Original Article

Association between perception of pre-pregnancy body weight and nutritional status during pregnancy: A cross-sectional study

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Background and Objectives: Perception of body weight often affects dietary intake and biological nutrient concentrations. However, the association during pregnancy has not been clarified. This study examined the association of the perceived pre-pregnancy body weight with nutrient intake and circulating nutrient concentrations during pregnancy. **Methods and Study Design:** The cross-sectional study was conducted at a university hospital in Tokyo, Japan, from 2010 to 2014. Nutrient intake was assessed using a diet history questionnaire. The circulating concentrations of some nutrients were measured. The participants were divided into the following groups based on the perceived pre-pregnancy body weight: thin group (TG, n=174), average group (AG, n=357), and fat group (FG, n=220). Analysis of covariance was performed to compare the nutritional status among the groups. **Results:** Women in the AG had significantly higher energy-adjusted intake of important nutrients such as eicosapentaenoic acid, docosahexaenoic acid, total dietary fiber, calcium, iron, and folate compared with women in the TG or FG. Among women with pre-pregnancy normal body mass index (BMI), intakes of nutrients such as potassium, calcium, magnesium, and vitamin B_1 and the serum 25-hydroxyvitamin D and β-carotene concentrations were significantly lower in the FG than in TG or AG. Among women with pre-pregnancy underweight, no significant differences were found in the nutritional status between the groups. **Conclusions:** Pregnant Japanese women who overestimate their pre-pregnancy body weight despite having a normal BMI may need to have their nutritional status carefully assessed as a high-risk population for several nutrient deficiencies.

Key Words: body image, micronutrients, nutrient intake, pregnancy, pre-pregnancy body weight

INTRODUCTION

Body image has recently received attention as a key factor in dietary intake.[1] Body image includes multidimensional self-perceptions and self-attitudes toward one's outer appearance.[2] In particular, women of reproductive age are likely to have distorted body image such as overestimation of their own body weight and excessive desire for thinness.[3] A previous study reported that overestimation of pre-pregnancy body weight in women with normal body mass index (BMI) or underestimation of pre-pregnancy body weight in overweight or obese women is more likely to lead to excessive gestational weight gain.[4] Since gestational weight gain depends on energy balance, defined as a balance between energy intake and energy expenditure, the association between body image and weight change may be mediated by dietary intake. However, the association between pre-pregnancy body image and dietary intake during pregnancy has not yet been examined.

Most Japanese women of reproductive age are likely to overestimate their body weight and have a desire to be thinner even though their BMI is normal or falls within the underweight range.[5] This often causes unnecessary dietary restrictions.[5] A history of dietary restriction before pregnancy was reported to be associated with self-judged dietary restriction during pregnancy.[6] This association may be because women with negative body image before pregnancy have a hard time accepting the weight gain during pregnancy.[7] A Western study also reported that women of reproductive age who had a desire for thinness were more likely to engage in unhealthy eating habits, including overeating and restrictive diets.[8] Likewise, during pregnancy, body image may affect the meal amount and the diet quality. Generally, the attitude and intention of dietary intake and weight control change during pregnancy because most pregnant women try to improve the dietary environment for their fetuses.[9,10] However, a nega-

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tive body image, such as body weight overestimation and desire for thinness, potentially prevents pregnant women in obtaining a better dietary intake. Thus, focusing on pre-pregnancy body image could be required to identify those at higher risk of poor diet quality and inadequate energy intake during pregnancy. This study focused on the perceived pre-pregnancy body weight as a body image type, and aimed to elucidate whether it affected the nutrient intake and circulating nutrient concentrations during pregnancy among Japanese women.

METHODS

Study participants and settings

This cross-sectional study used secondary data from two cohort studies conducted between June 2010 and June 2012[11] and between March and October 2014.[12] The first cohort study aimed to evaluate the effects of dietary guidance on the nutritional status during pregnancy, while the second cohort study aimed to examine the association between dietary intake and pregnancy outcomes. Pregnant Japanese women at 19–23 weeks of gestation who visited the outpatient department for a medical checkup were recruited at a university hospital in Tokyo, Japan. Women aged <20 years, with multiple pregnancies, who developed pregnancy-related complications such as gestational diabetes mellitus and hypertensive disorders of pregnancy, with physical disorders that might affect their dietary behaviors, with mental disorders, with fetal abnormalities, and with a history of fetal or neonatal death were excluded.

