推察されることなどが適切な体重増加につながったと考えられる。