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Correlation of Anthropometric Indices with Menstrual Characteristics and Female Reproductive Hormones

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Abstract **Original Research Article**

***Introduction*:** Excess body adiposity is an essential public health problem because it is associated with an increased risk of coronary heart disease, hypertension, type 2 diabetes mellitus, osteoarthritis, reproductive dysfunction, certain type of cancers and other disorders. The contribution of not only general measures of adiposity but also central measures of adiposity have been observed. ***Aim*:** To compare and correlate the body mass index BMI and central adiposity with menstrual characteristics and female reproductive hormones of oestrogen, progesterone and prolactin. ***Materials and Methods*:** This was a cross-sectional analytical study. 332 adult females aged between 20-50 were selected using the multi-stage sampling method. Data was collected on menstrual characteristic using questionnaire. Collection of blood samples was done using standard protocols. Data was analysed with SPSS version 25.0, differences in mean was done with analysis of variance ANOVA. Relationship among variables was done with Pearson's correlation, chi square $P \leq 0.05$ was statistically significant. ***Results*:** Menarcheal age was positively correlated with AC, WC, HC, W-HT-R, CI, BAI, AVI, ABSI and HI and was negatively correlated with WHR. Estrogen was negatively correlated with VAI, while progesterone was negatively correlated with ABSI. Prolactin was positively correlated with BMI, AC, WC, HC, WHR, W-HT-R, CI, BAI and AVI. ***Conclusion*:** Adiposity is linked to menarcheal age, oestrogen, progesterone and the hormone prolactin adiposity could be used to detect poor fertility outcomes or obesity induced hyperprolactinaemia.

Keywords: Obesity, Adiposity, Central, General, Hormones.

1 INTRODUCTION

The world health organization WHO in [1], estimated that more than 650 million people that are 18 years of age that are living with obesity have $\geq 30 kg/m^2$ While over 1.9 billion adults that is over age are overweight. Majority of this population are made of women of reproductive age [2]. Obesity known as a world -wide problem that causes a big economic burden, where it is estimated that obesity will sum about 48-66 billion dollars associated with the expenditure of health care by the year 2030 [3]. All over the world obesity have caused many deaths than underweight. Obesity is linked to various diseases like hypertension, atherosclerosis, diabetes mellitus, osteoarthritis and some type of cancers [4]. Studies suggest that obesity is associated with female reproductive problems, the strength of these associations differs by the obesity type and reproductive condition [5]. There are limited studies that shows correlation of anthropometric indices with menstrual characteristics and females reproductive hormones. The aim of this study was to determine correlate body mass index BMI and central adiposity with menstrual characteristics and female reproductive hormones of oestrogen, progesterone and prolactin among female residents of Port Harcourt in Rivers State.

2 MATERIALS AND METHODS

This was a cross-sectional analytical study conducted in females resident in Obio/Akpor and Port Harcourt local government areas in Rivers State Southern Nigeria among apparent non-pregnant adult females of reproductive age 20-50 years.

Ethical clearance was obtained from the research ethics committee of the University of Port Harcourt with reference number UPH/CEREMAD/REC/MM77/017. Informed consent of each subject was obtained.

2.1 Measurements of Anthropometric Indices

BMI was calculated as body weight (kg) divided by height (m2). Waist and hip circumferences was obtained using a measuring tape in standing position. Waist circumference was measured at

approximate midpoint between the lower margin of the last costal rib and the top of the iliac crest. Hip circumference was taken around the widest portion of the buttocks [6]. Waist-to-hip Ratio (WHR) was calculated from the above measurements by using the formula, WHR = waist circumference (cm) divided by hip circumference (cm). Waist to height ratio was calculated from the above measurements by using the formula, waist circumference (cm) divided by height (cm). The conicity index (C index) was derived using the following formula [7]CI $\frac{\text{Waist circumference (m)}}{0.109\sqrt{\frac{weight\,(kg)}{height\,(m)}}}$

Abdominal volume index: was calculated from waist and hip circumference
[2×(waist(cm))2+0.7cm×(w(cm) -hip(cm)-hip2)]/1000 [8]