Participants were provided with a questionnaire and were asked to answer the questionnaire while waiting for their checkups. Those who did not have sufficient time to complete the questionnaire in the hospital filled it out after returning home and submitted it by mail.

Variables and their measurement

The original questionnaire included demographic variables such as maternal age, parity, educational level, height, pre-pregnancy weight, presence of nausea or vomiting, and the use of supplements during the preceding 1-month period. Educational level was categorized as either high school/junior college/technical college degree or college/university degree. Pre-pregnancy BMI was calculated based on self-reported height and pre-pregnancy weight. The participants were classified as underweight (BMI <18.5 kg/m^2), normal BMI (18.5 ≤ BMI < 25.0 kg/m^2), and overweight or obesity (BMI ≥25.0 kg/m^2) based on the World Health Organization criteria.[13] Regular use of supplements was defined as the use of certain supplements four or more times per week. In addition, the participant's perception of pre-pregnancy body weight was determined using a single-choice question. The participants were asked to select their perceived pre-pregnancy body weight: thin, slightly thin, average, slightly fat, or fat. Women who perceived themselves as thin or slightly thin were assigned in the "thin group (TG)," those who perceived themselves as having an average body weight were assigned in the "average group (AG)," and those perceived themselves as slightly fat or fat were assigned in the "fat group (FG)."

We used a brief-type self-administered diet history questionnaire (BDHQ), which is a fixed-portion questionnaire, to assess nutrient intake in the previous month.[14] The estimated dietary intake of 58 selected food and beverage items was calculated using an *ad hoc* computer algorithm including the weighting factors in the BDHQ.[14] The consumption frequency of each item was determined using seven response options, ranging from "more than twice per day" to "almost never." The estimates from the BDHQ showed relatively high correlation coefficients with those from the 16-day dietary records in non-pregnant Japanese adults.[14] In addition, some of the nutrient intake estimates from the BDHQ were validated in pregnant Japanese women.[15,16] To reduce the effect of measurement errors, nutrient intake was adjusted for total energy intake using the nutrient density method.

We excluded participants who reported an extremely unrealistic energy intake from the analysis. Women with a reported energy intake of less than half the energy requirement for the lowest physical activity category (950 kcal/day for 20–29-year-old or 1000 kcal/day for 30–49-year-old) or more than 1.5 times the energy requirement for moderate physical activity (3300 kcal/day for 20–29-year-old or 3375 kcal/day for 30–49-year-old), according to the "Dietary Reference Intakes for Japanese," were excluded from the study.[17] Based on the criteria used in Sasaki et al,[18] the unrealistic energy intake criteria were determined.

The concentrations of plasma eicosapentaenoic acid (EPA), plasma docosahexaenoic acid (DHA), serum 25-hydroxyvitamin D (25(OH)D), serum folate, and serum β-carotene were measured in some participants who were recruited between June 2010 and June 2012. Non-fasting blood samples were drawn during routine blood tests at 19–23 weeks of gestation. Within 6 hours of blood collection, the blood samples were centrifuged for 10 minutes at 3,000 rpm to separate the serum and plasma, and then stored at −80°C until measurement. The plasma EPA and DHA concentrations were measured using a gas chromatograph. The serum folate concentrations were measured by chemiluminescent immunoassay using ADVIA Centaur® (Siemens AG Co.; Munich, Germany) with a Chemilumi ACS folate Ⅱ kit (Siemens Healthcare Diagnostics Co., Ltd.; Tokyo, Japan). The serum β-carotene concentrations were measured by high-performance liquid chromatography (HPLC). HPLC analysis was performed using a Waters HPLC system (Nihon Waters K.K., Japan). These assays were performed by Mitsubishi Kagaku Bio-Chemical Laboratories (Tokyo, Japan). The serum 25(OH)D concentrations were measured using a chemiluminescent immunoassay (LIAISON 25 OH Vitamin D TOTAL Assay; DiaSorin, Salugia, Italy) by Kyowa Medex Co., Ltd., Tokyo, Japan. This assay was used to monitor both vitamin D_2 and vitamin D_3 levels.

Ethical considerations

The study was approved by the Research Ethics Committee of Graduate School of Medicine and Faculty of Medicine, The University of Tokyo (no. 3197 and no. 10401). Each participant received oral and written information on the study protocol, the voluntary nature of their participation, and privacy considerations. Written informed consent was obtained from all the participants prior to the investigation.

