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Correlative Studies on Anthropometric Indexes for Identifying Obesity in Pregnancy

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Authors' contributions

This work was carried out in collaboration between all authors. Authors CEO, EMA and PRCE designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors AAA, RNA and OMO managed the literature searches, analyses of the study performed the spectroscopy analysis and author JCI managed the experimental process. All authors read and approved the final manuscript.

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ABSTRACT

Currently, Obesity in pregnancy is a major health problem across the globe. In the past 20 years, prevalence of Obesity in pregnancy has doubled, leading to a wide range of complications in pregnancy. To foretell and manage this condition, clinicians and other health practitioners adopts the body mass index (BMI-obtained by dividing weight (kg) with height (m^2)) approach in diagnosing obesity in pregnancy. This study correlates, apart from BMI, other indices for which obesity could be identified in pregnancy. To achieve this, a total of 578 pregnant women at

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different ages and trimesters were ethically sourced from selected antenatal/ maternal homes in Enugu State of Nigeria. Using ANOVA, and the Pearson product Moment correlation coefficients, Statistical measure of association (correlation) were conducted after obtaining their mid upper arm (MUA), Calf (C), waist (W), and Waist/hip Circumferences respectively. Obtained results showed a positive correlation with aforementioned parameters of weight and height, which contrarily suggests that BMI, not MUA, C, W, or Waist/hip Circumferences increased in the same proportion as mean weight, which actually depends also on foetal weight in pregnancy.

Keywords: Pregnancy; anthropometric indices; identifying obesity; non-BMI indices.

1. INTRODUCTION

Latin for "heavy", one Scientific term for the state of Pregnancy is gravidity (adjective "gravid"), and a pregnant female is sometimes referred to as a Gravida[1].Also known as gestation, Pregnancy is the period during which one or more offspring develop inside a woman [1]. Pregnancy starts when a male's sperm fertilizes a female's ovum (egg), and the fertilized ovum implants in the lining of the uterus [2,3]. Though multiple definitions exist for the "initiation of pregnancy", Healthcare providers normally count the initiation of pregnancy from the first day of the woman's last menstrual period. This choice was a result of inability to discern the point in time when the actual conception happened. Thus, in *in vitro* fertilisation, gestational age is calculated by days from oocyte retrieval+ 14 days (the 14 days before the known time of conception) [4].

The symptoms and discomforts of pregnancy are those presentations and conditions that result from pregnancy, but do not significantly interfere with activities of daily living; nor pose a threat to the health of the mother or baby. This is in contrast to pregnancy complications. Sometimes a symptom that is considered a discomfort can be considered a complication when it is more severe. For example, nausea can be a discomfort (morning sickness), but if, in combination with significant vomiting, it causes water-electrolyte imbalance it is a complication (hyperemesis gravidarum) [3,4,5].

Although Obesity is defined as a condition of excessive body fat, it is usually assessed clinically through body mass index (BMI), obtained by dividing weight by height [6]. As pregnancy progresses, this index are influenced by gestational weight gain in lean tissues, thus limiting its use in pregnancy [7]. The use of pre-pregnancy BMI as an indicator of obesity in pregnancy, may be complicated by the fact that the weight used for this calculation is frequently self-reported, producing inaccuracies [8]. In pregnancy, however, BMI is seldom used to predict risk, probably because it is believed to be unduly influenced by the increasing uterine volume. Among the various standardized sites for measuring waist circumference, the minimal waist, being most distant from the growing uterus, is likely to be less influenced [8].

As one of the major symptoms and discomforts of pregnancy, several Studies have established over the past 20 years, that the Prevalence of obesity during pregnancy has doubled, and obesity is strongly associated with adverse gestational and perinatal outcomes [9]. This clearly underscores the need for adequate research as anthropometric measurements of Pregnancy induced Obesity taken in the antenatal period may help predict increased risk of gestational diabetes, preeclampsia, eclampsia, foetal macrosomia, post-term delivery, and caesarean sections [10].

