ORIGINAL RESEARCH

Body fat percentage and Body Mass Index in association with menstrual irregularities in young adults. A cross-sectional study

Bryan Gervais de Liyis*, George David, Made Favian Budi Gunawan
Faculty of Medicine, Universitas Udayana, Denpasar, Bali, Indonesia

Article Info
Received Mar 26, 2024
Revised May 22, 2024
Accepted Jun 7, 2024
Published Aug 1, 2024

***Corresponding author:**
Bryan Gervais de Liyis
bryan.gervais
@student.unud.ac.id

Keywords:
BMI
Body fat
Menstrual irregularities
Reproductive health
Maternal health

ABSTRACT

Objective: Body fat percentage measures overall amount of fat as a proportion of total body weight. Basal metabolic index (BMI) is an unreliable predictor of body fat percentage as excess fat, lean, muscle, or bone density are indifferentiable. However, the relation between body fat percentage and BMI on menstrual characteristics are still unclear. The aim was to compare the correlations between body fat percentage and BMI towards menstrual characteristics.
Materials and Methods: A cross-sectional sample of 211 young adults was taken by means of cluster random sampling. Cross tabulations were performed between variables and Pearson's chi square value were observed. Multiple logistic regressions were performed to observe the odds ratio and 95% confidence interval.
Results: Body fat percentage was found to be associated with menstrual cycle (p=0.000) and menstrual bleeding period (p=0.000) but not daily pads usage, intermenstrual bleeding, and menstrual pains. Age was found not to correlate with any of the collected menstrual characteristic data. BMI was also found to be associated with menstrual cycle (p=0.008) and menstrual bleeding period (p=0.003). Further analysis showed that a one unit increase of body fat percentage was linearly correlated with increased of menstrual cycle by a factor of 1.109 days (p <0.01) and a decreased of menstrual bleeding period by a factor of 0.887 days (p <0.01).
Conclusion: Although both body fat percentage and BMI showed associations with menstrual cycle and menstrual bleeding period, only body fat percentage was linearly correlated with menstrual cycle and menstrual bleeding period.

How to cite: de Liyis BG, David G. Body fat percentage and Body Mass Index in association with menstrual irregularities in young adults. A cross-sectional study. Majalah Obstetri & Ginekologi (Journal of Obstetrics & Gynecology Science). 2024;32(2):80-88. doi: 10.20473/mog.V32I22024.80-88.

Highlights:

1. Body fat percentage and BMI were found to be associated with menstrual cycle and menstrual bleeding period.
2. The odds of having a prolonged menstrual cycle were increased by a factor of 1.109 with an increase of one unit of body fat percentage, while the odds of having a prolonged menstrual bleeding period was decreased by a factor 0.887 with an increase of one unit of body fat percentage.

INTRODUCTION

A study conducted among university students showed that BMI had the strongest correlation with body fat percentage when opposed to waist circumference, waist-to-height proportion, and body roundness index.[1] However, considering that BMI does not distinguish between fat mass and fat-free mass, the prevalence of obesity could be misrepresented. BMI is a poor indicator of personal fat mass as healthy people with a larger proportion of muscle might be mistakenly labeled as overweight. In a community study, women have a much higher fat mass relative to overall BMI than men.[2] There are several techniques for calculating the percentage of body fat, including magnetic resonance imaging (MRI), dual-energy X-ray absorptiometry (DXA), and air displacement plethysmography (ADP). However, their usage are extremely difficult in the typical clinical settings because to their massive cost, complexities, radiation hazard, and mobility due to size.[3,4]

By factoring in sex and age, the Clinica Universidad de Navarra-Body Adiposity Estimator (CUN-BAE) index is recommended as the best measure of body fat percentage. Using ADP as the gold standard in calculating body fat percentage, the study showed that the correlation between %BF derived from CUN-BAE formula was much more significant compared to %BF calculated from BMI and waist-to-height2 ratio.[5] Moreover, adipose accumulation has been demonstrated to be an effective predictor of mortality in overweight women and is known to result in a higher risk of acquiring obesity-related comorbidities, such as type 2 diabetes, cardiovascular disease and hormonal dysregulation.[6]

The menstrual cycle governs the fertile window during which conception happens. The fertility window is limited to six days every cycle which includes ovulation day and the five days prior.7 While ovum can only last up to 1 day in the female reproductive system, sperm can last up to 5 days. Since the menstrual cycle is the foundation for development of conception, menstrual cycle must be reviewed as a possible source of infertility. The precise effect of body fat percentage on menstrual cycles and menstrual bleeding has not yet been established, despite early research with limited sample numbers showing obesity connected with irregular menstrual cycles. Given the global growth in fat consumption and increasing obesity prevalence among reproductive women, the researchers found the need to establish the association between body fat percentage and menstrual irregularities.