Statistical analyses

The differences in demographic characteristics, nutrient intake, and circulating nutrient concentrations according to the perceived pre-pregnancy body weight were analyzed using one-way analysis of variance and post hoc Bonferroni tests for continuous variables and using the chi-square test for categorical variables. In addition, analysis of covariance was used to examine the differences in the energy-adjusted nutrient intake and circulating nutrient concentrations during pregnancy between the groups classified by the perceived pre-pregnancy body weight after adjusting for covariates. The covariates were chosen as variables that have previously been reported to affect the nutrient status during pregnancy:[19,20] age, parity, educational level, and pre-pregnancy BMI. In addition, regular use of supplements was adjusted for in the analyses of circulating concentrations. All statistical analyses were conducted using the Statistical Package for Social Science software (version 24.0; IBM Corp., Armonk, NY, USA). The differences were considered significant when the two-tailed p-value was <0.05.

RESULTS

Of 890 healthy pregnant women who were eligible, 819 (92.0%) agreed to participate in the study. A total of 784 women (88.1%) completed the questionnaire. After excluding 33 women with unrealistically low energy intake (n=26) and missing data (n=7), 751 women (84.4%) were analyzed. Among the participants, the plasma EPA and DHA concentrations of 210 women, serum 25(OH)D concentrations of 251 women, serum folate concentrations of 181 women, and serum β-carotene concentrations of 95 women were measured.

Table 1 presents the characteristics of the participants. A total of 174 women (23.2%) perceived their pre-pregnancy body weight as thin, 357 (47.5%) as average, and 220 (29.3%) as fat. The perceived pre-pregnancy body weight was significantly associated with pre-pregnancy BMI (p<0.001).

The differences in the nutrient intake between the three groups classified by the perceived pre-pregnancy body weight are shown in Table 2. Women in the AG had significantly higher levels of n-3/n-6 polyunsaturated fatty acids (p=0.030) and higher energy-adjusted intake of EPA (p=0.018), DHA (p=0.022), total dietary fiber (p=0.036), potassium (p=0.016), calcium (p=0.017), magnesium (p=0.024), phosphorus (p=0.035), iron (p=0.034), vitamin B_1 (p=0.025), vitamin B_2 (p=0.024), vitamin B_6 (p=0.031), vitamin B_{12} (p=0.044), and folate (p=0.039) compared with women in the TG or FG, after adjusting for covariates. On the contrary, no significant associations of pre-pregnancy BMI with important nutrient intake were found (data not shown).

Table 3 shows the differences in the nutrient intake between the groups classified by the perceived pre-pregnancy body weight in women with pre-pregnancy underweight and normal BMI, after adjusting for covariates. In participants with pre-pregnancy normal BMI, the FG had significantly lower energy-adjusted intakes of potassium (p=0.031), calcium (p=0.010), magnesium (p=0.044), phosphorus (p=0.024), vitamin B_1 (p=0.043), and vitamin B_2 (p=0.010) compared with the TG or AG. Daily intake of protein was also associated with the perceived pre-pregnancy body weight (TG, 56.7±16.0 g/day; AG, 61.2±16.7 g/day; FG, 57.3±18.3 g/day; p=0.019). By contrast, the daily intake of lipids and carbohydrates was not associated with the perceived pre-pregnancy body weight (p=0.205 and p=0.312, respectively; data not shown). In women with pre-pregnancy underweight, no difference was found in the energy-adjusted nutrient intake according to the perceived pre-pregnancy body weight, except for sodium intake (p=0.007). We could not analyze women with pre-pregnancy overweight or obesity, since all of them perceived their pre-pregnancy body weight as fat.

Serum β-carotene and plasma DHA concentrations were significantly associated with the perceived pre-pregnancy body weight, after controlling for covariates (p=0.001 and p=0.034, respectively; Table 4). In women with pre-pregnancy normal BMI, the serum 25(OH)D and serum β-carotene concentrations were significantly lower in the FG than in the other groups (p=0.029 and p=0.002, respectively). In women with pre-pregnancy underweight, no associations were observed between the perceived body weight and circulating nutrient concentrations (data not shown). Pre-pregnancy BMI was not associated with any circulating nutrient concentrations (data not shown).

DISCUSSION

This study clarified that the perception of pre-pregnancy body weight as fat was associated with lower energy-adjusted intake and circulating concentrations of several nutrients during pregnancy. Notably, the association was observed despite the absence of an association between pre-pregnancy BMI and nutritional status during pregnancy. In addition, among pregnant Japanese women with pre-pregnancy normal BMI, perception of pre-pregnancy body weight as fat, that is, weight overestimation was associated with lower energy-adjusted intake of essential nutrients such as potassium, calcium, and magnesium and lower circulating concentrations of 25(OH)D and β-carotene. These findings indicate that it is important to understand women's perception of pre-pregnancy body weight when providing nutritional guidance during pregnancy.

