

Relationship between body mass index and course of pregnancy in women

(妊婦の Body Mass Index と妊娠経過との関連)

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Table of contents

Abbreviations and acronyms.....	2
Introduction.....	3
Materials and methods.....	5
Results.....	7
Discussion.....	17
Conclusion.....	19
Acknowledgments.....	20
References.....	21
Japanese Abstract.....	23

Abbreviations and Acronyms

ANOVA: 分散分析 (analysis of variance)

BMI: 体格指数 (Body Mass Index)

DOHaD: 生活習慣病胎児期発症起源説 (developmental origins of health and disease)

FFQg : 食物摂取頻度調査 (Food Frequency Questionnaire Based on Food Groups)

GDM: : 妊娠糖尿病 (Gestational Diabetes Mellitus)

PFC: 脂質・タンパク質・炭水化物 (Protein・Fat・Carbohydrate)

SD: 標準偏差 (standard deviation)

Introduction

Suitable weight control during pregnancy is very important for the health of both the pregnant woman and her baby. Previous studies have reported that the amount of weight gained during pregnancy and the pre-pregnancy body mass index (BMI) can influence pregnancy, delivery, and newborn health ¹⁻⁴). For example, excess weight gain during pregnancy is associated with increased risk of hypertensive disorders, cesarean delivery, and large-for-gestational-age neonates ⁵). Being underweight before pregnancy increases the risk of having small-for-gestational-age and low-body-weight babies, whereas being overweight or obese before pregnancy increases the risk of having large-for-gestational-age babies with high birth weight or macrosomia, as well as the risk of subsequent overweight or obesity in these children when they reach adulthood ⁶). Children who are malnourished in utero or born underweight have a high probability of developing obesity, diabetes, lipid abnormalities, hypertension, and metabolic syndrome in adulthood; this is an example of “DOHaD” (the developmental origins of health and disease) ⁷). These findings indicate that the dietary status of pregnant women is reflected in the future health of their children. Therefore, nutritional management and weight management before pregnancy—not just during pregnancy—are important.

In Japan, weight control in pregnant woman is guided by charts released by the Ministry of Health, Labour, and Welfare for appropriate weight increase in pregnancy ⁸). Actual intakes of nutrients by pregnant women are probably less than the recommended values. One study has shown that the diets of 39.6% of Japanese pregnant women do not meet the recommended criteria ⁹). Recent Japanese data show that over 20% of young women are underweight (body mass index [BMI] <18.5 kg/m²), possibly because of the strong desire among contemporary young women to be thin ¹⁰). Although nutritional education on weight gain restriction has been undertaken in many Japanese hospitals or clinics following the recommendation charts, very few studies have been done on the adverse effects of excessive maternal weight gain on pregnancy outcome.

We attempted to clarify objectively the nutritional status of pregnant women by using the Food Frequency Questionnaire Based on Food Groups (FFQg), which can estimate daily dietary intake. Our aim was to evaluate the women's nutritional status and elucidate any associated problems; we also aimed to help reduce the incidence of abnormal outcomes of pregnancy by elucidating the relationship between nutritional status and course of pregnancy.

Materials and methods

Study design and subjects

This study was part of a prospective study. The FFQg question sheet was distributed to 223 pregnant women at 12 weeks gestation who attended one obstetrics clinic in the city of Hirosaki, in northern Honshu, between July 2011 and June 2012. We observed the women's statuses until delivery, and we obtained information on pregnancy, delivery, and newborn from medical records.

Dietary assessment and calculation of nutrient intakes

Dietary intake was assessed by using FFQg Ver. 3.0, developed by Yoshimura (Kenpaku-sha, Tokyo, Japan)¹¹⁾. The FFQ has been widely used for epidemiological purposes because it satisfies the above conditions¹²⁾. The FFQg can be used to estimate daily meal content from easy questions covering 29 food groups and 10 kinds of cooking method. In this established semiquantitative questionnaire, subjects state their frequency of intake (i.e. food frequency) and amount of food intake (i.e. portion size) over a period of 1 week in 1 or 2 recent months. The established software "Excel-eiyokun" Ver. 5.0 and FFQg Ver. 3.0 (Kenpaku-sha, Tokyo, Japan)¹³⁾ was used to calculate daily intakes of nutrients from foods. This method has been shown in Japan to be reliable and valid¹⁴⁾.

