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Association of normal weight obesity with lifestyle and dietary habits in young Thai women: A cross-sectional study

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ABSTRACT

Background: The risk of lifestyle-related diseases in normal weight obesity (NWO), a condition, in which the body mass index (BMI) is normal but the body fat mass is high, has attracted a lot of attention. However, there are no reports on the association between NWO and lifestyle, eating habits, and other health risks in Thai people. BMI alone cannot be used to identify individuals with NWO; thus, some students with NWO develop metabolic abnormalities without receiving any intervention. This study aimed to examine the differences in anthropometrics, lifestyle, and eating habits among young Thai women and their association with the BMI and the body fat ratio (BFR).

Methods: A total of 250 female Thai university students of normal body type ($18.5 \leq \text{BMI} < 25.0$ kg/m^2) were classified as having non-normal weight obesity (NO-NWO) if their BFR was <30.0% or NWO if their BMI and BFR were >30.0%. The lifestyle and eating habits of the two groups were compared. We conducted logistic analysis with the presence or absence of NWO as the dependent variable, and the dietary habit items of "eating greasy foods," "eating ultra-processed foods (UPF)," and "drinking sweetened beverages" as the objective variables.

Results: Among the study participants who were of normal body type, 46.8% were NWO. The participants in the NWO group consumed UPF more frequently (odds ratio [OR], 2.04; $p = 0.014$) and sweetened beverages more regularly (OR, 1.92, $p = 0.041$) than those in the NO-NWO group.

Conclusion: UPF and sweetened beverage consumption was more common in individuals with NWO. Identifying the risk factors for NWO is essential to help individuals make lifestyle changes to prevent its progression and complications.

1. Introduction

Thailand's population with obesity is increasing in tandem with rising income levels and the adoption of westernized diets [1,2]. In 2016, the percentage of the overweight population exceeded 30%, and the obese rate (body mass index [BMI] m > 30 kg/m^2), also exceeded 10%. Thailand's high obese rate is the second highest among the Association of Southeast Asian Nations after Malaysia [3]. According to Global Health Metrics (2020), Thailand's leading causes of death have changed from infectious diseases and injuries a decade ago to lifestyle-related diseases, such as ischemic heart disease and stroke, for which obesity is a risk factor [4]. Thailand's population with obesity extends to its youth, with the obesity rate among Thai youth in their 20s reportedly increasing from 13.0% to 24.1% between 2012 and 2018 [5].

Meanwhile, normal weight obesity (NWO), a condition in which the BMI is normal but high body fat content is present, has become increasingly concerning worldwide. NWO has been reported to increase the risk of cardiovascular morbidity and mortality [6]. It is essential to identify the health risks associated with this condition, as body composition is not measured during routine physical examinations. However, there are no reports on the relationship between NWO and lifestyle, eating habits, and other health risks among Thai people.

Maintaining proper body shape from adolescence is one of the most critical factors in preventing lifestyle-related diseases and extending healthy life expectancy. Thus, nutrition and health education are essential. However, it is challenging to identify university students as having

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NWO based solely on their BMI; thus, some students with NWO develop metabolic abnormalities without receiving adequate medical care. Identifying the risk factors for NWO may help young people make lifestyle changes to prevent its progression [7]. Therefore, in this study we used the BMI and the body fat ratio (BFR) to examine differences in anthropometrics, lifestyle, and eating habits among young Thai students.

2. Methods

2.1. Participants

Between 2017 and 2020, 507 Thai female university students living near Thaniyaburi and Chiang Mai were recruited for this cross-sectional study, and 113 thin (BMI <18.5 kg/m^2) and 144 overweight women (BMI ≥ 25.0 kg/m^2) were excluded from the analysis. We enrolled 250 women who were in the normal BMI range, as classified by the World Health Organization ($18.5 \leq$ BMI<25.0 kg/m^2) (8). The participants were fully informed of the nature of the study prior to participation, and consent was obtained by their response to the questionnaire. The study was conducted with the approval of the Otsuma Women's University Life Science Research Ethics Review Committee (date of approval: July 2, 2014). The author received a research grant from the Asahi Group ScienceFoundation to conduct this study. The authors declare that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest. All authors reviewed the manuscript, and all approved the submission for publication.