Contrary to our expectation, energy intake, which is related to weight control during pregnancy, was not associated with the perceived pre-pregnancy body weight in our study. Our finding would support the result of Hayashi et al,[7] which indicated that the perceived pre-pregnancy body weight was not related to gestational weight gain among Japanese women. On the other hand, women who overestimate their pre-pregnancy body weight might attempt to practice unnecessary dietary restrictions during pregnancy, which would be more likely to lead to lower essential micronutrient intake, as shown in this study. This difference in micronutrient intake due to perceived pre-pregnancy weight was seen in energy-adjusted intake, suggesting that underreporting had little effect on the results. Women who overestimated their pre-pregnancy body weight could have decreased intake of meat, dairy

Table 1. Participant characteristics

		Perceived pre-pregnancy body weight			F	*p*
	All participants (n=751)	Thin (n=174)	Average (n=357)	Fat (n=220)		
	Mean±SD or n (%)	Mean±SD or n (%)	Mean±SD or n (%)	Mean±SD or n (%)		
Age (year)	34.9±4.2	34.6±4.0	34.7±4.0	34.9±4.5	2.585	0.076†
Gestational age (weeks)	19.5±2.1	19.8±2.0	19.4±2.2	19.5±2.1	1.324	0.267†
Parity: Primipara (n (%))	285 (37.9)	58 (33.3)	138 (38.7)	89 (40.5)		0.327‡
Educational level (n (%))						0.621‡
University or above	448 (59.7)	108 (62.1)	214 (59.9)	126 (57.3)		
Junior/technical college or high school	303 (40.3)	66 (37.9)	143 (40.1)	94 (42.7)		
Height (cm)	159±5	160±6	160±5	158±5	4.030	0.018†
Pre-pregnancy weight (kg)	52.2±7.5	46.4±4.1	50.8±4.4	59.1±8.4	251.808	<0.001†
Pre-pregnancy BMI (kg/m^2)	20.6±2.7	18.2±1.0	19.9±1.2	23.5±2.9	446.924	<0.001†
Underweight (<18.5 kg/m^2)	147 (19.6)	112 (64.4)	35 (9.8)	0 (0.0)		<0.001‡
Normal weight (18.5–24.9 kg/m^2)	554 (73.8)	62 (35.6)	322 (90.2)	170 (77.3)		
Overweight (>25.0 kg/m^2)	50 (6.7)	0 (0.0)	0 (0.0)	50 (22.7)		
Weight in the second trimester (kg)	54.9±7.6	49.3±4.4	53.5±4.9	61.6±8.4	214.909	<0.001†
BMI in the second trimester (kg/m^2)	21.6±2.8	19.4±1.3	21.0±1.5	24.5±2.9	369.332	<0.001†
Underweight (<18.5 kg/m^2)	49 (6.6)	38 (22.5)	11 (3.1)	0 (0.0)		<0.001‡
Normal weight (18.5–24.9 kg/m^2)	607 (82.1)	131 (77.5)	338 (96.3)	138 (63.0)		
Overweight (>25.0 kg/m^2)	83 (11.2)	0 (0.0)	2 (0.6)	81 (37.0)		
Smoking (n (%))	6 (1.2)	1 (0.6)	2 (0.6)	3 (1.4)		0.535‡
Nausea /vomiting (n (%))	212 (28.4)	44 (25.3)	95 (27.0)	73 (33.2)		0.162‡
Regular supplementation§ (n (%))						
Iron	189 (25.2)	47 (27.0)	92 (25.8)	50 (22.7)		0.583‡
Vitamin B complex	164 (21.9)	42 (24.1)	80 (22.4)	42 (19.2)		0.469‡
Folic acid	344 (45.8)	85 (48.9)	161 (45.1)	98 (44.5)		0.650‡
Vitamin C	82 (10.9)	25 (14.4)	36 (10.1)	21 (9.5)		0.245‡

BMI: body mass index; SD: standard deviation.
†One-way analysis of variance.
‡Chi-square test.
§Regular supplementation was defined as taking supplements four or more times per week.

