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Original Paper

Differences in Dietary Intake of Women with Standard Weight but Varying Body Fat Percentages in Japan

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Abstract

"Hidden obese people" have a high body fat percentage (BFP) despite having a normal BMI (18.5 <BMI ≦ 25.0 BFP ≧30) due to an excessive accumulation of visceral fat, which increases their risk of lifestyle-related diseases. We aimed to identify factors that contribute to hidden obesity among Japanese female students at the Nutritionist Training Facility University using their anthropomorphic measurements, lifestyle characteristics and nutritional intake. Characteristics of participants with hidden obesity physique (18.5 <BMI ≦ 25.0 and BFP >30%) (n = 160) and standard physique (18.5 <BMI ≦ 25.0 and BFP <30%) (n = 376) were compared using Student's t-test or Welch's t-test. The participants with hidden obesity physique have lower intake of energy (p = 0.044) and fat (p = 0.036) and a higher intake of carbohydrates (p = 0.023), cereals (p = 0.009) and sugary beverages (p = 0.020). This study suggests that a reduction in carbohydrate-dense foods is effective in preventing hidden obesity.

Keywords

Body fat percentage, BMI, Carbohydrate-dense foods, hidden obesity

1. Introduction

Body mass index (BMI) which is calculated from the height and weight is used as an indicator of obesity worldwide (WHO Expert Consultation, 1995). The report of a WHO Expert Consultation stated that at BMIs lower than the existing WHO cut-off point for overweight (= 25 kg/m2), a substantial proportion of Asian people have a high risk of type 2 diabetes and cardiovascular disease (WHO Expert Consultation, 2004). However, an excessive accumulation of body fat is a risk factor for many diseases such as diabetes mellitus, dyslipidaemia of lipid metabolism, hypertension, and myocardial diseases (Wulan, Westerterp, & Plasqui, 2010). Therefore, it is important to consider not only body weight but also body fat in assessing for obesity.

Compared to other developed countries, the percentage of young Japanese women who are categorized as underweight (BMI <18.5) is high. The Japan national survey of 2017 showed that 20.7% of Japanese women in their twenties were underweight (Ministry of Education, Culture, Sports, Science & Technology in Japan, 2017). Additionally, among persons with a BMI within the normal range, persons with normal body weight with a high body fat percentage (BFP), the so-called 'hidden obese persons' are of increasing importance (Omori, Tanaka, & Nakajima, 2016). The 'hidden obesity' among young women is thought to be due to a decrease in muscle mass and bone mass, and an increase in body fat volume among persons whose diet is of poor quality due to a strong "desire for thinness" (Niibori, Hatsushika, Takanami, & Akedo, 2013). People with a strong "desire to be thin" tend to have a high score on the Eating Attitude Test (EAT-26), which is a screening test for eating disorders (Uehara & Sakakibara, 2015). Among young women, there is a risk of consuming a poor diet due to a strong desire to be slender, resulting in anemia, menstrual abnormality and eating disorders (Nicholls & Viner, 2005). In addition, of the body weight of a young woman also affects her future pregnancies and childbirth. Pregnant women who are underweight have a higher risk of giving birth to infants of low weight (Suzuki, Nomura, Takenoshita, Ando, & Kido, 2016). A mothers' weight in pregnancy also affects foetal development (Kiserud et al., 2018) and predisposes to the infant to an earlier onset of lifestyle-related diseases (Fukuoka, 2016). Additionally, after menopause, there is an increased risk of osteoporosis and fractures. Therefore it is important to institute the appropriate measures to maintain a healthy body weight (Gallagher & Tella, 2014).

In the literature, there are reports that illustrate that the BMI is an indicator of the relationship between adolescent female physique and nutritional status (Koike, Hardy, & Richards, 2016); however, limited reports exist that consider BFP as an indicator of nutrition status (Parizkova, 1994). In this study, we assessed the nutritional status of young women using BMI and BFP by classifying them as follows: (BMI <18.5), (18.5 ≦ BMI < 25.0 and BFP <30), (18.5 ≦ BMI < 25.0 and BFP ≧30) and (BMI ≧ 25.0). We then compared the food and nutrient intake of participants with "standard physique" (18.5 ≦ BMI < 25.0 and 20 ≦ BFP <30) to those of participants with "hidden obesity physique" (18.5 ≦ BMI < 25.0 and BFP ≧30) (Sasamori, 2002).