2.2. Measurements and variables

Height was measured by In Lab 550 (In Body Japan Inc., Tokyo, Japan), while the body weight, BFR, basal metabolic rate, and muscle mass were measured by ACCUNIQ BC300 (Toyo Medic Co., Ltd., Tokyo, Japan).

The BMI (kg/m^2) was calculated based on the height and weight, and patients were categorized as "thin," "normal," and "obese" if their BMI <18.5, 18.5–25, and ≥ 25 kg/m^2, respectively. In this study, only those with a "normal" body size between a BMI of 18.5 and 25.0 were included in the analysis. Those with a BFR $<30.0\%$ were classified as having non-NWO (NO-NWO), and those with a BFR $>30.0\%$ as having NWO, based on the combination of BMI and BFR.

A survey on lifestyle and eating habits was conducted using a self-administered questionnaire. For lifestyle, respondents were asked to choose from "live alone," "live with a roommate," or "in a dormitory." Regarding exercise, the respondents were asked to respond to the question concerning their habitual exercise habits by selecting "none," "once a week," "twice a week," or "three or more times a week." The average daily walking time in everyday life, including commuting to university, was answered in a descriptive format. The respondents were asked, "How much sleep did you get every night in the last year?," and they chose "less than 5 h," "between 5 and 6 h," "between 6 and 7 h," "between 7 and 8 h," or "more than 8 h" Regarding the frequency of bowel movements, responses to the question, "How often do you have bowel movements?" were obtained from the following options: "at least once daily," "5–6 times a week," "3–4 times a week," and "less than twice a week." For the question "How soft are your usual stools?," the respondents were asked to choose "soft stools," "normal stools," "hard stools," or "diarrhea and constipation repeatedly." Regarding smoking habits, responses were obtained to the question, "Have you ever smoked more than one cigarette a day?" from the options of "yes," "in the past but not at present," and "currently smoking." Regarding the menstrual cycle, the respondents were asked, "Is your menstrual cycle regular?" Their answers were obtained by selecting "approximately regular" or "irregular." The respondents were also asked concerning their usual eating habits and answered questions regarding "eating breakfast," "eating until full," "eating a meal with nutritional balance in mind," "eating a variety of foods," "eating fast," "eating an evening meal after dinner," "eating snacks between meals," "eating meat dishes," "eating fish," "eating dairy products," "eating fruits," "eating vegetables," "eating salty seasonings," "eating spicy seasonings," "eating sweet snacks," "eating salty snacks," "eating traditional Thai snacks," "eating oily foods," "eating ultra-processed foods (UPF)," "eating fast food," "drinking sugar-sweetened beverages," "trying new foods and dishes," and "using umami seasonings." For each question, the respondents were given the options of "rarely," "1–2 days a week," "3–4 days a week," or "almost every day."

2.3. Statistical analysis

Participants of this cross-sectional study were classified into the NO-NWO and NWO groups, and physical measurements, lifestyle, and eating habits were compared between the two groups. Qualitative variables were analyzed by the Chi-square test or Fisher's exact probability test, and quantitative variables were analyzed by Student's *t*-test.

In addition, logistic analysis was conducted with the presence of NWO as the dependent variable and the food habit items of "eating greasy food," "eating UPF," and "drinking sugar-sweetened beverages" as the objective variables. In the analysis, multivariate analysis was also conducted using "menstrual cycle" and "softness of usual stool" as adjustment variables, which are items that showed differences between the "NO-NWO" and "NWO" groups in the lifestyle items. SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) was used for the analysis, and the significance level was set at 5% (two-tailed test).

3. Results

3.1. Basic information and body measurements

NWO was detected in 46.8% of the study participants who were of normal body type (BMI, 18.5–25.0 kg/m^2). There was no difference in age or height between the NO-NWO and NWO groups. The weight, BMI, and BFR of the NWO group were significantly higher than those of the NO-NWO group (all $p < 0.001$). Muscle mass in the NWO group was lower than that in the NO-NWO group, but this difference was not statistically significant ($p = 0.084$). There was no difference in the basal metabolic rate between the NWO and NO-NWO groups (Table 1).