Statistical analysis

Data were expressed as means \pm standard deviation (SD). Differences between groups were tested for statistical significance by using Student's t-test, or one-way ANOVA and multiple comparison. All data analyses were performed with IBM SPSS statistics 19 on a Windows operating system. A P-value of less than 0.05 was considered statistically significant.

Ethical approval

All procedures were approved by the Ethics Committee of Hirosaki University, and informed consent was obtained from all participants.

Results

Overall characteristics of participants

Two hundred and twenty-three participants completed the FFQg and were included in the validation study. Tables 1 and 2 show the patient characteristics. Participants ranged in age from 18 to 41 years, with a mean age of 29.6 ± 4.4 years. Mean \pm SD height was 158.9 ± 5.4 cm, pre-pregnancy body weight was 52.0 ± 7.4 kg, and pre-pregnancy BMI was 20.5 ± 2.6 kg/m². Mean \pm SD weight gain during pregnancy was 9.5 ± 3.1 kg, length of gestation was 39.1 ± 7.4 weeks, and infant birth weight was 3119.7 ± 364.6 g.

The women were classified by pre-pregnancy BMI as follows: 44 (19.7%) were underweight (BMI <18.5 kg/m²), 164 (73.5%) were of normal weight (BMI 18.5–24.9 kg/m²), and 15 (6.7%) were overweight (BMI ≥ 25.0 kg/m²). Ninety-seven (43.5%) were primiparous and 126 (56.5%) were multiparous; 173 (79.7%) had spontaneous deliveries, 24 (11.0%) had vacuum-assisted deliveries, and 19 (8.8%) had cesarean deliveries. The average infant birth weight was significantly lighter in the underweight group than in the normal group ($P < 0.05$) (Figure 1.).

Outcomes

One hundred and forty-seven women (65.9%) had uneventful pregnancies. Thirteen subjects (5.8%) were hospitalized for threatened premature delivery, 11 (8.9%) for impaired glucose tolerance, and 2 (0.9%) for other problems. Two (0.9%) subjects had pregnancy-induced hypertension syndrome. Twelve (5.4%) required emergency transport; 18 (8.1%) were transferred to other hospitals by the reasons at their own request or because of the need for particular medical procedures, and 15 (6.7%) returned to their home towns for delivery.

To investigate the relationship between pre-pregnancy weight and outcome, pre-pregnancy BMI was scored as underweight, 1; normal weight, 2; and overweight, 3. The average score of subjects who gave birth normally was 1.87; that of subjects who did

not have normal births (i.e. were hospitalized for threatened premature delivery or stillbirth or required transfer to specialist units) was 1.85. There was no significant difference between the two scores.

Nutrient intakes

We estimated the intakes of energy and various nutrients, as calculated by using the FFQg (Table 3). The mean (\pm SD) daily intakes of total energy, protein, total lipids, and carbohydrates were 1717.7 \pm 364.8 kcal, 57.4 \pm 14.6 g, 58.7 \pm 16.8 g, and 234.5 \pm 48.6 g, respectively. The mean (\pm SD) intakes of calcium, iron, total fiber, and salt were 519.6 \pm 185.5 mg, 6.5 \pm 1.9 mg, 11.1 \pm 3.2 g, and 8.1 \pm 2.4 g, respectively. The mean (\pm SD) intakes of protein energy ratio, fat energy ratio, and carbohydrate energy ratio were 13.4 \pm 1.7 %, 30.5 \pm 4.1 %, and 56.1 \pm 5.1 %.

In our analysis by pre-pregnancy BMI, the mean (\pm SD) intake of total energy in the underweight, normal, and overweight groups was 1814.3 \pm 336.3 kcal, 1687.5 \pm 372.2 kcal, 1764.8 \pm 329.0 kcal. There was no significant difference among these energy intake of three groups. Significantly more fat was consumed by underweight subjects than by those of normal weight ($P < 0.041$).