MATERIALS AND METHODS

Ethics

The study was conducted in accordance with the accordance of the International Conference on Harmonization – Good Clinical Practice (ICH-GCP). Ethical clearance (208/UN14.2.2.VII.14/LT/2022) was obtain on February 2nd 2022 with protocol number 2022.01.1.0017 from Udayana Research Ethics Commission Unit. This study adopted a clustered random sampling method to select 211 participants from a public University in Indonesia between June 2022 and August 2022 as the respondents. Ten people from each class were selected randomly as participants.

Study design

The research was an analytical observational study using a cross-sectional method to find the relationship between body mass index and menstrual cycle irregularities. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist was used in this research.

Participants and study size

The minimum number of respondents needed is as shown below:

$$n = \frac{Z^2 p(1-p)N}{d^2(N-1) + Z^2 p(1-p)}$$

Therefore,

$$n = \frac{1{,}96^2(0.275)(1-0{,}275)(354)}{0{,}05^2(354-1) + 1{,}96^2(0.275)(1-0.275)} = 164.482 \sim 165 \text{ participants}$$

n: Minimum sample size
N: The number of approachable respondents
Z: Level of significance (1.96; 95% confidence interval)
p: Prevalence of overweight women (27.5%)
d: Limit of error or absolute precision (0.05)

The inclusion criteria were as follows: (1) Respondents had to consent to partake in the interview and show that they comprehended the research's topic, (2) Respondents are checked for their weight and height at the same point of time, and (3) Respondents have gone through puberty and were experiencing menstrual cycle. The exclusion criteria were as follows: (1) Respondents who changed their diet or exercise specifically in the past year, (2) Respondents who have been diagnosed with chronic or hormonal disorders affecting cycle regularity, (3) Respondents who have consumed any kind of hormonal birth control pills, and (4) Respondents who have been receiving medication for a condition for the past year.

Variables

The independent variable used in this study were BMI and body fat percentage. Body Mass Index is an index calculated based weight in kilograms divided by the square of height in meters obtained from the interview. The Asian Body Mass Index category was used to determine the appropriate group according to the BMI formula. BMI will be categorized into Underweight <18.5, Normal weight 18.5 – 22.9, and Overweight 22.9 - 29.9. The scale used was ordinal scale. Body fat percentage was calculated with CUN-BAE formula proposed by Gomez-Ambrosi et al.[8]

BF% = -44.988 + (0.503 × age) + (10.689 × sex) + (3.172 × BMI) - (0.026 × BMI2) + (0.181 × BMI × sex) - (0.02 × BMI × age)? (0.005 × BMI2 × sex) + (0.00021 × BMI2 × age)

Age was measured in years and sex was classified as men=0 and women=1. Body fat percentage was classified to Low fat percentage <25%, Normal body fat percentage 25% - 35%, and High body fat percentage >35%. The scale used was ordinal scale. Age was used as a control variable to normal hormonal change. The age of the respondent was calculated from the difference between the date of birth and the date of interview. Age was be categorized into <19 years, 19-20 years, and >20 years. The scale used was interval scale.

Dependent variables used were menstrual cycle and menstrual bleeding period. Menstrual cycle period is the distance of days between the menstrual cycle and the next cycle. The results of the answers are grouped as regular and irregular. Short menstrual cycle is indicated by a cycle of <21 days, the duration of normal menstrual cycle is 21 – 35 days, and longer duration of menstrual cycle is >35 days. The scale used was ordinal scale. Menstrual bleeding period is the number of days of active menstrual bleeding during menstruation. The results of the answers are grouped as regular and irregular. Regular results are indicated by menstrual duration of 3-7 days while irregular with menstrual duration <3 days or >7 days. Some potential confounding variables were nutritional intake, type of diet followed, physical activity, and stress.