3.2. Lifestyle

There was no difference in the frequency of bowel movements between the NO-NWO and NWO groups, but the NWO group had a smaller proportion of participants with normal stools that were not diarrhea or constipation than the NO-NWO group. However, the difference was not significant ($p = 0.070$). The NWO group had a higher percentage of

Table 1
Basic information and biological indicators of the participants.

		NO-NWO (n = 133)	NWO (n = 117)	p-value[a]
		Mean ± SD	Mean ± SD	
Age	years	20.1 ± 0.9	20.3 ± 1.3	0.098
Height	cm	159.7 ± 6.0	159.1 ± 5.9	0.445
Weight	kg	51.4 ± 5.3	56.1 ± 6.3	<0.0001
BMI	kg/m^2	20.1 ± 1.3	22.1 ± 1.7	<0.0001
Body fat ratio	%	25.3 ± 4.0	33.6 ± 2.9	<0.0001
Muscle mass	g	28.4 ± 9.5	25.5 ± 16.9	0.084
Basal metabolic rate	kcal	1185.4 ± 105.7	1190.2 ± 94.6	0.707

NO-NWO: ($18.5 \leq$ BMI<25.0 kg/m^2) and the body fat ratio is $<30\%$.
NWO: ($18.5 \leq$ BMI<25.0 kg/m^2) and body fat ratio is $>30.0\%$.
SD, standard deviation; BMI, body mass index.
[a] Student's *t*-test.

irregular menstrual cycles than the NO-NWO group, but this difference was not significant ($p = 0.079$). No differences in exercise habits, residential type, sleep duration, or smoking habits were observed. The participants in the NWO group walked less per day than those in the NO-NWO group, but this difference was not significant ($p = 0.291$; Table 2).

3.3. Dietary habits

The NWO group of young Thai women was less likely than the NO-NWO group to respond “almost daily” to the item “eat oily food” ($p = 0.047$). The NWO group was more likely than the NO-NWO group to respond “almost daily” to the item “eat UPF” ($p = 0.036$). Moreover, the NWO group was more likely than the NO-NWO group to respond “almost daily” to the item “drink sugar-sweetened beverages; ” however, the difference was not significant ($p = 0.073$) (Table 3).

3.4. Association between NWO and dietary habits

Logistic analysis showed that frequently eating UPF was positively associated with NWO. Results of the multivariate analysis adjusting for walking time, menstrual cycle, and typical stool softness were similar, with a 2.04-fold higher risk of NWO in participants who ate UPF “almost daily” compared to those who ate UPF “rarely” ($p = 0.014$). The frequency of drinking added sugar beverages was also associated with NWO. The results of a multivariate analysis adjusting for walking time, menstrual cycle, and typical stool softness were similar, with a 1.92-fold higher risk of NWO in participants who drank sweetened beverages “almost daily” compared to those who “rarely” drank them ($p = 0.041$; Table 4).

Table 2
Lifestyle habits of non-normal weight-obese and normal weight obese individuals.

	NO-NWO (n = 133)	NWO (n = 117)	p-value[a]
Walking time (per day)			
Minutes (mean ± SD)	78.7 ± 105.4	64.4 ± 74.2	0.291
Exercise habits			
Not habitually	23.6	19.8	0.311
Once a week	24.3	23.3	
Twice a week	35.7	31.0	
More than three times a week	16.4	25.9	
Type of residence			
Living alone	4.7	6.1	0.200
Living with family	34.7	44.7	
Dormitory	60.6	49.1	
Sleep duration			
Less than 5 h	7.5	6.0	0.919
5 h to less than 6 h	33.8	32.5	
6 h to less than 7 h	34.6	32.5	
7 h to less than 8 h	19.6	23.9	
8 h or more	4.5	5.1	
Frequency of bowel movements			
At least once daily	57.9	61.5	0.949
5–6 times/week	12.8	12.0	
3–4 times/week	21.1	18.8	
Less than twice weekly	8.3	7.7	
State of bowel movements			
Loose stools	2.3	6.0	0.070
Normal stools	87.1	74.1	
Hard stools	4.6	9.5	
Cycles of diarrhea and constipation	6.1	10.3	
Smoking habits			
Never	91.7	90.6	0.869
Previous smoker	3.8	5.1	
Current smoker	4.5	4.3	
Menstrual Cycle			
Generally regular	54.1	41.6	0.079
Irregular	46.0	58.4	