Change in weight gain during pregnancy according to pre-pregnancy BMI

We examined change in weight gain during pregnancy according to pre-pregnancy BMI (Fig. 2), as well as average weight gain before delivery (Fig. 3). Weight gain before delivery in underweight, normal weight, and overweight subjects was 11.1 \pm 2.4 kg, 9.3 \pm 3.1 kg, and 6.9 \pm 3.0 kg. Body weight gain in the underweight group was significantly higher than in the normal and overweight groups, and weight gain in the overweight group was significantly lower than in the others ($P < 0.001$).

Changes in blood pressure during pregnancy according to pre-pregnancy BMI

We examined changes in systolic blood pressure, diastolic blood pressure, and mean

blood pressure during pregnancy (Fig. 4). Overall, blood pressure in the overweight group was high and that in the underweight group was low, although blood pressure levels overall were within the normal range. Blood pressure was significantly higher in the overweight group than in the other groups at some points of gestation.

Table 1. Subject characteristics and pregnancy outcomes

Indicator	(n = 223)
Pre-pregnancy body mass index (BMI: kg/m ²)	
<18.5	44 (19.7%)
18.5–24.9	164 (73.6%)
≥25.0	15 (6.7%)
Parity	
Primiparous	97 (43.5%)
Multiparous	126 (56.5%)
Mode of delivery (n = 217)	
Spontaneous	173 (79.7%)
Vacuum extraction	24 (11.0%)
Cesarean	19 (8.8%)
Other	1 (0.5%)
Outcome	
Normal	147 (65.9%)
Threatened abortion / preterm delivery	13 (5.8%)
Impaired glucose tolerance, GDM	11 (4.9%)
Hospitalization for other reasons	2 (0.9%)
Stillbirth	1 (0.4%)
Pregnancy-induced hypertension	2 (0.9%)
Hospital transfer at patient's request	4 (1.8%)
Hospital transfer by for medical reasons	14 (6.3%)
Emergency transport	12 (5.4%)
Homecoming delivery	15 (6.7%)
Others	2 (0.9%)

Data are expressed as numbers, with percentages in parentheses

Table 2. Subject characteristics by pre-pregnancy BMI category

		Overall	Pre-pregnancy BMI category		
		(n = 223)	<18.5 (n = 44)	18.5–24.9 (n = 164)	≥25.0 (n = 15)
Age	(years)	29.6 ± 4.4	28.3 ± 4.3	29.9 ± 4.5	29.4 ± 3.1
Height	(cm)	158.9 ± 5.4	158.0 ± 6.1	159.2 ± 5.3	159.1 ± 5.4
Pre-pregnancy weight	(kg)	52.0 ± 7.4	43.6 ± 3.9	52.8 ± 5.2	67.6 ± 4.8
Pre-pregnancy BMI	(kg/m ²)	20.5 ± 2.6	17.4 ± 0.8	20.8 ± 1.6	26.7 ± 1.2
Weight gain ^a	(kg)	9.5 ± 3.1	11.1 ± 2.4	9.3 ± 3.1	6.9 ± 3.0
Gestation length ^b	(weeks)	39.1 ± 1.2	38.9 ± 1.4	39.2 ± 1.2	39.4 ± 1.4
Infant birth weight ^b	(g)	3119.7 ± 364.6	2974.9 ± 325.3	3157.4 ± 361.9	3118.7 ± 416.6

Data are expressed as means ± SD.