1.1 Aim of Study

This study aimed at identifying some anthropometric parameters that can be used to index obesity in pregnancy. Specifically, the study investigated:

i. Some Anthropometric parameters – Weight, Height, Mid arm, Calf, Waist, and Hip Circumferences at different trimesters in Pregnant women.
ii. Identify the relationship between Body Mass Index (BMI) and the aforementioned Anthropometric Parameters (i. above) at different trimesters in pregnancy.
iii. Ascertain the normal limit/range of these Anthropometric parameters at different trimesters of Pregnancy.

2. METHODOLOGY

2.1 Resources and Sources

In this study, the following resources were used in the course of data collection:

2.2 Participants

Pregnant women, who were at different trimesters and ages, and had regularly attended antenatal screenings for selected maternity homes/hospitals, were recruited for this study.

2.3 Equipments

A standard weighing scale (for weight measurements), a meter rule, as well as a non-stretchable measuring tape for height and width mensuration were obtained for the exercise. Other necessary resources were the Urinometer (for urine analysis), review of obstetric Ultrasound results, as well as blood glucose monitoring devices. The use of Urinometer was informed by the need to ascertain the levels of metabolites in urine, so as to aid selection criteria for which previous findings/theories were based.

2.4 Protocol

Subjects for this Study were accessed after obtaining ethical clearance/approval from the Research and Ethics Committee of the University of Nigeria's Teaching Hospital (UNTH), Enugu, Nigeria. Ethical clearance was also obtained from the Hospital managements of Mother of Christ Specialist Hospital, St Patricks Hospital and Maternity, Colliery Hospital, as well as Balm and Gilead Specialist Hospital; all cited in Enugu State of Nigeria. Also, prior to actual investigation, subjects' verbal informed consent/permission was obtained. Those whose permission were not granted were left without contempt.

2.5 Selection Criteria

Selection of subjects for participation was based on available literature, with the pre supposition that; conditions such as pre-eclampsia, gestational diabetes, cardiac diseases, as well as HIV-AIDS may alter nutritional status and weight gain; including anthropometric indicators for obesity in pregnancy. Such indicators as; Weight, mid arm, Calf, Waist, and Hip Circumferences [11].

2.5.1 Inclusion criteria

Pregnant women who were sure of their dates, and were willing to participate in the Study were included. Prior to investigation, selected women were assumed to be healthy by physical observation.

2.5.2 Exclusion criteria

Pregnant women with raised blood pressure, pre-enclampsia, gestational diabetes, cardiac diseases, oedema, jaundice, fever, pallor, as well as HIV-AIDS were exempted from this study.

2.6 Procedure

First, an open questionnaire was administered to participants before actual examination. The questionnaire was designed to obtain information on required parameters. Such variables as; age, last menstrual period, parity, education status, occupation, past medical history, as well as current trimester were obtained.

Physical examination of subjects followed next with the goal of ascertaining the chances of being ill with oedema, jaundice, fever, and raised blood pressure, which certainly may have affected the results [11]. Routine investigations such as urinalysis, blood sugar, HIV screening, and obstetric ultrasound scans were then reviewed. This was necessary for exemption of women with diabetes, proteinuria, as well as twin gestation. All of the above measurements were taken between the hours of 9.00 and 12.00.

Weight was then measured while individual was minimally dressed using T160 Health scale. Height measurement followed with subject standing on the scale without any foot wears against a wall. Body mass index (BMI) was then calculated from obtained weight, divided by height (in meters square). Mid Arm circumference was then measured to the nearest millimetres, using non-stretchable tapes at the midpoint between the Acromion and Olecranon processes with the upper limb loosely hanged by the side. Measurements took place on the left arm.

Calf circumference was then taken at standing points where the calf's diameter was widest. This was also measured on the left. Waist circumference was measured by identifying the upper border of the hip bone and placing the stretchable tape round the subject at that level, with tape resting on the navel. Hip circumference was measured at the widest portion of the Gluteal region. Waist to hip ratio was calculated by dividing mean waist values by mean hip values; following three repetitive measurements at three different positions.

2.7 Statistical Analysis

Using SPSS version 15, Evaluation of collected data for statistical significance was carried out with ANOVA. P-values less than 0.05 were taken to be statistically significant.

3. RESULTS

Firstly, we present results in tabular form as obtained for all groups.