NO-NWO: ($18.5 \leq$ BMI<25.0 kg/m^2) and the body fat ratio is $<30\%$.
NWO: ($18.5 \leq$ BMI<25.0 kg/m^2) and the body fat ratio is $>30.0\%$.
BMI, body mass index.
[a] Chi-square test except for walking time, which was derived via Student's *t*-test.

Table 3
Dietary habits of non-normal weight-obese and normal weight obese individuals.

	NO-NWO (n = 133)	NWO (n = 117)	p-value[a]
I eat ___ almost daily	%	%	
breakfast	20.3	22.2	0.443
until full	48.9	53.9	0.522
meals with nutritional balance in mind	9.8	8.6	0.572
a variety of foods	17.3	24.8	0.320
fast	16.0	20.7	0.693
an evening meal after dinner	18.8	19.8	0.910
snacks between meals	19.6	28.2	0.294
meat dishes	52.6	56.0	0.633
fish	6.8	7.7	0.684
dairy products	12.8	18.0	0.453
fruits	19.6	16.2	0.614
vegetables	33.1	31.6	0.896
salty seasonings	6.8	6.8	0.276
spicy seasonings	7.5	9.5	0.749
sweet snacks	10.5	6.8	0.404
salty snacks	13.6	11.1	0.161
traditional Thai snacks	0.8	2.6	0.769
oily foods	8.3	5.1	0.047
ultra-processed foods (UPF)	7.6	17.1	0.036
fast food	10.5	10.3	0.405
new foods and dishes	3.1	6.8	0.113
sugar-sweetened beverages	13.6	20.5	0.073
umami seasonings	15.9	24.8	0.229

NO-NWO: ($18.5 \leq$ BMI<25.0 kg/m^2) and the body fat ratio is $<30\%$.
NWO: ($18.5 \leq$ BMI<25.0 kg/m^2) and the body fat ratio is $>30.0\%$.
Choices: 1, few; 2, 1–2 days per week; 3, 3–4 days per week; 4, almost every day.
BMI, body mass index.
[a] Chi-square test except for “eat until full” and “eat meat dish,” which was derived via Fisher's exact test.

4. Discussion

This study aimed to determine the prevalence and factors associated with NWO among young Thai women. The percentage of NWO among Thai female university students of a normal body type (BMI, 18.5–25.0 kg/m^2) was 46.8%. Compared with the participants in the NO-NWO group, those in the NWO group ate UPF and consumed sugar-sweetened beverages more frequently, indicating unhealthy dietary habits. To the best of our knowledge, this is the first study to report the prevalence of NWO and the factors associated with it in young Thai women.

For a long time, obesity has been classified based on the BMI, as the BMI can be easily calculated from height and weight and has been validated in various epidemiological studies [8]. However, BMI alone cannot determine body fat composition. NWO with high body fat percentage, even at a normal BMI, has been identified as an essential factor affecting the health of college students and is associated with increased metabolic disorders, cardiovascular disease, and all-cause mortality [9,10]. Therefore, timely detection and intervention are essential to prevent obesity and other metabolic diseases in individuals with NWO. The cutoff values of BFR used to determine NWO vary by the study population, sex, and ethnicity, and no clear criteria have been established [9]. Based on the NWO definition, we set the cutoff value of BFR at $\geq$30% for the Thai female university students who participated in this study [11]. The percentage of participants with NWO in this study was higher than that of Chinese [12] and Japanese female college students [13] reported in other studies, in which similar cutoff values were adopted.

Table 4
Logistic analysis with normal weight obesity as the dependent variable.