Table 2. Differences in the energy-adjusted nutrient intake between the groups classified by the perceived pre-pregnancy body weight

	Perceived pre-pregnancy body weight			ANOVA†		ANCOVA¶	
	Thin (n=174)	Average (n=357)	Fat (n=220)				
	Mean±SD	Mean±SD	Mean±SD	F	*p*	F	*p*
Energy (kcal/day)	1560±351	1591±363	1540±401	1.341	0.262	1.319	0.268
Protein (% energy)	15.0±2.2	15.3±2.4	14.8±2.5	2.776	0.063	2.832	0.060
Lipid (% energy)	29.1±4.5	29.1±4.6	28.9±5.0	0.162	0.851	0.657	0.519
PUFA (% energy)	6.85±1.28	6.92±1.32	6.91±1.36	0.153	0.858	0.495	0.610
n-3 PUFA (% energy)	1.26±0.31	1.31±0.36	1.27±0.32	1.861	0.156	2.293	0.102
n-6 PUFA (% energy)	5.57±1.05	5.58±1.07	5.62±1.12	0.132	0.876	0.402	0.669
n-3/n-6	0.23±0.05	0.24±0.06	0.23±0.04	3.311	0.037	3.531	0.030
EPA (% energy)	0.11±0.07	0.13±0.08	0.11±0.07	3.857	0.022‡,§	4.059	0.018
DHA (% energy)	0.20±0.10	0.22±0.12	0.20±0.10	3.656	0.026‡,§	3.837	0.022
Carbohydrate (% energy)	55.2±5.5	54.9±5.8	55.5±6.2	0.693	0.500	0.830	0.437
Total dietary fiber (g/1000 kcal)	7.43±2.00	7.59±1.91	7.14±2.13	3.457	0.032§	3.341	0.036
Sodium (mg/1000 kcal)	2232±402	2320±448	2283±451	2.418	0.090	2.995	0.051
Potassium (mg/1000 kcal)	1491±351	1511±345	1428±355	4.756	0.021§	4.165	0.016
Calcium (mg/1000 kcal)	329±94	334±94	312±95	3.726	0.025§	4.080	0.017
Magnesium (mg/1000 kcal)	136±28	139±28	133±29	3.195	0.042§	3.758	0.024
Phosphorus (mg/1000 kcal)	573±98	589±102	565±107	3.080	0.047§	3.365	0.035
Iron (mg/1000 kcal)	4.32±0.98	4.44±0.95	4.25±1.01	2.869	0.057	3.395	0.034
Zinc (mg/1000 kcal)	4.53±0.55	4.57±0.59	4.48±0.57	1.511	0.221	1.752	0.174
Copper (mg/1000 kcal)	0.64±0.10	0.65±0.10	0.63±0.10	1.398	0.248	1.831	0.161
Vitamin D (μg/1000 kcal)	5.90±3.34	6.57±4.24	5.99±3.78	2.350	0.096	2.510	0.082
α-tocopherol (mg/1000 kcal)	4.56±0.88	4.64±0.90	4.48±0.96	2.057	0.129	2.170	0.115
Vitamin B_1 (mg/1000 kcal)	0.48±0.08	0.48±0.08	0.46±0.08	4.122	0.017§	3.701	0.025
Vitamin B_2 (mg/1000 kcal)	0.72±0.15	0.73±0.10	0.70±0.10	3.379	0.035§	3.761	0.024
Vitamin B_6 (mg/1000 kcal)	0.70±0.15	0.71±0.15	0.67±0.15	3.462	0.024§	3.475	0.031
Vitamin B_{12} (μg/1000 kcal)	4.04±1.63	4.46±2.16	4.17±1.96	2.997	0.051	3.131	0.044
Folate (μg/1000 kcal)	195±65	200±62	187±64	2.802	0.061§	3.265	0.039
Vitamin C (mg/1000 kcal)	76.1±29.8	77.0±30.5	71.6±27.5	2.373	0.094	2.160	0.116
β-carotene (μg/1000 kcal)	2255±1286	2313±1209	2108±1342	1.805	0.165	2.255	0.106

DHA: docosahexaenoic acids; EPA: eicosapentaenoic acids; PUFA: polyunsaturated fatty acid; SD: standard deviation.
†One-way analysis of variance and post hoc Bonferroni tests.
‡A significant difference between "Thin" vs "Average".
§A significant difference between "Average" vs "Fat".
¶Analysis of covariance. Adjusted for age, parity (1: multipara; 0: primipara), education levels (1: university or above, 0: others), and pre-pregnancy body mass index (1: underweight, 2: normal body mass index, 3: overweight).