Visceral adiposity index VAI (Females) = [waist circumference (cm)/ (36.58+ (1.88×BMI)] × (triglyceride /0.81) × (1.52/HDL-K

Body adiposity index BAI (Females) = [Hip circumference (cm) / height (m) 1.5]-18
A body shape index ABSI = WC / BMI2/3 × Height1/2
Hip index . $\frac{\text{Hip circumference (m)}}{Height\,in\,cm\sqrt{weight\,in\,kg}}$

2.2 Statistical Analysis

Carried out using statistical package for social sciences (SPSS) version 25.0. Differences in mean was determined using analysis of variance (ANOVA). Relationship or association between variables was determined using Pearson's correlation, chi-square, as appropriate. Significant values was determined at P≤ 0.05.

3. RESULTS

Table 1: Anthropometric characteristics of subjects in the study population

Parameters	Class	Frequency	Percentage %
BMI (kg/m^2)	<18.5 (underweight)	17	4.7
	18.5-24.99 (normal)	147	44.1
	25-29.99 (Overweight)	118	36.1
	>=30(Obese)	50	15.1
	Total	332	100.0
Abdominal circumference (cm)	<88cm	193	59.8
	>88cm	139	40.2
	Total	332	100.0
Waist circumference (cm)	<=88cm	182	56.5
	>88cm	150	43.5
	Total	332	100
Hip circumference (cm)	<97cm	136	42.1
	97-108cm	106	32.1
	>108cm	90	25.8
	Total	332	100.0
Conicity index (CI)	Low (1.04-1.36)	270	83.6
	Middle(1.37-1.50)	62	16.4
	Total	332	100.0
Abdominal volume index (AVI)	Optimal (<=0.700)	214	64.9
	Non-optimal (>7.00)	118	35.1
	Total	332	100.0
Waist to hip ratio (WHR)	<=0.85	93	26.8
	>0.85	239	73.2
	Total	332	100.0
Waist to height ratio (W-HT-R)	<=0.5	247	75.9
	>0.5	85	24.1
	Total	332	100.0

Table 2: Distribution of subjects according to menstrual characteristics

Parameters	Class	Frequency	Percentage (%)
Menarcheal age (years)	<12 years	56	15.4
	12-14 years	194	64.9
	>14 years	82	19.7
	Total	332	100.0
Menstrual cycle length (days)	<26 days	4	1.3
	26-30 days	251	77.3
	>14 days	77	21.4

	Total	332	100.0
Bleeding duration (days)	<4days	121	37.1
	4-5 days	186	55.5
	>5days	25	7.4
	Total	332	100.0

Table 3: Impact of menstrual cycle length on anthropometric indices among subjects (M±SD)

Anthropometric variables	Menstrual cycle length (Days)			P-values
	<26 days	26-30 days	>30 days	
BMI(kg/m^2)	27.98±3.23	25.36±4.23	24.7±4.30	0.206
Abdominal circumference (cm)	85.60±13.6	84.91±11.9	84.32±13.7	0.924
Waist circumference (cm)	85.20±.8.13	87.40±12.1	86.01±13.1	0.647
Hip circumference (cm)	105.0± 9.02	99.10±12.1	98.82±13.1	0.555
Waist hip ratio (WHR)	0.81±0.06	0.88±0.04	0.86±0.04	0.000*
Waist to height ratio (W-HT-R)	0.53±0.05	0.53±0.07	0.52±0.07	0.650
Conicity index (CI)	1.67±0.08	1.24±0.10	1.24±0.10	0.207
Visceral adiposity index (VAI)	1.52± 0.15	1.42± 0.72	1.47± 0.15	0.833
Body adiposity index (BAI)	33.47±3.34	29.83±6.10	29.67±5.89	0.393
Abdominal volume index (AVI)	14.93±2.85	15.68±4.27	15.26±4.60	0.722

Table 4: Impact of age at menarche on anthropometric indices of subjects (M±SD)