2. Method

2.1 Participants and Ethical Considerations

We measured the height, weight and body fat ratios of 670 female students at the Nutritionist Training Facility University located in Tokyo Japan between 2012 and 2017. We assessed lifestyle characteristics using questionnaire, dietary intake using a food frequency questionnaire and assessed their food intake, total energy and nutrient intake.

Informed consent was obtained from all students. This study was approved by the Ethics Committee of the Otsuma Women's University (Permission number: 25-0006).

2.2 Determination of Physique and Biochemical Indicators

Height was measured using a metal height gauge YS 101 - S (Yoshida Works Co., Ltd.). Body weight, BFP, body fat mass, muscle mass and basal metabolism were measured using a body composition analyser InBody770 (In Body Japan Co., Ltd.). BMI was calculated using the following formula:

$$\text{BMI} = \text{weight (kg)} / (\text{height (m)})^2$$

Study participants were classified using BMI and BFP as follows into 4 groups; "BMI <18.5", "18.5 ≦ BMI < 25.0 and BFP <30", "18.5 ≦ BMI < 25.0 and BFP ≧ 30" and "BMI ≧ 25".

Blood pressure and pulse were measured using digital automatic sphygmomanometer HEM-7000 (OMRON Ltd.). Osteo sono-assessment index (OSI) was measured using Ultrasonic bone evaluation device AOS-100NW (Hitachi Aloka Medical Ltd.).

2.3 Assessment of Lifestyle Characteristics

Participants were asked about average weekly exercise time which is stronger than the intensity of walking. Residence were asked using the following categories: "living alone, living with family, or dormitory". Bowel frequency was asked using the following categories: "once a day or more than once a day, 5-6 times per week, 3-4 times per week, twice per week or less than twice per week". Bowel movement was asked using the following categories: "loose stool, normal stool, hard stool, or repetition of diarrhea and constipation". Sleeping time was asked using the following categories: "less than 5 hour, 6 hour, 7 hour, or more than 8 hour". Satisfaction of daily life was asked using the following categories: "satisfied, anything satisfied, anything is not satisfied, and not satisfied". Menstrual cycle was asked using the following categories: "regularly and irregularly".

2.4 Estimation of Food and Nutrient Intakes

Information on dietary intake was obtained using a 165-item semi-quantitative food frequency questionnaire (FFQ). Participants were asked to report their average frequency of consumption and portion size for each item during the past year. Nutrient intake was evaluated using a previously described method (Sasaki, Kobayashi, Ishihara, & Tsugane, 2003). The FFQ was modified as follows. Participants were presented with the eight frequency categories that included: none, once/month, 2-3 times/month, once/week, 2-3 times/week, 4-6 times/week, once/day and more than 2 times/day. Portion sizes were also described for every food item. Coefficients for the categories of relative portion size were presented in the five categories of 0.5, 0.75, 1.0, 1.25 and 1.5.

The composition values of the 165 foods on the FFQ were multiplied by the frequencies and relative portion sizes for the food items from the FFQ. Intakes of total energy and 38 nutrients for each food were calculated using a food composition table developed for the FFQ based on the Standard Tables of Food Composition in Japan, 2017 edition (Watanabe & Kawai, 2018). Food and nutrient intake were energy adjusted using the residual method (Henriquez-Sanchez et al., 2009). Estimated nutrient intake was validated using a 3-day dietary record, a modified FFQ that gives reasonably valid estimates of energy, and nutrient and food intake (Takada, 2017).