Data measurement and bias

Height and weight were calculated in a consistent manner. Selection bias was prevented by using random sampling instead of non-random sampling, while measurement bias was avoided by Cronbach's Alpha reliability test. Cronbach's Alpha reliability test showed the data to be reliable with a value of 0.639 (>0.6).

Statistical methods

The mean, standard deviation (SD), and absolute frequencies (%) of the ordinal variables were used in a descriptive analysis to determine the characteristics of the individuals. In terms of quantitative variables, researchers used cross tabulation and Pearson chi square to assess the distribution correlations between age, BMI, and body fat percentage in relation to categories of menstrual cycle, menstrual bleeding, daily pads usage, intermenstrual bleeding, and menstrual pains. Researchers performed multivariate logistic regression adjusted for age, BMI, and body fat percentage. Researchers provided the odds ratio (Exp(B)), Wald chi square, estimate, and 95% confidence interval. This study used analytic models to examine the data, taking into account the numerous clusters and strata. The data were imported into Microsoft Excel, cleaned up, and coded before being exported to SPSS version 25 for analysis. A P value of less than 0.05 was used to determine the degree of significance.

RESULTS AND DISCUSSION

There were 211 participants in this study. The mean of weight, height, BMI, and body fat percentage were 55.50 (SD±9.49), 1.60 (SD±0.05), 21.75 (SD±3.39), and 33.16 (SD±6.61) respectively. The distribution of BMI category was 16.6% for BMI less than 18.5, 48.8% for BMI 18.5 – 22.9, and 34.6% for BMI more than 22.9. Similarly, 8.5% of participants had a body fat percentage of <25%, 55.9 % had a body fat percentage of 25-35%, and 35.5% had a body fat percentage of >35% (Table 1).

Table 1. Baseline characteristic of study population

	n (%)	Mean	SD	CI (95%)	
				Lower	Upper
Age		19.65	1.13	19.50	19.81
Menarche		12.07	1.23	11.90	12.24
Weight	211 (100)	55.50	9.49	54.21	1.60
Height		1.60	0.05	1.59	1.60
BMI		21.75	3.39	21.29	22.2
Underweight (<18.5)	35 (16.6)	17.34	1.01	-	-
Normal weight (18.5 – 22.9)	103 (48.8)	20.57	1.15	-	-
Overweight (>22.9)	73 (34.6)	25.53	3.92	-	-
Body fat percentage		33.16	6.61	32.26	34.06
Low fat %	18 (8.5)	22.34	2.40	-	-
Normal fat %	118 (55.9)	30.25	2.85	-	-
High fat %	75 (35.5)	40.32	3.96	-	-

The study collected menstrual characteristics which includes menstrual cycle, menstrual bleeding, daily pads usage, intermenstrual bleeding, and menstrual pains. Out of 211 participants, 12 women had menstrual cycle of less than 21 days (5.7%), 168 women had menstrual cycles of 21 – 35 days (79.6%), and 31 women had menstrual cycle of more than 35 days (14.7). In regards of menstrual bleeding period, 15 women experienced less than 3 days of menstrual bleeding per cycle (7.1%), 190 women experienced 3 – 7 days of menstrual bleeding per cycle (90.0), and 6 women experienced more than 7 days of menstrual bleeding per cycle (2.8%). Daily pads usage was used to estimate the amount of blood loss during menstrual bleeding period. Data showed that 23.2% of participants used 1 – 2 pads daily, 64.0% of participants used 3 – 4 pads daily, and 12.8% of participants used more than 4 pads daily. Intermenstrual bleeding was uncommon with a prevalence of 1.4% among participants. In terms of menstrual pains, 23.7% participants did not experience any form of pain during menstrual period. Out of all participants, 33.6% experienced menstrual pain at least once daily, 33.2% experienced menstrual pains at least twice daily, and 9.5% experienced menstrual pains more than twice daily (Table 2).

The Pearson' chi square test is a statistical analysis used to evaluate whether categorical variables are associated with each other in sets of ordinal/nominal attributes. Table 3 showed analytic cross tabulations between menstrual characteristics data compared with body fat percentage, BMI, and age. Both body fat percentage and BMI were found to have correlations only with irregularities in menstrual cycle ($p <0.05$) and menstrual bleeding period ($p <0.05$), but not daily pads usage, intermenstrual bleeding, and menstrual pains. Age was found not to correlate with any of the collected menstrual characteristic data, thus indicating that menstrual abnormalities development is not a normal physiological condition in early adulthood.