Choices	n	(%)	Univariate analysis		Multivariate analysis[a]	
			OR	(95% CI)	OR	(95% CI)
Eating oily foods						
1	37	(14.8)	ref.		ref.	
2	129	(51.6)	1.811	(0.853–4.024)	1.843	(0.745–4.931)
3	66	(26.4)	3.009	(1.314–7.190)	2.599	(0.972–7.444)
4	17	(6.8)	1.136	(0.325–3.772)	1.072	(0.178–5.407)
P_{trend}			0.132		0.248	
Eating ultra-processed foods (UPF)						
1	25	(10.0)	ref.		ref.	
2	111	(44.4)	0.805	(0.335–1.968)	0.653	(0.226–1.948)
3	83	(33.2)	1.368	(0.558–3.422)	1.719	(0.588–5.256)
4	30	(12.0)	2.545	(0.864–7.837)	2.035	(0.579–7.478)
P_{trend}			0.012		0.014	
Drinking sugar-sweetened beverages						
1	29	(11.6)	ref.		ref.	
2	92	(36.8)	0.721	(0.310–1.699)	0.821	(0.294–2.402)
3	86	(34.4)	1.415	(0.609–3.341)	1.765	(0.632–5.198)
4	42	(16.8)	1.641	(0.635–4.319)	1.917	(0.606–6.332)
P_{trend}			0.039		0.041	

Choices: 1, few; 2, 1–2 days per week; 3, 3–4 days per week; 4, almost every day.
OR, odds ratio; CI, confidence interval.
[a] Adjusted for walking time, menstrual cycle, and stool softness.

Unhealthy practices, including a sedentary lifestyle and little physical activity are known to be influential causes of body fat accumulation in young individuals [14]. We compared daily physical activity between the groups using walking time and frequency of exercise per week. The walking time was approximately 15 min more in the NO-NWO than in the NWO group (no significant difference). Moreover, the percentage of respondents who reported having a habitual exercise routine three or more times per week was not significantly different between the groups. This was supported by a systematic review of sedentary behavior and obesity in youth and a systematic review of meta-analyses that found no evidence of a causal relationship between sedentary behavior and obesity in childhood [15]. However, a combination of aerobic and resistance exercise for adolescents with sarcopenic obesity, characterized by low muscle mass and high body fat percentage, has been reported to reduce body fat mass [16]. The present study cannot clarify whether obesity causes a sedentary lifestyle and lack of exercise, or vice versa, or whether the two are simply related.

The prevalence of constipation in adults worldwide is approximately 16% [17], and women are twice as likely as men to be at risk for constipation [18]. Obesity is suggested as a risk factor for constipation, but findings are inconsistent [18–23]. Individuals with obesity are reported to have unhealthy diets that lack sufficient vegetables, whole grains, fiber, and fluid intake, in addition to lack of exercise, which are risk factors for constipation [24]. Furthermore, the prevalence of diarrhea in individuals who are obese has been reported to be higher than the corresponding in those of standard weight. Excessive carbohydrate and fat intake in individuals who are obese is hypothesized to be the underlying etiology of chronic diarrhea [25–28]. Moreover, malabsorption of bile acids is suggested to be more common in individuals who are obese than in those with an average BMI [29,30]. These findings regarding the association between obesity and functional defecation disorders, such as constipation and diarrhea, classify obesity by the BMI, but no reports have examined NWO using the body fat percentage. Our study showed no difference in bowel movement frequency in the NWO and NO–NOW groups, but a higher percentage of participants with NWO reported hard stools and were also more likely to report soft stools.

Adiponectin is a bioactive substance derived from adipose tissue, and its secretion is negatively correlated with obesity or increased body fat percentage [31]. It has also been reported that adiponectin secretion does not fluctuate throughout the menstrual cycle in women who are obese [32]. Lack of adiponectin changes in women with obesity may be a factor explaining the complex mechanism behind obesity-related female infertility. In the present study, a higher proportion of participants with NWO had irregular menstrual cycles. This suggests the need for weight management interventions that take body fat percentage into consideration, to prevent fertility problems and achieve pregnancy and childbirth. In contrast, it has been reported that the potential protective effects of hormonal contraceptives and changes in adiponectin may be responsible for irregular menstruation in obesity and normal-weight obesity [33], but this is unclear in this study.