^a Total of 169 subjects (BMI <18.5, n = 31; 18.5–24.9, n = 126; ≥25.0, n = 12)

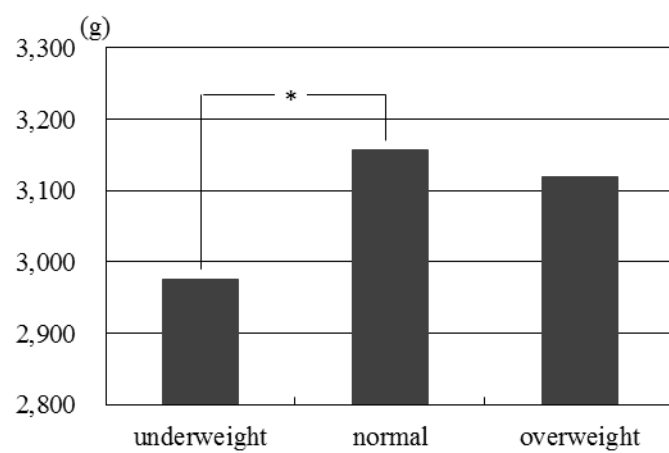
^b Total of 214 subjects (BMI <18.5, n = 41; 18.5–24.9, n = 158; ≥25.0, n = 15)

Table 3. Daily intake of selected nutrients in pregnant women, as obtained from the FFQg

		Overall (n = 223)	Pre-pregnancy BMI category			P value
			<18.5 (n = 44)	18.5–24.9 (n = 164)	≥25.0 (n = 15)	
energy	(kcal)	1717.7 ± 364.8	1814.3 ± 336.3	1687.5 ± 372.2	1764.8 ± 329.0	0.107
water	(g)	795.4 ± 219.1	815.2 ± 178.1	790.9 ± 231.7	786 ± 193.4	0.798
protein	(g)	57.4 ± 14.6	60.6 ± 13.8	56.4 ± 15.0	59.0 ± 10.8	0.220
fat	(g)	58.7 ± 16.8	63.2 ± 15.4	57.0 ± 16.8	64.2 ± 17.1	0.041*
carbohydrate	(g)	234.5 ± 48.6	245.6 ± 47	231.7 ± 49.5	232.4 ± 41.5	0.237
sodium	(mg)	3161.4 ± 956.2	3197.1 ± 827.8	3152.3 ± 996.2	3156.3 ± 912.5	0.963
potassium	(mg)	1953.7 ± 561.0	2062.6 ± 468.6	1923.2 ± 588.5	1967.4 ± 485.5	0.343
calcium	(mg)	519.6 ± 185.5	529.5 ± 167.9	514.5 ± 191.1	545.3 ± 179.7	0.767
magnesium	(mg)	203.5 ± 55.7	214 ± 47.4	200.8 ± 58.0	202.9 ± 51.2	0.377
iron	(mg)	6.5 ± 1.9	7.0 ± 1.8	6.3 ± 2.0	6.8 ± 1.8	0.082
zinc	(mg)	6.9 ± 1.8	7.2 ± 1.8	6.8 ± 1.8	6.9 ± 1.3	0.169
cholesterol	(mg)	265.7 ± 84.4	287.7 ± 91.4	259.4 ± 83.3	269.7 ± 68.7	0.141
salt	(g)	8.1 ± 2.4	8.1 ± 2.1	8.0 ± 2.5	8.1 ± 2.3	0.957
protein energy ratio	(%)	13.4 ± 1.7	13.3 ± 1.8	13.3 ± 1.8	13.4 ± 1.0	0.987
fat energy ratio	(%)	30.5 ± 4.1	31.1 ± 3.9	30.1 ± 4.1	32.5 ± 4.2	0.059
carbohydrate energy ratio	(%)	56.1 ± 5.1	55.5 ± 5.0	56.5 ± 5.2	54.1 ± 3.6	0.148