Table 2. Menstrual characteristic of study population

Menstrual characteristics	n (%)
Menstrual cycle	
< 21 days	12 (5.7)
21 – 35 days	168 (79.6)
> 35 days	31 (14.7)
Menstrual bleeding	
< 3 days	15 (7.1)
3 – 7 days	190 (90.0)
> 7 days	6 (2.8)
Daily pads usage	
1 – 2 pads	49 (23.2)
3 – 4 pads	135 (64.0)
> 4 pads	27 (12.8)
Intermenstrual bleeding	
Yes	3 (1.4)
No	208 (98.6)
Menstrual pains	
0	50 (23.7)
1	71 (33.6)
2	70 (33.2)
> 2	20 (9.5)

Table 3. Cross tabulation of body fat percentage, BMI, and age on menstrual characteristics

	Body fat percentage			Pearson Chi-Square	BMI			Pearson Chi-Square	Ages			Pearson Chi-Square	Total
	< 25% body fat percentage (%)	25 – 35 % body fat percentage (%)	> 35% body fat percentage (%)		Under-weight	Normal weight	Over-weight		< 19	19 – 20	> 20		
Menstrual cycle													
< 21 days	6 (50.0)	4 (33.3)	2 (16.2)	32.474 ***; p= 0.000	6 (50.0)	4 (33.3)	2 (16.7)	13.703 ***; p= 0.008	4 (33.3)	8 (66.7)	0 (0.0)	10.126; p= 0.052	12
21 – 35 days	12 (7.1)	99 (58.9)	57 (33.9)		27 (16.1)	85 (50.6)	56 (33.3)		37 (22.0)	92 (54.8)	39 (23.2)		168
> 35 days	0 (0.0)	15 (48.4)	16 (51.6)		2 (6.5)	14 (45.2)	15 (48.4)		2 (6.5)	17 (54.8)	12 (38.7)		31
Menstrual bleeding													
< 3 days	6 (40.0)	1 (6.7)	8 (53.3)	28.001 ***; p= 0.000	6 (40.0)	1 (6.7)	8 (53.3)	16.227 ***; p= 0.003	3 (20.0)	8 (53.3)	4 (26.7)	0.735; p= 0.947	15
3 – 7 days	12 (6.3)	114 (60.0)	64 (33.7)		27 (14.2)	101 (53.2)	62 (32.6)		38 (20.0)	106 (55.8)	46 (24.2)		190
> 7 days	0 (0.0)	3 (50.0)	3 (50.0)		2 (33.3)	1 (16.7)	3 (50.0)		2 (33.3)	3 (50.0)	1 (16.7)		6
Daily pads usage													
1 - 2	9 (18.4)	23 (46.9)	17 (34.7)	8.793; p= 0.066	14 (28.6)	18 (36.7)	17 (34.7)	8.285; p= 0.082	14 (28.6)	30 (61.2)	5 (10.2)	8.333; p= 0.080	49
3 - 4	7 (5.2)	81 (60.0)	47 (34.8)		17 (12.6)	73 (54.1)	45 (33.3)		24 (17.8)	71 (52.5)	40 (29.6)		135
> 4	2 (7.4)	14 (51.9)	11(40.7)		4 (14.8)	12 (44.4)	11 (40.7)		5 (18.5)	16 (59.3)	6 (22.2)		27
Intermenstrual bleeding													
Yes	0 (0.0)	1 (33.3)	2 (66.7)	1.367; p= 0.505	0 (0.0)	1 (33.3)	2 (66.7)	1.559; p= 0.459	0 (0.0)	2 (66.7)	1 (33.3)	0.795; p=6.72	3
No	18 (8.7)	117 (56.3)	73 (35.1)		35 (16.8)	102 (49.0)	71 (34.1)		43 (20.7)	115 (55.3)	50 (24.0)		208
Menstrual pains													
0	4 (8.0)	26 (52.0)	20 (40.0)	2.135; p= 0.907	10 (20.0)	21 (42.0)	19 (38.0)	1.973; p= 0.922	9 (18.0)	26 (52.0)	15 (30.0)	9.264; p= 0.159	50
1	6 (8.5)	39 (54.9)	26 (36.6)		10 (14.1)	35 (49.3)	26 (36.6)		14 (19.7)	37 (52.1)	20 (28.2)		71
2	5 (7.1)	42 (60.0)	23 (32.9)		12 (17.1)	36 (51.4)	22 (31.4)		19 (27.1)	38 (54.3)	13 (18.6)		70
> 2	3 (15.0)	11 (55.0)	6 (30.0)		3 (15.0)	11 (55.0)	6 (30.0)		1 (5.0)	16 (80.0)	3 (15.0)		20
Total													
	18 (8.5)	118 (55.9)	75 (35.5)		35 (16.6)	103 (48.8)	73 (34.6)		43 (20.4)	117 (55.5)	51 (24.2)		211