Anthropometric variables	Menarcheal age (years)			P-values
	<12 years	12-14 years	>14 years	
BMI (kg/m^2)	24.01±4.46	25.67±4.20	24.87±4.06	0.033*
Abdominal circumference (cm)	76.95±11.1	86.04±12.00	86.21±12.5	0.000*
Waist circumference (cm)	80.40±11.3	88.33±12.26	87.51±11.8	0.000*
Hip circumference (cm)	91.63±12.6	99.7±11.8	102.4±11.5	0.000*
Waist to hip ratio (WHR)	0.87±0.03	0.88±0.04	0.85±0.04	0.000*
Waist height ratio(W-HT-R)	0.49±0.07	0.54±0.07	0.53±0.06	0.000*
Conicity index (CI)	1.18±0.09	1.25±0.10	1.26±0.09	0.000*
Visceral adiposity index(VAI)	1.52±0.73	1.42±0.75	1.39±0.44	0.610
Body adiposity index (BAI)	26.15±6.58	30.18±5.91	31.39±4.93	0.000*
Abdominal volume index (AVI)	13.28±3.87	16.00±4.32	15.76±4.19	0.000*

Table 5: Correlation of anthropometric parameters, menstrual characteristics and female sex hormones

Parameters	Correlation coefficient	MA	MCL	BD	Estrogen	Progesterone	Prolactin
BMI(kg/m^2)	R	0.057	-0.084	-0.047	-0.001	0.073	0.171
	P-value	0.304	0.128	0.393	0.983	0.185	0.002**
Abdominal	R	0.215	-0.016	-0.032	-0.026	-0.022	0.129
circumference(cm)	P-value	0.000**	0.770	0.556	0.632	0.684	0.018*
Waist	R	0.186	-0.039	-0.004	-0.001	-0.032	0.181
circumference(cm)	P-value	0.001**	0.478	0.939	0.981	0.557	0.001**
Hip circumference	R	0.277	-0.033	0.015	-0.001	-0.016	0.115
(cm)	P-value	0.000**	0.551	0.779	0.979	0.765	0.037*
Waist hip ratio	R	-0.161	-0.038	-0.051	-0.008	-0.046	0.224
(WHR)	P-value	0.000**	0.491	0.353	0.883	0.406	0.000**
Waist height ratio	R	0.170	-0.056	-0.029	0.020	-0.002	0.188
(W-HT-R)	P-value	0.002**	0.308	0.595	0.722	0.977	0.001**
Conicity index	R	0.241	0.000	0.019	0.011	-0.093	0.131
CI)	P-value	0.000**	0.997	0.728	0.841	0.091	0.017*
Visceral adiposity	R	-0.002	0.005	-0.070	-0.108	-0.037	-0.012
Index (VAI)	P-value	0.976	0.932	0.205	0.050*	0.499	0.833
Body adiposity	R	0.242	-0.059	-0.023	0.034	0.037	0.118
Index (BAI)	P-value	0.000**	0.282	0.674	0.536	0.508	0.032*
Abdominal volume	R	0.187	-0.034	0.003	-0.003	-0.032	0.182
index(AVI)	P-value	0.001**	0.538	0.956	0.951	0.558	0.001**
A body shape	R	0.236	0.029	0.039	0.009	-0.121	0.077
Index (ABSI)	P-value	0.000**	0.597	0.482	0.870	0.028*	0.163
Hip index (HI)	R	0.387	0.018	0.049	0.020	-0.063	0.000
	P-value	0.000**	0.745	0.370	0.718	0.255	0.995

Table 1 This table shows the anthropometric characteristics of subjects which are BMI, abdominal circumference, waist circumference, hip circumference, WHR, W-HT-R, CI and AVI, shows their class frequency and percentage.

Table 2 Shows distribution of subjects according to menstrual characteristics which are menearcheal age, bleeding duration and menstrual cycle length, shows their class, frequency and percentage.

Table 3 Impact of menstrual cycle length on anthropometric indices: there was a significant difference between waist hip ratio WHR with menstrual cycle length.

Table 4 Shows impact of age at menarche on anthropometric indices: BMI and anthropometric indices varies significantly according to the age at menarche.