2.5 Statistical Analysis

Participants were classified into 4 groups, however only two groups were indicated in the analysis: "standard physique" (18.5 ≦ BMI < 25.0 and BFP <30) and "hidden obesity physique" (18.5 ≦ BMI < 25.0 and BFP ≧ 30%). Differences in biochemical indicators, food and nutrient intake estimated from FFQ by physique status, and exercise time were assessed using the Student's t-test or Welch's t-test. Lifestyle characteristics were assessed using the Fisher's exact test. Data were analyzed using SAS statistical software ver. 9.4. (SAS Institute Inc.). All analyses were considered significant at the 0.05 level.

3. Result

A total 670 participants were interviewed. They were categorized as follows: lean students (n = 101), fat students (n = 33) and normal BMI (n = 536) who were then classified into standard physique (n = 376) and hidden obesity physique (n = 160) groups.

The distribution of participants by physique status is shown in Table 1. Of the 670 participants, 376 (56.1%) had a standard physique and 160 (23.9%) a hidden obesity physique.

Biological indicators of participants by physique status are shown in Table 2. Participants with a standard physique were taller than those with a hidden obesity physique (p=0.033). Conversely, when compared to participants with a standard physique, those with hidden obesity physique were heavier and had higher BMI, BFP, Body fat mass (p<0.0001) and diastolic blood pressure (p=0.002).

Lifestyle characteristics of participants by physique status are shown in Table 3. There were no statistically significant differences between participants with a standard physique and those with a hidden obesity physique. The frequency of bowel movements did not differ by physique status. There was a higher proportion of participants with hard stool among those with a hidden obesity physique compared to those with a standard physique (p=0.081). Although participants with hidden obesity physique spent less time exercise than those with standard physique, this was not statistically significant (p=0.530).

Energy and nutrient intake for 38 nutrients of participants by physique status are shown in Table 4. Energy intake was higher (p=0.044) and total fat and saturated fat intake were also higher (p=0.036, p=0.017) among participants with a standard physique compared to participants with a hidden obesity physique. Conversely, compared to participants with a standard physique, carbohydrate intake was

higher (p=0.023) and Manganese and Iodine intake also were higher (p=0.001, p=0.013) among participants with a hidden obese physique.

Food intake by participant physique status is shown in Table 5. The intake of cereals and beverages other than alcohol was higher (p=0.009, p=0.020) among participants with a hidden obese physique compared to that among participants with a standard physique. In this study, drinking-water was not included in their beverages and there were no differences in the estimated intake of drinking-water by physique status (data not shown). Conversely, compared to participants with a hidden obesity physique, the intake of confectionery was higher (p=0.047) among participants with a standard physique.

Table 1. The Distribution of the Physique of the Participant (n=670)

	Frequency	%
BMI <18.5	101	15.1
18.5 ≦ BMI <25.0 and BFP <30	376	56.1
18.5 ≦ BMI <25.0 and BFP ≧ 30	160	23.9
BMI ≧ 25	33	4.9

Table 2. Biological Indicator of Standard Group and Hidden Obese Group

		Standard group (n=376)			Hidden obese group (n=160)			P value*
		mean	±	SD	mean	±	SD	
Height	cm	158.8	±	4.9	157.8	±	5.1	0.0333
Weight	kg	51.2	±	4.6	55.2	±	4.7	<0.0001
BMI		20.3	±	1.2	22.1	±	1.3	<0.0001
Body fat percentage (BFP)	%	25.8	±	2.6	32.3	±	2.0	<0.0001**
Body fat mass	g	13.3	±	2.3	17.9	±	2.1	<0.0001
Muscle mass	g	35.7	±	3.1	35.2	±	2.9	0.079
Basal metabolism	kcal	1182.0	±	82.2	1184.2	±	81.3	0.773
Systolic blood pressure	mmHg	105.5	±	9.8	106.3	±	10.3	0.379
Diastolic blood pressure	mmHg	66.7	±	7.1	69.2	±	8.9	0.002**
Pulse	times	72.7	±	11.2	74.4	±	10.8	0.093
Osteo sono-assessment index	OSI($\times 10^6$)	2.9	±	0.4	2.9	±	0.3	0.908**

Hidden obese group; Participants with 18.5≦BMI<25.0 and BFP ≧ 30; Standard group; Participants with 18.5≦BMI<25.0 and 20 ≦ BFP <30.