While it is inevitable that diet impacts the increase in body fat percentage [34], we focused on the effects of sugary beverage consumption and UPF consumption among different dietary habits. Several studies have reported that consuming sugar-sweetened beverages is a risk factor for overweight, obesity, and type 2 diabetes [35]. This study suggests that the consumption of sweetened beverages is associated with increased body fat percentage in Thailand, as the odds ratio for NWO among those who drink sweetened beverages almost daily was 1.9 times that of those who rarely drink them. A meta-analysis of longitudinal data revealed that children who consume one sugar-sweetened beverage daily are 55% more likely to be overweight than those who consume less [35]. Moreover, a previous report indicated that consuming sugar-sweetened beverages is associated with increased body fat percentage and body weight [36]. Furthermore, a meta-analysis of cohort studies reported that individuals who consume 1–2 servings of sweetened beverages per day have a 26% higher risk of developing type 2 diabetes than those who drink none or very little [37]. Restrictions on the marketing and promotion of sweetened beverages to children, regulations on the availability of sweetened beverages in schools, and increased taxation have been implemented in some regions [38,39]. Interestingly, some reports have suggested that proactive environmental measures that reduce exposure to taste cues, in the form of limiting the marketing of sugar-sweetened beverages, can reduce the risk of obesity in vulnerable populations [40]. However, this is not reflected in policies in the Asian region, including Thailand.

Fast food intake is associated with overweight, increased abdominal fat, impaired insulin and glucose homeostasis, lipid and lipoprotein disturbances, and induction of systemic inflammation and oxidative stress, and has also been reported to increase the risk of developing diabetes, metabolic syndrome, and cardiovascular disease [41]. This study found no association between NWO and the frequency of fast or snack food consumption. Nevertheless, UPF consumption was higher in the NWO group that reported almost daily UPF consumption. Both prospective cohort studies and randomized controlled trials have reported a higher risk of overweight or obesity in groups with a higher frequency than in groups with a lower frequency of UPF intake [42–44].

To our knowledge, this is the first study to accurately measure body fat percentage using the ACCUNIQ BC300 in young Thai individuals and to use the measurement results to examine related risk factors. In addition, the age range of the study was small because it was conducted on female university students. Therefore, our results were not affected by age or other factors associated with age. As the survey included questions regarding 23 different dietary habits, it was possible to examine the association of various dietary habits with NWO.

One of the limitations of this study was its cross-sectional nature. Thus, temporal relationships between the factors identified could not be inferred. Additionally, the respondents' lifestyle and eating habits were self-reported, which may have introduced bias. Moreover, the number of participants is also not large and the results of this study's survey of university students may not be representative of all young women in Thailand. To predict dietary risk for the progression of NWO among young Thai people, it is necessary to expand the target population beyond university students and perform longitudinal studies.

5. Conclusion

In this study, we found that 46.8% of young Thai women of normal body size (BMI, 18.5–25.0 kg/m^2) had NWO. Moreover, the NWO group had a higher frequency of UPF and added-sugar beverage consumption. Identifying the risk factors for NWO is essential to help individuals make lifestyle changes to prevent its progression and complications.

Author contribution

MK and PP co-conceptualized and co-designed the study. AP and SK coordinated and supervised data collection, and critically reviewed the manuscript. MK is the first author on this study. All contributors reviewed, edited, and approved the final submission and publication.

Ethical review and consent to participate

The study was conducted with the approval of the Otsuma Women's University Life Science Research Ethics Review Committee (date of approval: July 2, 2014). All the procedures involving human participants were performed according to the ethical standards of the institutional and/or national research committee and conformed with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. All participants provided informed consent by participating in the study.

Data availability

The authors confirm that the data supporting the findings of this study are available within the article or its supplementary materials.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Minatsu Kobayashi reports financial support was provided by Asahi Group Holdings Ltd.

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