*p <0.05, **p <0.01, ***p<0.001

A parametric statistical test called the Wald chi squared test may determine whether a group of independent variables is considered to be significant for a model or not. The difference between the chi square and the walt chi square is the denominator: variances (Wald) vs means (Chi-square). In Wald chi squared test, body fat percentage showed linear correlations menstrual cycles (positive estimate), menstrual bleeding (negative estimate). No statistically significant linear correlation was found between BMI and any menstrual characteristics. Multiple logistic regression was conducted on numeric values of body fat percentage and BMI with menstrual characteristics. Multiple linear regression employs a straight line to evaluate the connection between a quantitative predictor variable and two or more independent variables. Exponentiating the coefficients yields odds ratios. The chances change for a unit increase in the predictor is predicted by Exp(B). The odds of having a prolonged menstrual cycle were increased by a factor of 1.109 with an increase of one unit of body fat percentage, while the odds of having a prolonged menstrual bleeding period was decreased by a factor 0.887 with an increase of one unit of body fat percentage (Table 4).

Table 4. Multivariate logistic regression of body fat percentage and BMI on menstrual characteristics

Variables		Wald Chi Square	Estimate	Exp(B)	CI (95%)	
					Lower	Upper
Menstrual Cycle	< 21 days	0.274	0.489	1.570	0.290	8.500
	21 – 35 days	29.503***	8.059***	214.695	30.932	1490.181
	> 35 days	-	-	-	-	-
Body fat percentage		11.241**	0.162**	1.109	1.052	1.169
BMI		0.410	0.265*	0.969	0.881	1.066
Menstrual Bleeding	< 3 days	11.951**	-20.081**	0.013	0.001	0.153
	3 – 7 days	2.485	-1.649	6.414	0.636	64.659
	> 7 days	-	-	-	-	-
Body fat percentage		12.026**	-0.410**	0.949	0.887	0.974
BMI		3.678	-0.752**	0.082	0.776	1.003
Daily pads usage	1 - 2	0.040	1.284	0.864	0.205	3.640
	3 - 4	14.985***	4.916***	19.981	4.386	91.024
	> 4	-	-	-	-	-
Body fat percentage		3.332	0.077	1.033	0.989	1.078
BMI		1.857	0.155	1.060	0.975	1.154
Intermenstrual bleeding	Yes	10.042**	-92.690	1.121E-5	0.724E-9	0.13
	No	-	-	-	-	-
Body fat percentage		5.061*	-1.835	0.826	0.700	0.976
BMI		5.418*	-3.176	0.726	0.554	0.951
Menstrual pains	0	9.752**	-1.902**	0.125	0.034	0.462
	1	0.852	-0.566	0.550	0.154	1.959
	2	4.230*	2.452**	3.941	1.067	14.562
	> 2	-	-	-	-	-
Body fat percentage		1.996	-0.024	0.973	0.937	1.011
		2.455	-0.052	0.943	0.876	1.015

*p <0.05, **p <0.01, ***p<0.001

An analytic cross tabulation was performed to observe the categorical distributions and correlations of variables. Our study found that Pearson chi squared showed significant correlation between both body fat percentage and BMI with menstrual cycle and menstrual bleeding period. Both body fat percentage and BMI did not show any correlation with any other menstrual characteristics. Moreover, the control variable age was found not to be correlated with any of the menstrual characteristic, showing menstrual irregularities not to be part of a normal physiological progression. Statistically, out of 31 participants who experienced a menstrual cycle of more than 35 days, 51.6% had a body fat percentage of more than 35% and 48.5% had an overweight BMI.