Table 3. Differences in the energy-adjusted nutrient intake between the groups classified by the perceived pre-pregnancy body weight of women with pre-pregnancy underweight and normal body mass index

	Pre-pregnancy underweight (n=147)						Pre-pregnancy normal body mass index (n=554)						
	Perceived pre-pregnancy weight		ANOVA[†]		ANCOVA[§]		Perceived pre-pregnancy weight			ANOVA[†]		ANCOVA[§]	
	Thin (n=112)	Average (n=35)	F	*p*	F	*p*	Thin (n=62)	Average (n=322)	Fat (n=170)	F	*p*	F	*p*
	Mean±SD	Mean±SD					Mean±SD	Mean±SD	Mean±SD				
Energy (kcal/day)	1583±358	1487±334	1.981	0.161	2.528	0.114	1516±340	1602±365	1548±417	1.996	0.137	2.158	0.117
Protein (% energy)	15.0±2.1	15.4±3.1	0.511	0.460	0.651	0.421	14.9±2.4	15.3±2.3	14.8±2.3	2.814	0.061	2.902	0.056
Lipid (% energy)	29.3±4.24	29.2±4.3	0.034	0.855	0.001	0.971	28.7±5.0	29.1±4.6	29.3±4.9	0.332	0.718	0.447	0.640
PUFA (% energy)	6.93±1.20	6.76±1.48	0.447	0.505	0.329	0.567	6.74±1.42	6.94±1.30	6.96±1.34	0.684	0.505	0.857	0.425
n-3 PUFA (% energy)	1.27±0.28	1.30±0.36	0.170	0.681	0.301	0.584	1.24±0.36	1.32±0.36	1.28±0.31	1.417	0.243	1.631	0.197
n-6 PUFA (% energy)	5.63±1.01	5.44±1.19	0.893	0.346	0.755	0.387	5.47±1.13	5.60±1.06	5.66±1.11	0.704	0.495	0.838	0.433
n-3/n-6	0.23±0.04	0.24±0.05	1.754	0.187	2.063	0.153	0.23±0.05	0.24±0.06	0.23±0.04	2.291	0.102	2.431	0.089
EPA (% energy)	0.11±0.06	0.14±0.08	2.756	0.099	2.986	0.086	0.11±0.08	0.13±0.08	0.11±0.07	2.449	0.087	2.587	0.076
DHA (% energy)	0.20±0.10	0.23±0.11	2.571	0.111	2.699	0.103	0.20±0.12	0.22±0.12	0.20±0.10	2.412	0.091	2.532	0.080
Carbohydrate (% energy)	54.9±5.2	55.0±6.6	0.015	0.902	0.007	0.933	55.7±6.2	54.9±5.7	55.2±6.1	0.534	0.587	0.640	0.528
Total dietary fiber (g/1000 kcal)	7.37±1.85	7.69±1.90	0.762	0.384	0.786	0.377	7.51±2.25	7.58±1.91	7.18±2.21	2.217	0.110	2.363	0.095
Sodium (mg/1000 kcal)	2232±351	2435±475	7.500	0.007	7.384	0.007	2233±487	2308±444	2283±458	0.748	0.474	0.839	0.433
Potassium (mg/1000 kcal)	1468±331	1519±372	0.586	0.445	0.639	0.425	1528±386	1511±342	1432±357	3.283	0.038	3.512	0.031
Calcium (mg/1000 kcal)	325±86	349±128	1.594	0.209	1.716	0.192	337±108	333±89	308±90	4.544	0.011[‡]	4.648	0.010
Magnesium (mg/1000 kcal)	135±25	139±31	0.763	0.384	0.742	0.390	138±31	139±27	133±28	3.010	0.050	3.150	0.044
Phosphorus (mg/1000 kcal)	577±95	589±119	0.269	0.605	0.513	0.475	566±104	589±101	562±99	3.622	0.027[‡]	3.778	0.024
Iron (mg/1000 kcal)	4.28±0.88	4.38±0.88	0.375	0.542	0.403	0.526	4.36±1.15	4.45±0.96	4.22±1.02	2.860	0.058	2.932	0.054
Zinc (mg/1000 kcal)	4.54±0.53	4.49±0.78	0.205	0.651	0.075	0.785	4.50±0.60	4.58±0.57	4.47±0.53	2.204	0.111	2.252	0.106
Copper (mg/1000 kcal)	0.64±0.10	0.63±0.09	0.128	0.721	0.182	0.670	0.64±0.10	0.65±0.10	0.63±0.10	2.030	0.132	2.056	0.129
Vitamin D (μg/1000 kcal)	5.79±2.83	6.93±4.10	3.481	0.064	3.736	0.055	6.09±4.15	6.53±4.26	5.86±3.64	1.574	0.208	1.688	0.186
α-tocopherol (mg/1000 kcal)	4.50±0.81	4.68±0.90	1.175	0.280	1.606	0.207	4.66±1.00	4.64±0.89	4.57±0.95	0.384	0.681	0.465	0.629
Vitamin B_1 (mg/1000 kcal)	0.47±0.08	0.47±0.07	0.003	0.953	0.036	0.850	0.48±0.09	0.48±0.08	0.46±0.08	2.925	0.055	3.167	0.043
Vitamin B_2 (mg/1000 kcal)	0.72±0.14	0.75±0.18	0.891	0.347	0.896	0.346	0.72±0.17	0.73±0.15	0.69±0.14	4.740	0.009[‡]	4.682	0.010
Vitamin B_6 (mg/1000 kcal)	0.70±0.14	0.70±0.14	0.010	0.921	0.053	0.818	0.70±0.16	0.71±0.15	0.68±0.16	2.384	0.093	2.525	0.081
Vitamin B_{12} (μg/1000 kcal)	4.06±1.54	4.63±2.04	3.088	0.081	3.391	0.068	4.01±1.82	4.44±2.18	4.19±2.01	1.556	0.212	1.572	0.208
Folate (μg/1000 kcal)	192±60	202±61	0.772	0.381	0.872	0.352	200±73	200±62	186±65	2.739	0.066	2.902	0.056
Vitamin C (mg/1000 kcal)	73.7±27.3	82.0±40.9	1.908	0.169	1.929	0.167	80.2±34.1	76.4±29.1	72.3±28.0	1.964	0.141	2.211	0.111
β-carotene (μg/1000 kcal)	2123±1141	2214±1504	0.143	0.706	0.231	0.631	2465±1490	2330±1177	2161±1431	1.546	0.214	1.708	0.182