* Student t-test; ** Welch's t-test

Table 3. Lifestyle Characteristics of Standard Group and Hidden Obese Group

	Standard group (n=376)	Hidden obese group (n=160)	P value*
Exercise time			
min per 1 week	58.2±127.6	50.9±111.6	0.530**
Residence			
alone	18.6	20.0	0.548
with family	77.7	75.6	
dormitory	3.7	3.8	
Bowel frequency			
≧ once a day	52.8	45.0	0.331
5-6 times / week	18.1	23.8	
3-4 times / week	21.1	23.1	
< 2 times / week	8.0	8.1	
Bowel movement			
loose stool	8.0	6.9	0.081
normal stool	76.8	68.8	
hard stool	11.7	20.0	
repetition of diarrhea and constipation	3.5	4.4	
Sleeping time			
less than 5 hour	30.4	25.6	0.430
6 hour	55.2	61.3	
7 hour	13.1	11.9	
more than 8 hour	1.3	1.3	
Satisfaction of life			
satisfied	16.3	17.5	0.313
anything satisfied	65.1	57.5	
anything is not satisfied	14.4	20.6	
not satisfied	4.0	3.8	
Menstrual cycle			
regularly	72.5	73.0	0.861
irregularly	25.6	26.4	

Hidden obese group; Participants with 18.5≦BMI<25.0 and BFP ≧ 30; Standard group; Participants with 18.5≦BMI<25.0 and 20 ≦ BFP <30.

* Fisher's exact test; ** Student's t-test

Table 4. Energy and Nutrient Intake* of Standard Group and Hidden Obese Group**

	Standard group (n=376)			Hidden obese group (n=160)			P value*
	mean	±	SD	mean	±	SD	
Energy (kcal)	1654.8	±	548.9	1568.3	±	407.0	0.044**
Protein (g)	53.3	±	7.1	52.1	±	6.6	0.074
Total fat (g)	52.1	±	10.1	50.0	±	10.4	0.036
SFA (g)	18.0	±	4.2	17.0	±	4.4	0.017
MUFA (g)	18.2	±	3.8	17.5	±	3.9	0.082
PUFA (g)	10.6	±	2.6	10.3	±	2.6	0.318
Cholesterol (mg)	234.1	±	73.6	234.2	±	76.4	0.993
Carbohydrate (g)	204.3	±	27.0	210.1	±	25.8	0.023
Total dietary fibers (g)	8.7	±	2.2	8.4	±	2.4	0.251
Natrium（mg)	1672.9	±	577.5	1664.6	±	643.3	0.884
Potassium (mg)	1867.3	±	391.5	1845.5	±	422.3	0.565
Calcium (mg)	492.0	±	185.8	465.8	±	175.0	0.129
Magnesium (mg)	206.0	±	37.7	203.1	±	42.2	0.419
Phosphorus (mg)	846.8	±	146.3	825.5	±	136.0	0.117
Iron (mg)	6.1	±	1.3	6.1	±	1.4	0.936
Zinc (mg)	6.9	±	0.8	6.8	±	0.7	0.861
Copper (mg)	0.9	±	0.2	0.9	±	0.2	0.743
Manganese (mg)	2.8	±	1.0	3.1	±	1.3	0.001**
Iodine (μg)	629.4	±	202.4	682.3	±	232.6	0.013**
Serene (μg)	48.7	±	11.1	48.4	±	10.7	0.768
Chrome (μg)	4.3	±	1.7	4.1	±	1.7	0.302
Molybdic (μg)	156.8	±	53.2	159.1	±	53.2	0.648
Alpha-carotene (μg)	365.2	±	293.4	398.2	±	326.5	0.249
Beta-carotene (μg)	1674.6	±	876.7	1727.4	±	1043.0	0.575**
Vitamin A (μg)	587.3	±	413.1	550.1	±	329.5	0.270**
Vitamin D (μg)	4.4	±	1.7	4.3	±	1.7	0.699
Alpha-tocopherol (mg)	5.9	±	2.1	5.8	±	2.1	0.640
Vitamin K (μg)	179.98	±	102.2	169.2	±	110.5	0.276
Vitamin B_1 (mg)	0.71	±	0.11	0.69	±	0.1	0.210
Vitamin B_2 (mg)	1.1	±	0.31	1.14	±	0.30	0.754
Niacin (mgNE)	11.3	±	2.3	11.3	±	2.14	0.767
Vitamin B_6 (mg)	0.9	±	0.1	0.9	±	0.1	0.833
Vitamin B_{12} (μg)	4.6	±	1.8	4.4	±	1.7	0.267