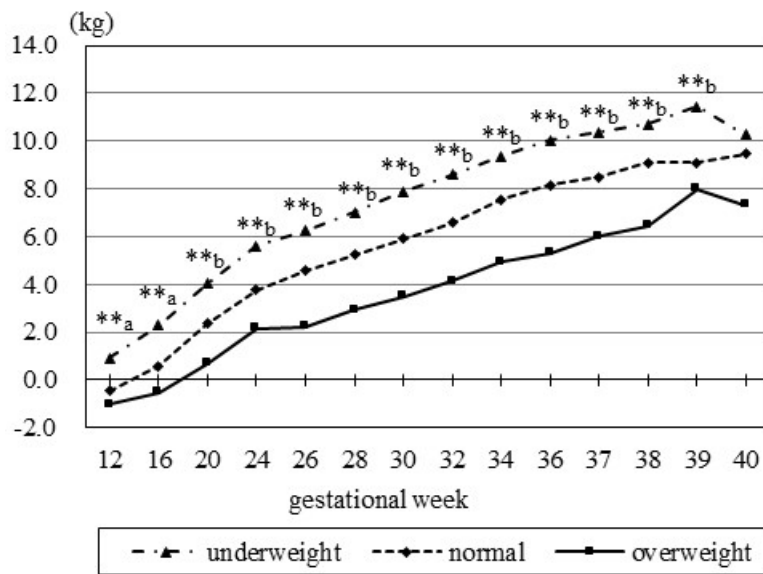
* $P < 0.05$ by one way ANOVA

Data are expressed as means ± SD.



* $P < 0.05$ by one-way ANOVA and multiple comparison

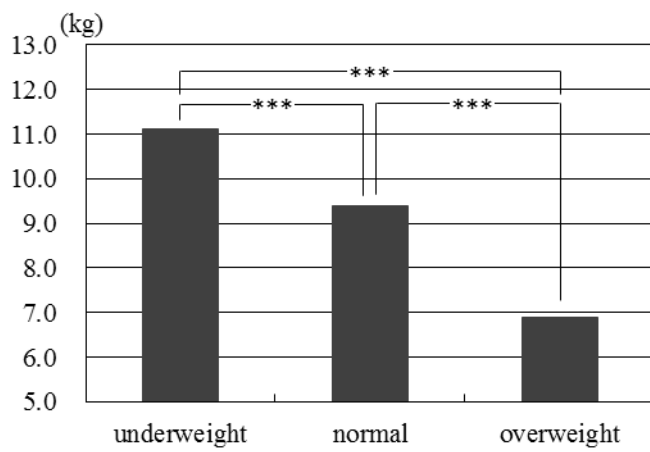
Figure 1. Comparison of average infant birth weights