DHA: docosahexaenoic acids; EPA: eicosapentaenoic acids; PUFA: polyunsaturated fatty acid; SD: standard deviation.

[†]One-way analysis of variance and post hoc Bonferroni tests.

[‡]A significant difference between “Average” vs “Fat”.

[§]Analysis of covariance. Adjusted for age, parity (1: multipara; 0: primipara), and education levels (1: university or above, 0: others).

Table 4. Differences in the circulating nutrient concentrations between the groups classified by the perceived pre-pregnancy body weight

	All participants								Pre-pregnancy normal body mass index							
	Perceived pre-pregnancy body weight						ANCOVA[†]		Perceived pre-pregnancy body weight						ANCOVA[‡]	
	Thin		Average		Fat				Thin		Average		Fat			
	n	Mean±SD	n	Mean±SD	n	Mean±SD	F	*p*	n	Mean±SD	n	Mean±SD	n	Mean±SD	F	*p*
EPA (μg/mL)	39	33.1±23.0	103	30.2±20.7	68	29.2±16.5	0.580	0.561	19	32.9±20.6	92	30.2±20.7	53	28.4±16.8	0.500	0.607
DHA (μg/mL)	39	142±33	103	127±35	68	139±36	3.443	0.034	19	139±33	92	127±35	53	136±37	1.292	0.278
25(OH) D (ng/mL)	51	9.8±3.8	123	10.8±5.2	76	9.5±4.4	3.025	0.050	25	10.0±3.3	110	10.8±5.3	57	9.0±3.8[††]	3.617	0.029
Folate (ng/mL)	36	10.1±4.2	95	10.7±4.7	61	10.0±5.1	0.959	0.385	17	10.6±4.5	85	10.6±4.8	47	9.6±4.4	1.564	0.213
β-carotene (μg/dL)	17	54.9±21.7	52	40.0±16.6	26	28.4±15.5[§, ¶, ††]	7.745	0.001	10	52.3±18.2	47	39.9±16.6	20	29.1±16.9[¶]	6.858	0.002

DHA: docosahexaenoic acids; EPA: eicosapentaenoic acids; SD: standard deviation; 25(OH)D: 25-hydroxyvitamin D.
[†]Analysis of covariance. Adjusted for age, parity (1: multipara; 0: primipara), education levels (1: university or above, 0: others), pre-pregnancy body mass index (1: underweight, 2: normal BMI, 3: overweight), corresponding dietary intake, and regular supplement use.
[‡]Adjusted for age, parity (1: multipara; 0: primipara), education levels (1: university or above, 0: others), corresponding nutrient intake, and regular supplement use.
[§]Bonferroni test, a significant difference between "Thin" and "Average".
[¶]Bonferroni test, a significant difference between "Thin" and "Fat".
[††]Bonferroni test, a significant difference between "Average" and "Fat".