Folate (μg)	224.6	±	61.6	229.1	±	65.6	0.441
Pantothenic acid (mg)	5.2	±	0.9	5.1	±	0.9	0.294
Biotin (μg)	26.5	±	6.5	26.6	±	6.2	0.800
Vitamin C (mg)	65.0	±	24.9	68.1	±	28.5	0.238**
Salt (g)	4.2	±	1.5	4.1	±	1.6	0.815
Alcohol (g)	4.0	±	6.6	3.7	±	6.8	0.574

Hidden obese group; Participants with 18.5≦BMI<25.0 and BFP ≧ 30; Standard group; Participants with 18.5≦BMI<25.0 and BFP <30.

* Student t-test, ** Welch's t-test, *** each nutrient were adjusted with residual method

Table 5. Food Intake* of Standard Group and Hidden Obese Group**

	Standard group (n=376)			Hidden obese group (n=160)			P value*
(g)	mean	±	SD	mean	±	SD	
cereals	223.2	±	59.6	237.8	±	58.6	0.009
Potatoes and starches	25.2	±	14.4	24.2	±	15.2	0.483
Sugars	3.0	±	3.3	2.7	±	2.8	0.375**
Beans	39.0	±	24.8	36.3	±	28.4	0.283**
Nuts and seeds	1.6	±	3.1	1.6	±	2.8	0.834
Vegetables	125.0	±	58.2	125.7	±	65.0	0.906
Green vegetables	48.5	±	26.2	46.8	±	27.4	0.507
White vegetables	71.3	±	39.6	73.3	±	41.4	0.590
Pickles	5.3	±	6.0	5.5	±	7.9	0.807**
Fruits	80.3	±	59.7	76.0	±	58.9	0.448
Mushroom	8.3	±	6.7	8.0	±	5.8	0.528**
Seaweed	5.1	±	4.7	4.6	±	4.0	0.249**
Fish	39.0		18.0	37.9		17.0	0.505
Meats	71.8		30.1	69.2		30.3	0.358
Eggs	23.0	±	16.6	25.2	±	16.2	0.167
Dairy	169.7	±	132.7	160.7	±	111.9	0.423**
Fats & Oils	9.5	±	3.7	9.3	±	3.5	0.440
Confectionery	76.3	±	45.0	68.6	±	38.5	0.047**
Alcohol beverage	54.2	±	92.9	54.4	±	127.9	0.986**
Beverage other than alcohol	836.6	±	609.9	1004.4	±	817.8	0.020**

Hidden obese group; Participants with 18.5≦BMI<25.0 and BFP ≧ 30; Standard group ; Participants with 18.5≦BMI<25.0 and BFP <30.

* Student t-test; ** Welch's t-test; *** each food were adjusted with residual method.

4. Discussion

In our study, 24% of participants had hidden obesity, even though their BMIs were within the normal range. In a study of young Taiwanese, 29.7% of women were diagnosed with hidden obesity (Hung, Chen, Guo, Chang, & Jan, 2017). There were differences in biological indicators, lifestyle, nutrients and food intake between the standard physique group and hidden obesity physique group. In particular, the hidden obesity group had a higher intake of cereals, beverages and carbohydrates.