We further performed multiple linear regressions on both body fat percentage and BMI towards the menstrual characteristic to observe any linear association. The results showed that only body fat percentage was linearly significant towards menstrual cycle and menstrual bleeding period, and not BMI. We found that with an increase of 1% body fat percentage, the odds of having a prolonged menstrual cycle were increased by 1.109 times and the odds of having a prolonged menstrual bleeding period were decreased by 0.887 times. This suggested body fat percentage as one of the risk factors in developing menstrual cycle and menstrual bleeding period irregularities. These irregularities were caused by an imbalance in hormone levels which was characterized by a major increase in estrogen levels.

One of the most abundant androgen hormones was testosterone. Testosterone could be considered as a circulating pro-hormone and can be converted to 5a-dihydrotestosterone (DHT) with 5a-reductase types 1 and 2 enzymes, and to 17-beta-estradiol/estrogen with aromatase enzymes found in adipose tissue.[9] Fat tissue aromatized androgens to estrogen hormones. In the body, the aromatization process of androgens into estrogen occurred in the granulosa cells of fat tissue, so an increase in the amount of body fat tissue would cause an increase in the amount of estrogen hormone formed.[10] Eventually, it would disrupt the balance of reproductive hormones in the female body leading to menstrual irregularities. When fat mass increased showed by an increased body fat percentage, aromatase expression and estrogen levels also increased.[11] The main hormone acting on the proliferation phase was estrogen. The length of the menstruation varies owing to differences in the duration of the proliferation phase.[12] As estrogen was the major hormone in proliferation phase, the duration changed in response to hormonal level imbalance. The increase in adipose tissue caused abnormalities in the hypothalamic-pituitary-gonadal system, resulting in an increase in available estrogen levels.[13,14] In healthy premenopausal women, estrogen was synthesized in the ovaries following the control of gonadotropin-releasing hormone from the pituitary.

Aromatization of the A ring of testosterone to produce estradiol in the human body was mediated by the P450 aromatase enzyme.[15-17] This process produced the hormone estrogen in large quantities.[18] When levels of 17-beta-estradiol increased, negative feedback occurs to the anterior pituitary to decrease the levels of FSH and LH produced.[19] The increased in estrogen produced negative feedback to the hypothalamus to decrease GnRH secretion and the pituitary to decrease FSH and LH secretion. Subsequently, it also indirectly reduced the levels of 17-beta-estradiol and progesterone produced by ovaries.[20] Inconsistency of sex hormones in the body caused menstrual cycles irregularities due to dysregulation of the Hypothalamic-Pituitary-Gonadal (HPG) axis.[21] The reduced natural production of sex hormones had an uneven impact on the distribution of sex hormones.

We hypothesized that the delay in reaching the critical level of FSH and progesterone due to estrogen imbalance caused shorter menstrual bleeding periods. This was indicated by the correlation between high body fat percentage and menstrual bleeding period of less than 3 days. Research conducted by Kafaei-Atrian et al found that the duration of bleeding had a significant relationship with body weight, and waist, hip and arm circumference.[22]

However, this study was not comparable with other studies of menstrual duration. Several studies have shown an increase in the period of menstrual bleeding for more than 7 days in respondents with an obese body mass index.[22,23] The difference in these findings could be caused by differences in the distribution of fat in the body. General indicators of obesity such as body fat mass, body fat percentage, and body mass index did not significantly affect menstrual disorders, but fat mass in the upper body and the ratio of hip to thigh fat in obese women had more influence on irregularity in menstrual duration.[22,24] Recent studies had shown a positive relationship between changes in menstrual status and the distribution of central obesity.[25] In addition to the quantity of body fat, the distribution of body fat also played an important role in reproductive health. Visceral fat was metabolically more active than subcutaneous fat, and played a greater role in obesity-related chronic diseases. The characteristics of the menstrual cycle could be affected by a higher amount of visceral fat.[26] Researchers suspected that there were several factors that could influence this, namely differences in the number of research samples, differences in external stress, differences in nutrition, and differences in fat distribution. This study could not definitively determine whether there were any other additional factors that might affect menstrual characteristics. However, this study supported body fat percentage as a risk factor of menstrual irregularities and that managing body weight would serve as an effective treatment approach.

Nevertheless, this study still has several shortcomings, such as not reviewing internal factors (genes, stress, and hormones) and external factors (diet, drugs, and exercise) apart from the body mass index and fat percentage of the respondents. Further research is also needed to control for some confounding variables with multivariate analysis.