Table 5 Shows correlation of anthropometric indices with menstrual characteristics and female sex hormones. Menarcheal age was positively correlated with AC, WC, HC, W-HT-R, CI, BAI, AVI, ABSI and HI and was negatively correlated with WHR. Estrogen was negatively correlated with VAI. Progesterone was negatively correlated with ABSI. Prolactin was positively correlated with BMI, W.C, H.C, A.C, WHR, W-HT-R, C.I BAI and AVI.

4. DISCUSSION

Our study observed influence of adiposity on the age at menarche and the sex hormones oestrogens, progesterone and prolactin.

The significant differences between menstrual cycle length and WHR can be attributed to hormonal, regulation, metabolic health and reproductive efficiency. Women with a higher WHR are more likely to experience irregular and longer cycles, while those with lower WHR tend to have more regular cycle, reflecting better metabolic and hormonal balance [9].

The significant differences in BMI and adiposity indices with age at menarche results from hormonal, early menarche will result to prolonged exposure to estrogen, which aids the accumulation of fats and high BMI while late menarche is associated to delayed estrogen exposure, resulting in lower fat accumulation [10]. Nutritional and growth in childhood is linked with early menarche, resulting to a higher adiposity and BMI later in life [11]. Environmental and Genetic factors: Socio-economic status, the level of physical activity and habit also influence both menarche timing and long-term body composition.

Positive correlation between age at menarche and anthropometric indices AC,WC, HC, W-HT-R, CI, BAI, AVI, ABSI and HI and was negatively correlated with WHR This is consistent with a more current longitudinal study that was carried out by [12], that evaluated the relationship between sexual maturation, central obesity, excess weight in females and reported in females sexual maturation is positively correlated with weight and they also present greater central adiposity. The possible explanations that could be explained between menarcheal age and obesity is that high levels of pre-pubertal BMI will result to an increase in the availability and production of oestrogen through many mechanisms which will lead to early menarche. Another explanation is that early age at menarche was linked with higher levels of oestrogen that will lead to the increase in the deposition of fats in the peripheral adipose tissues [13]. The positive correlation between later menarche and increased adiposity indices is primarily driven by hormonal regulation and metabolic programming, genetic influences and inflammation-related molecular pathways.

Estrogen was negatively correlated with visceral adiposity index VAI this is similar to the findings of [14], were they reported a negative correlation between oestrogen and the central anthropometric indices of waist hip ratio WHR from their study. From this study the significant correlation between central obesity indices with oestrogen could be as a result of gain in weight of the body and an increase in adipose tissues specifically in the central region or area of the body can affect the steroid hormones like oestrogens, androgens balance of steroid and sex hormone binding globulin SHBG. Changes that occurs in the sex hormone binding globulin will result in the release of oestrogens and androgens in the target tissues. Protective role of estrogen in fat distribution**:** Estrogen help regulate fat storage, promoting subcutaneous fat accumulation that is fat under the skin rather than visceral fat which is fat found around organs is more harmful. Higher estrogen levels are associated with lower visceral fat, which reduces metabolic and cardiovascular risks. Impact of metabolic syndrome: Since visceral adiposity index is a marker of metabolic health, lower estrogen levels could indicate metabolic syndrome risk which is a cluster of conditions, including obesity, high blood sugar and abnormal cholesterol levels. Influence of Insulin Sensitivity: Estrogen plays a role in maintaining insulin sensitivity. A decrease in estrogen levels could result to higher insulin resistance, increasing the risk of diabetes.

A negative correlation between estrogen and visceral adiposity index suggests that higher estrogen levels may help reduce harmful visceral fat, promoting better metabolic and cardiovascular health. This highlights the importance of estrogen balance in women approaching menopause to reduce risk associated with metabolic disorders and obesity.