Although it the body fat mass is higher in persons with a hidden obesity physique, there were no differences in muscle mass and bone density between the two groups. In this study, participants with a standard physique spent more time exercise, but the difference in exercise time did not seem to be enough to affect muscle mass or bone density. There were only two persons with a standard physique and three persons with a hidden obesity physique that were diagnosed with hypertension based on a systolic blood pressure of 140 mm Hg or more or diastolic blood pressure of 90 mm Hg or more. However, the mean of blood pressure was higher among persons with a hidden obesity physique, especially the diastolic blood pressure. In a recent study of college students that explores differences in blood pressure levels across adiposity, it was found that both waist circumference and fat mass percentages acted as mediators between cardiorespiratory fitness and blood pressure (Diez-Fernandez et al., 2017).

In persons with a hidden obesity physique, a higher proportion had hard stools; on the other hand, their dietary fiber intake was low. Dietary fiber intake is effective in relieving constipation (Suares & Ford, 2011; Yang, Wang, Zhou, & Xu, 2012). On the other hand, the intake of water or fluid foods relieves hard stools (Kira, 2013). Although persons with a hidden obesity physique had a higher intake of beverages (other than alcohol), there were no differences in the estimated intake of drinking-water or water amount in foods by physique status.

The diet consumed by the hidden obesity group was characterized by a low intake of fat and SFA and a high intake of carbohydrates. In addition, they had a low intake of sweets and a high intake of cereals and sweet beverages other than alcohol. In a study of women in New Zealand, the BFP was directly related to the energy density diet pattern, such as red meat, processed meat or deep-fried foods (Schrijvers, McNaughton, Beck, & Kruger, 2016). Because our study participants were young women, particularly among those with a hidden obesity physique, it is possible they reduced the intake of fat and sweets for the purposes of dieting, which may have led to an increase in the intake of cereals and sweet beverages. Several randomized controlled trials have reported differences in the effect of low-carbohydrate diets and low-fat diet on weight reduction (Tobias et al., 2015). Low-fat diet, particularly low SFA diet, has generally been evaluated for its effectiveness in reducing CVD risk (Hu & Willett, 2002). However, low-carbohydrate diets are associated with not only reduction in body weight, but also a reduction in the levels of total cholesterol and triglyceride and an increase in HDL cholesterol levels (Bueno, de Melo, de Oliveira, & da Rocha Ataide, 2013). A recent randomized controlled trial reported no differences in the effect of low-carbohydrate diets and low-fat diet on

weight reduction (Gardner et al., 2018). Although the effect of low-carbohydrate diets and low-fat diet on the weight reduction is controversial, there may be a number of our study participants who had a desire to reduce their weight that selected the low-fat diet. Because the hidden obesity group tended to refrain from total fat intake, SFA intake and snack intake, and the hidden obesity group was expected to have a strong desire to lose weight.

This study had some limitations. Firstly, because participants were students at the Nutritionist Training Facility University, they may have been knowledgeable about the relationship between nutrition and health risks, and this may have had implications on the differences in their eating and lifestyle habits. Nevertheless, dietary intake among persons with a hidden obesity physique was characterized by a low intake of fat, a low intake of SFA and a high intake of carbohydrates. Secondly, although the FFQ used to estimate food and nutrient intake in this study has been validated, the accuracy of the absolute value of the available intake may not be guaranteed due to the type of the dietary survey conducted. However, our results appear to correctly reflect the difference in the average value of the food and nutrient intake level in the hidden obesity group and the standard group. Thirdly, we could only compare the daily exercise time of the hidden obesity group to the standard group; the intensity of the exercise and the activity level in the daily life were not made.

5. Conclusion

In this study, approximately one quarter of young women with standard BMI were reclassified as having a hidden obesity physique based on a body fat ratio of 30% or more. Among all participants, those with a hidden obesity physique had a low intake of fat, a low intake of SFA and a high intake of carbohydrates. Obesity is not only identified by BMI but also by BFP (hidden obesity), which is related to the risk of diabetes mellitus, abnormality of lipid metabolism, hypertension and myocardial disease. Therefore, the results of this study should be utilized in dietary education in order to reduce the number of persons with hidden obesity.

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