CONCLUSION

This study found correlations between body fat percentage and BMI towards irregularities in menstrual cycle and menstrual bleeding period. However, only body fat percentage was found to be linearly correlated with both menstrual cycle and menstrual bleeding period. An increase in one unit body fat percentage led to an increase of prolonged menstrual cycle by a factor of 1.109 and a decrease of prolonged menstrual bleeding by a factor of 0.887. Based on the results of this study, the researchers encourage further large-scale clinical trial studies and raise awareness on the effects of high body fat percentage towards menstrual cycle irregularities.

DISCLOSURES

Acknowledgment

Not applicable.

Conflict of interest

The authors declare that they have no competing interests.

Funding

No external funding was received.

Author Contribution

BGdL and GD analyzed and interpreted the patient data, performed examination and was a major contributor in writing the manuscript. The authors have read and approved the final manuscript.

REFERENCES

1. Del Moral-Trinidad LE, Romo-González T, Carmona Figueroa YP, et al. Potential for body mass index as a tool to estimate body fat in young people. Enferm Clin (Engl Ed). 2021;31(2):99-106. English, Spanish. doi: 10.1016/j.enfcli.2020.06.080. Epub 2020 Sep 12. PMID: 32933847.
2. Nuttall FQ. Body Mass Index: Obesity, BMI, and health: A critical review. Nutr Today. 2015;50(3): 117-28. doi: 10.1097/NT.0000000000000092. Epub 2015 Apr 7. PMID: 27340299; PMCID: PMC 4890841.
3. Belarmino G, Horie LM, Sala PC, et al. Body adiposity index performance in estimating body fat in a sample of severely obese Brazilian patients. Nutr J. 2015;14:130. doi: 10.1186/s12937-015-0119-8. PMID: 26717977; PMCID: PMC4697330.
4. Dominguez LJ, Sayón-Orea C, Gea A, et al. Increased adiposity appraised with CUN-BAE is highly predictive of incident hypertension. The SUN Project. Nutrients. 2021;13(10):3309. doi: 10.3390/nu13103309. PMID: 34684310; PMCID: PMC8537177.
5. Molina-Luque R, Yañez AM, Bennasar-Veny M, et al. A comparison of Equation Córdoba for Estimation of Body Fat (ECORE-BF) with Other prediction equations. Int J Environ Res Public Health. 2020;17(21):7940. doi: 10.3390/ijerph 17217940. PMID: 33138089; PMCID: PMC 7662211.
6. Zhang H, Tong TK, Kong Z, et al. Exercise training-induced visceral fat loss in obese women: The role of training intensity and modality. Scand J Med Sci Sports. 2021;31(1):30-43. doi: 10.1111/ sms.13803. Epub 2020 Sep 4. PMID: 32789898.
7. Kleinschmidt TK, Bull JR, Lavorini V, et al. Advantages of determining the fertile window with the individualised Natural Cycles algorithm over calendar-based methods. Eur J Contracept Reprod Health Care. 2019;24(6):457-63. doi: 10.1080/1362 5187.2019.1682544. Epub 2019 Nov 18. PMID: 31738859.
8. Gómez-Ambrosi J, Silva C, Catalán V, et al. Clinical usefulness of a new equation for estimating body fat. Diabetes Care. 2012;35(2):383-8. doi: 10.2337/dc11-1334. Epub 2011 Dec 16. PMID: 22179957; PMCID: PMC3263863.
9. Venkatesh VS, Grossmann M, Zajac JD, et al. The role of the androgen receptor in the pathogenesis of obesity and its utility as a target for obesity treatments. Obes Rev. 2022;23(6):e13429. doi: 10.1111/obr.13429. Epub 2022 Jan 27. PMID: 35083843; PMCID: PMC9286619.
10. Lee HK, Lee JK, Cho B. The role of androgen in the adipose tissue of males. World J Mens Health. 2013;31(2):136-40. doi: 10.5534/wjmh.2013.31.2. 136. Epub 2013 Aug 31. PMID: 24044108; PMCID: PMC3770848.
11. Mair KM, Gaw R, MacLean MR. Obesity, estrogens and adipose tissue dysfunction - implications for pulmonary arterial hypertension. Pulm Circ. 2020;10(3):2045894020952019. doi: 10.1177/2045894020952023. PMID: 32999709; PMCID: PMC7506791.
12. Thiyagarajan DK, Basit H, Jeanmonod R. Physiology. In: Menstrual Cycle. Treasure Island (FL): StatPearls Publishing LLC, 2022.
13. Tsatsanis C, Dermitzaki E, Avgoustinaki P, et al. The impact of adipose tissue-derived factors on the hypothalamic-pituitary-gonadal (HPG) axis. Hormones (Athens). 2015;14(4):549-62. doi: 10.14310/horm.2002.1649. PMID: 26859602.
14. Haque N, Tischkau SA. Sexual dimorphism in adipose-hypothalamic crosstalk and the contribution of aryl hydrocarbon receptor to regulate energy homeostasis. Int J Mol Sci. 2022;23(14):7679. doi: 10.3390/ijms23147679. PMID: 35887027; PMCID: PMC9322714.
15. Chan HJ, Petrossian K, Chen S. Structural and functional characterization of aromatase, estrogen receptor, and their genes in endocrine-responsive and -resistant breast cancer cells. J Steroid Biochem Mol Biol. 2016;161:73-83. doi: 10.1016/j.jsbmb. 2015.07.018. Epub 2015 Aug 13. PMID: 2627 7097; PMCID: PMC4752924.
16. Litwack G. Chapter 12 - Androgens. In: Litwack G. BT-H Hormones (fourth edition). Academic Press, pp. 287–311.
17. Avendaño C, Menéndez JC. Chapter 3 - Anticancer drugs that modulate hormone action. In: Avendaño C, Menéndez JCBT-MC of AD. Medicinal chemistry of anticancer drugs (Second edition). Boston: Elsevier, pp. 81–131.
18. Norman AW, Henry HL. Steroid hormones: Chemistry, biosynthesis, and metabolism. In: Norman AW, Litwack G. Hormones (third edition). San Diego: Academic Press, pp. 27–53.
19. Howard SR. Interpretation of reproductive hormones before, during and after the pubertal transition-Identifying health and disordered puberty. Clin Endocrinol (Oxf). 2021;95(5):702-15. doi: 10.1111/cen.14578. Epub 2021 Aug 8. PMID: 34368982; PMCID: PMC9291332.