products, and pulses, which contain nutrients associated with the perceived pre-pregnancy body weight. Previous studies on non-pregnant women indicated that women who overestimated their body weight had lower intake of certain foods, such as fast foods, fried foods, staple foods, and sugar-sweetened beverages.[5,21,22] While these studies showed a decrease in foods and beverages that are harmful to health or contribute to weight gain, our study with pregnant women found a decrease in the intake of nutrients that provide health benefits during pregnancy rather than harm. We speculate that the differences in the types of foods reduced may be influenced by food preferences, appetites, and psychological backgrounds during pregnancy. For instance, many pregnant women experience food cravings that are difficult to control due to the hormonal changes during pregnancy.[23] Common cravings include fast foods and sweets. Since it is difficult to decrease the intake of these foods, it is possible that the intake of other foods may have been restricted. Thus, dietary characteristics specific to pregnant women might have influenced the differences in the results between non-pregnant and pregnant women. Although it is unclear whether the dietary restrictions on certain foods in pregnant women who overestimate their pre-pregnancy body weight are conscious or unconscious, healthcare professionals will need to consider the possibility that the perceived pre-pregnancy body weight may affect the intake of important nutrients.

One of the notable findings in this study was that the overestimation of pre-pregnancy body weight in women with normal BMI was associated with lower circulating concentrations of 25(OH)D and β-carotene. In particular, the mean 25(OH)D concentration of women who overestimated pre-pregnancy body weight was below the criteria for severe deficiency (10ng/mL), although it was higher than the criteria for severe deficiency in other women. Deficiency of such important nutrients increases the risk of adverse pregnancy outcomes. Maternal vitamin D deficiency leads to increased risks of preterm birth,[24] gestational diabetes mellitus,[25] and preeclampsia.[26] β-carotene concentrations are positively associated with fetal bone development.[27] Women with pre-pregnancy normal BMI who overestimate pre-pregnancy body weight might need to be carefully evaluated for these nutrient deficiencies as a high-risk population. However, the effects of the perceived pre-pregnancy body weight on the nutrient intake and circulating nutrient concentrations were inconsistent, with no differences in the vitamin D and β-carotene intakes according to the perceived body weight but significant differences in the circulating nutrient concentrations. One possible reason of the different results between nutrient intake and circulating concentrations is that the time period covered by the diet history questionnaire does not correspond to the time period in which circulating concentrations reflect the dietary intake. For example, the circulating 25(OH)D concentrations reflect the dietary intake over a longer period of time than that of the previous month assessed using the dietary questionnaire, which was used in the current study. In addition, the 25(OH)D concentrations reflect not only the vitamin D intake (vitamin D2+D3) but also the vitamin D3 produced in the skin after exposure to sunlight. Thus, the associations of perceived body weight with nutrient intake and circulating concentrations may have different results. However, both of these results will need to be considered in identifying women at high risk for inadequate nutritional status during pregnancy and in providing more effective nutritional guidance. In particular, women with normal BMI who overestimate their pre-pregnancy body weight should be noted as high risk for inadequate nutritional status.

This study has four limitations. First, the participants were asked about their perception of pre-pregnancy body weight during the second trimester. Hence, recall bias may have affected the results. Second, women who feel fat tended to underreport their dietary intake.[28] However, we used the energy-adjusted nutrient intake as an indicator to reduce the influence of underreporting on the results.[29] Third, pre-pregnancy body weight was self-reported and may differ from the actual weight. Nevertheless, we speculated that such differences would be relatively small because a strong correlation between self-reported and measured weight has been previously reported in Japanese women.[30] Fourth, the number of participants whose circulating nutrient concentrations were measured was small; thus, this might have limited the study's statistical power.

Conclusion

Nutrient intake during pregnancy was affected by the perceived pre-pregnancy body weight. In particular, overestimation of pre-pregnancy body weight was associated with lower intake and circulating concentrations of some important nutrients among pregnant Japanese women with pre-pregnancy normal BMI. For better nutritional status during pregnancy, healthcare professionals should provide nutritional guidance, taking into consideration women's perception of pre-pregnancy body weight.

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AUTHOR DISCLOSURES

The authors declare that they have no conflicts of interest.

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