**a: $P < 0.01$ for underweight vs. normal and for underweight vs. overweight by one-way ANOVA and multiple comparison

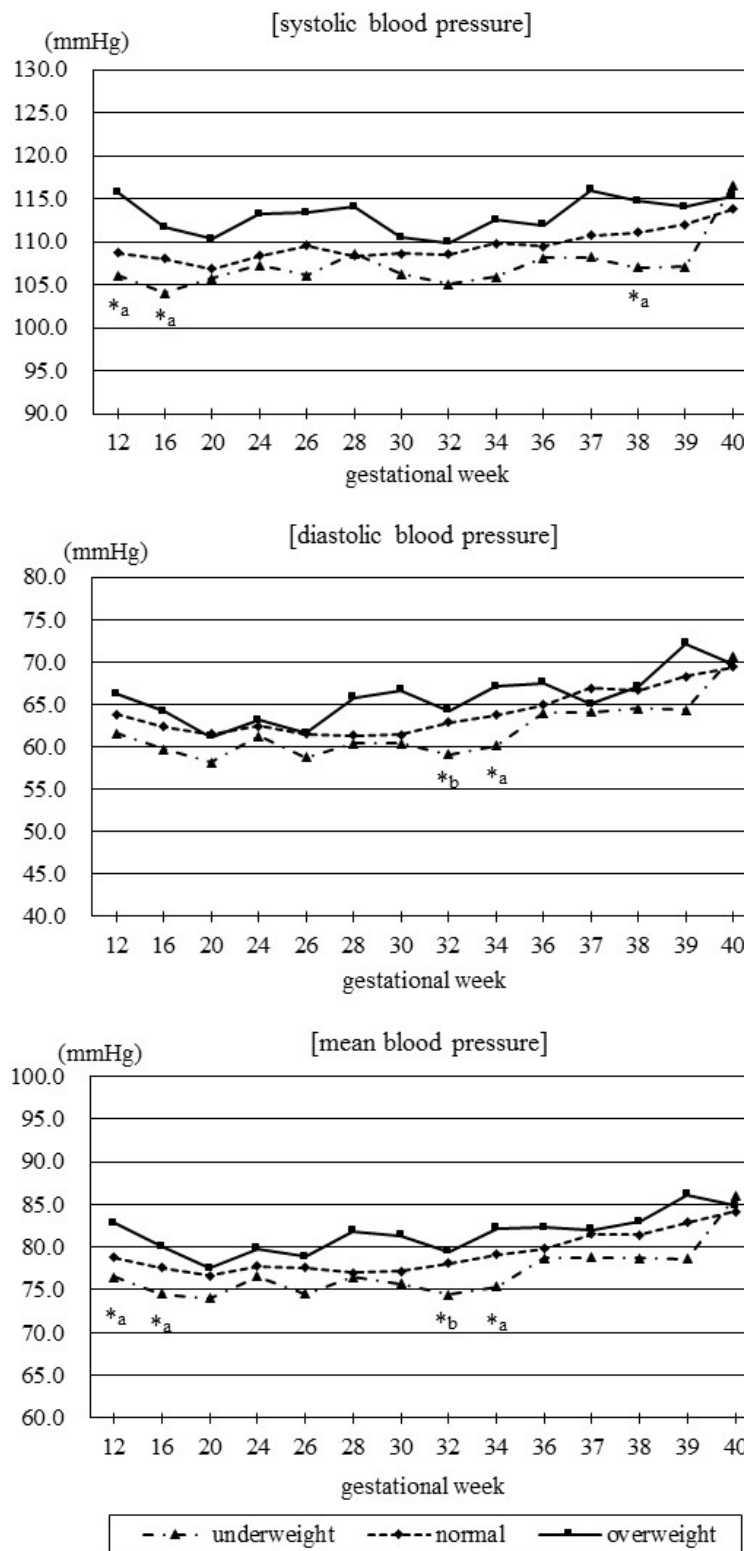
**b: $P < 0.01$ for all three combinations by one-way ANOVA and multiple comparison

Figure 2. Changes in body weight gain during pregnancy



***: $P < 0.001$ by one-way ANOVA and multiple comparison

Figure 3. Comparison of average weight gain up to delivery



*a: $p < 0.05$ at the underweight vs overweight by one way ANOVA and multiple comparison

*b: $p < 0.05$ at the underweight vs normal by one way ANOVA and multiple comparison

Figure 4. Changes in systolic blood pressure, diastolic blood pressure, and mean blood pressure during pregnancy

Discussion

Our aim was to investigate nutritional balance and nutritional requirements in pregnant women and to examine how they were related to the course of pregnancy, with a focus on pre-pregnancy BMI.

Estimation of nutritional intakes revealed a significant change in fat intake by BMI category: underweight women consumed significantly more fat than normal. Energy intake did not differ significantly among groups, but fat as a percentage of the total energy intake in all groups exceeded 30%, although 20% to 30% is the recommendation. Overall, this suggests that fat intake is slightly excessive and nutritional balance is not optimal, especially among underweight woman. Previous study, which examined the nutritional status and PFC balance (that mean the balance of protein, fat, and carbohydrate energy ratio) using the FFQ by comparing weight gain during pregnancy in Japanese women, shows that all the groups with weight gain had a shortage of nutrient intake and the groups of overweight and underweight had significantly higher intakes of fat ¹⁵⁾. It might not be considered carefully about the balance of the meal, since it can be tolerate more weight gain in the case of underweight pregnant women than other groups. Disturbance of eating habits and misconceptions about physique among young women are social issues. Moreover, inappropriate weight management can greatly affect the health of the fetus and the mother.

Our analysis of the relationship between pre-pregnancy BMI and outcome revealed no significant differences among groups. Birth weight was significantly less in newborns of underweight pregnant women than in those of normal-weight pregnant women. This result was similar those of previous studies. The overall incidence of pregnancy-induced hypertension was only 0.9% in our study, although it is known to be about 5% to 10% ¹⁶⁾ or 2.4% ¹⁷⁾ in Japan. This difference is probably because our survey was done at a maternity clinic, not in a hospital. Pregnant women who have pregnancy or delivery risk factors are usually sent to general hospitals, not clinics; the clinic population therefore

likely contained a relatively large percentage of women with normal pregnancies.