Progesterone was negatively correlated with a body shape index ABSI this is similar to the study of [14], they reported that the central obesity indices of

waist to hip ratio WHR were significantly negatively correlated with serum progesterone. These findings are also consistent with the findings of other studies where obesity have been linked with longer time to pregnancy and waist to hip ratio WHR was well established, as a more reliable cue to the history of female reproduction[15]. The significant correlation from this study between central adipose indices of a body shape index ABSI with progesterone could be explained by the strong association between central adiposity with sex hormones that includes progesterone. Progesterone and fat distribution: Progesterone influences fat storage and distribution through its interaction with oestrogens and androgens. Higher progesterone levels such as in the luteal phase of the menstrual cycle or pregnancy, promote subcutaneous fat deposition rather than visceral fat accumulation which may lower ABSI. It down regulates lipoprotein lipase in visceral adipose tissue while promoting fat storage in gluteofemoral regions. Progesterone enhances adiponectin secretion, which improves insulin sensitivity and reduces central fat accumulation. Progesterone and cortisol regulation: Progesterone acts as a competitive inhibitor of 11β-hydroxysteroid dehydrogenase type 1 (11β-HSD1), reducing cortisol activation in adipose tissue. Lower cortisol activity in visceral fat may decrease central fat accumulation and lower ABSI. Progesterone has anti-inflammatory effects that reduce chronic low-grade inflammation associated with obesity. The negative correlation between progesterone and ABSI is likely due to progesterone influence on fat distribution, insulin sensitivity, cortisol metabolism and inflammation. Higher progesterone level subcutaneous fat deposition and visceral adiposity, leading to lower ABSI and potentially lower metabolism.

A positive correlation was seen between prolactin body mass index BMI, abdominal circumference AC, waist circumference WC, hip circumference HC, waist hip ratio WHR, waist height ratio W-HT-R, conicity index CI, body adiposity index BAI, and abdominal volume index AVI this is consistent with [15] they demonstrated that there is enhanced secretion in obese patient, they evaluated patients with morbid obesity and dose. In addition a study on obese females proved that high body mass index BMI and visceral adipose tissues are linked with high secretion rate of prolactin [16]. This findings is in agreement with a previous report where a positive correlation was observed between waist circumference with prolactin [14]. The positive correlation could possibly suggest poor fertility outcomes or obesity-induced hyperprolactinemia. The significant correlation between central obesity indices of waist to hip ratio WHR with prolactin from this study is consistent with the findings of [17], they reported a weak positive correlation between waist to hip ratio WHR with serum prolactin. Some studies have reported a significantly high prevalence of obesity especially among patients with hyperprolactinemia, irrespective of the causes of hyperprolactinemia and the degree of obesity [18]. The proposed mechanism can be either the disruption of central nervous system dopaminergic response or the stimulation of lipogenesis [19]. Contrary to our findings of [20], they reported that prolactin levels were negatively correlated with waist circumference. Prolactin influences the balance by modulating appetite, metabolism and adipogenesis. It interacts with the hypothalamic leptin-melanocortin pathway, which regulates food intake. Lipogenesis and fat accumulation: Prolactin receptors are found in adipose tissue, where it stimulates lipogenesis increasing fat storage and body weight. Prolactin interacts with insulin and growth hormone pathways, influencing fat metabolism and glucose homeostasis. Chronic hyperprolactinemia is associated with increased insulin resistance signalling by inhibiting IRS-1 (Insulin receptor substrate -1) and P13K-Akt (Phosphoinositide, 3-kinase-AK+). Prolactin enhances lipoprotein lipase (LPL) activity leading or resulting to increased lipid uptake in adipocytes, particularly in the abdominal region.

Obesity has a negative impact on the reproductive potential because of the physiological alterations that occur in the hypothalamic-pituitary-ovarian axis, this can result to hormonal changes in the reproductive system [21].

5. CONCLUSION

This present study has clearly shown that adiposity affects the age at menarche because of the positive correlation between age at menarche and central obesity indices. BMI and central obesity indices can alter the level of female reproductive hormone prolactin because of the positive correlation with anthropometric indices which can result to obesity induced hyperprolactinaemia. This can also affect the female reproductive system and also fertility. Adiposity is associated with many health problems which also includes reproductive dysfunction. Regular screening test should be done in other to prevent excess body adiposity that can result to different health problems. Strict diet avoiding fatty and junk foods and exercise should be practiced.

Consent: It is applicable.
Ethical Approval: Ethical approval was sort for and was given by the research ethical committee of the university of Port Harcourt.

Competing Interests: Authors have declared that no competing interests exists.

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