20. Kauffman AS. Neuroendocrine mechanisms underlying estrogen positive feedback and the LH surge. Front Neurosci. 2022;16:953252. doi: 10.3389/fnins.2022.953252. PMID: 35968365; PMCID: PMC9364933.
21. Arao Y, Hamilton KJ, Wu SP, et al. Dysregulation of hypothalamic-pituitary estrogen receptor α-mediated signaling causes episodic LH secretion and cystic ovary. FASEB J. 2019;33(6):7375-86. doi: 10.1096/fj.201802653RR. Epub 2019 Mar 13. PMID: 30866655; PMCID: PMC6529333.
22. Kafaei-Atrian M, Mohebbi-Dehnavi Z, Sayadi L, et al. The relationship between the duration of menstrual bleeding and obesity-related anthropometric indices in students. J Educ Health Promot. 2019;8:81. doi: 10.4103/jehp.jehp_24_18. PMID: 31143798; PMCID: PMC6512224.
23. Mittiku YM, Mekonen H, Wogie G, et al. Menstrual irregularity and its associated factors among college students in Ethiopia, 2021. Front Glob Womens Health. 2022;3:917643. doi: 10.3389/fgwh.2022.917643. PMID: 36081684; PMCID: PMC9445616.
24. Nuttall FQ. Body Mass Index: Obesity, BMI, and Health: A Critical Review. Nutr Today. 2015;50(3):117-28. doi: 10.1097/NT.0000000000000092. Epub 2015 Apr 7. PMID: 27340299; PMCID: PMC4890841.
25. Chen X, Xi H, Ji L, et al Relationships between menstrual status and obesity phenotypes in women: a cross-sectional study in northern China. BMC Endocr Disord. 2020;20(1):91. doi: 10.1186/s12902-020-00577-6. PMID: 32571278; PMCID: PMC7310131.
26. Ray G. Association of dietary factors with menstrual cycle characteristics. J Gastroenterol Hepatol Res. 2015;4(6): 1649–52. Available from: http://www.ghrnet.org/index.php/joghr/article/view/1192.

`