Even though the incidence of pregnancy-induced hypertension was very low, the changes in blood pressure showed some differences according to pre-pregnancy BMI. In general, blood pressure during pregnancy is greater toward the third trimester of pregnancy than in the beginning. Blood pressure in the overweight pregnant women remained higher than in the other groups, although it was in the normal range. There is evidence of an association between high baseline BMI and increased blood pressure in pregnancy ¹⁸⁾.

The state of health of mother and child is influenced by the degree of self-discipline in terms of lifestyle in pre-pregnancy, not only during pregnancy. It is hard to say whether all young women recognize this. Like eating habits before pregnancy, those during pregnancy tend to be ingrained and unlikely to change markedly. Although health guidance of individual pregnant women is important and is done at many hospitals, health education for all ages is also becoming important.

There was a limitation of the present study. This study was conducted in only one obstetric clinic of the small province of Japan, and the sample size was small. Therefore, it is not intended that expresses the current situation in Japan.

Conclusion

The effects of nutrition on the course of pregnancy were not well defined. However, pre-pregnancy BMI may influence the course of pregnancy in terms of maternal weight gain and blood pressure and infant weight.

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妊娠中の適切な栄養管理は、母児の健康のために非常に重要である。妊娠中の体重管理においては、厚生労働省が示す推奨体重増加量のチャートに基づいて保健指導がなされているが、多くの場合は体重の増減のみが注目され、全体的な栄養バランスの評価を行うことは難しい。本研究では、妊婦の栄養摂取状況を明らかにし、さらに妊娠経過との関連について明らかにすることを目的とした。

A 市内の産科クリニックに通院する妊婦の妊娠 12 週の妊婦健康診査時に、食物摂取頻度調査 (FFQg: Food Frequency Questionnaire Based on Food Groups) を行い、各種栄養素摂取量や食品群別摂取量を算出した。また、FFQg の対象となった妊婦の妊娠・分娩経過に関する情報を診療録より得た。分析には統計解析ソフト IBM SPSS Statistics 19 を用い、有意水準は 5% とした。なお、本研究は弘前大学大学院医学研究科倫理委員会の承認を得て実施した。

対象者 223 名の平均年齢は 29.6 ± 4.4 歳、非妊時 BMI (Body Mass Index: kg/m^2) による分類では、やせ群 ($\text{BMI} < 18.5$) 44 名 (19.7%)、標準群 ($18.5 \leq \text{BMI} < 25.0$) 164 名 (73.5%)、肥満群 ($\text{BMI} \geq 25.0$) 15 名 (6.7%) であった。147 名 (65.9%) が分娩まで問題なく経過した。非妊時 BMI と妊娠・分娩経過との関連では、異常経過との関連に有意差はみとめられなかった。新生児の出生体重は $3,119 \pm 364.6\text{g}$ であり、やせ群の児の出生体重は標準群と比較して有意に少なく ($p < 0.05$)、この結果は先行研究の報告と同様であった。妊娠中の血圧の変化においては、全体的にやせ群では低く肥満群では高く推移し、肥満群では正常範囲内ではあるものの一部の週数の血圧がやせ群よりも有意に高かった ($p < 0.05$)。FFQg より算出された栄養素摂取量について非妊時 BMI により分析した結果、やせ群の脂質摂取量は正常群と比較して有意に多かった。

($p<0.05$)。また、対象者全体の PFC バランスでも脂質の割合は 30%を超え、妊婦全体として脂質が多い食生活になっている現状が明らかになった。

今回の調査においては栄養摂取状況と妊娠経過との間に明確な関連はみられなかった。しかしながら、非妊時 BMI は母体体重増加や血圧の推移、新生児出生体重など妊娠・分娩経過に影響を与えることが示唆された。妊娠中の栄養管理のみならず、妊娠前からの適切な食生活や健康管理が重要である。