4. DISCUSSION

Table 1 Shows Socio-demographic distribution of respondents by Age. Noticeable from the table is that; mean ages of women (in years) for first, second, and third trimesters were 28.86±5.26, 28.11±4.29, and 28.39±4.20 respectively. This implies that the mean age of sampled women was highest between 1-3 months (1st Trimester), and lowest between 4-6 months (2nd Trimester) of gestation. Globally, there is a trend on maternal age as increasing from approximately 21years in the 1970s to 27 years in the last two decades [12]. These changes can be traceable to the interest and numerical increase of women in carriers on financial security than child bearing [13]. As seen in this study (Table 3), less than one-fifth of the participating women were pre-occupied with non-paid domestic duties. The rest were either full time students, self-employed, or had paid duties outside their homes. This agrees with the perspective of Bachrach, [13].

Table 1. Socio-demographic distribution of respondents by age (Trimesters)

Age	Group A (1st trimester)	Group B (2nd trimester)	Group C (3rd trimester)	Total
15-19	0(0%)	2(1%)	2(1%)	4
20-24	33(23%)	35(17%)	37(16%)	109
25-29	59(41%)	98(47%)	101(44%)	265
30-34	25(18%)	56(28%)	74(32%)	160
≥ 35	26(18%)	15(7%)	17(7%)	61
Total	**143(100%)**	**206(100%)**	**229(100%)**	**578**

Values are expressed in simple percentage for sampled groups by age range. For first, second, and third trimesters, mean ages of women (in years) were 28.86±5.26, 28.11±4.29, and 28.39±4.20 respectively. ANOVA proved significant at f < f-crit. =1.44, p=0.32

Table 2. Gravidity of women by group (Trimesters)

Gravidity	Group A (1st trimester)	Group B (2nd trimester)	Group C (3rd trimester)	Total
Primigravida	73(51%)	105(51%)	94(41%)	272
Gravida 2	39(27%)	43(28%)	62(27%)	144
Gravida 3	18(13%)	30(15%)	32(14%)	80
Gravida 4	8(6%)	12(6%)	23(10%)	43
Grand Multiparous	5(3%)	16(8%)	18(8%)	39
Total	**143(100%)**	**206(100%)**	**229(100%)**	**578**

Values are expressed in simple percentage for sampled groups by Gravidity. ANOVA proved an insignificant difference between groups as x^2 =3.39,f > f-crit. =0.18

Table 3. Occupation of women by group (Trimesters)

Occupation	Group A (1st trimester)	Group B (2nd trimester)	Group C (3rd trimester)	Total
Self Employed	53(37%)	52(25%)	62(27%)	167(29%)
Paid	33(23%)	43(21%)	60(26%)	136(23%)
Employments	20(14%)	43(21%)	38(17%)	101(18%)
Students	37(26%)	68(33%)	69(30%)	174(30%)
Total	**143(100%)**	**206(100%)**	**229(100%)**	**578**

Full time Students (30%) and self-employed (29%) were predominant occupations of respondent women in all three trimesters (Groups). Approximately 23% of the women had paid duties outside the homes as their occupation, while 18% were with non paid domestic Duties. Values are expressed in simple percentage for sampled groups by Occupation

Also from Table 4, the mean weight (in kilogram) is observed to have progressively increased from first to third trimester, while mean height remained the same. The explanation for this increase may be linked to the increasing size of the foetus as well as primary and secondary organs of the reproductive system; i.e. breast, Uterus, etc [14]. Also as seen in Table 4, BMI increased in the same proportion as mean weight. Hence, the use of BMI in identifying Obesity in pregnancy is not specific as weight increased as gestational age, while keeping height constant.

Table 4. P values of differences in mean (between Trimesters) as returned by ANOVA

Anthropometric parameters	Group A (1st trimester)	Group B (2nd trimester)	Group C (3rd trimester)	F	P
Age (Years)	28.86±5.26	28.11±4.29	28.39±4.20	1.44	0.32
Weight (kg)	72.48±13.58	75.91±13.59	81.15±14.34	18.35	0.008
Height (meters)	1.61±0.05	1.62±0.06	1.62±0.06	0.89	0.41
BMI (kg/m^2)	27.72±4.98	28.71±4.44	30.72±4.80	20.02	0.001
MUAC (cm)	30.47±3.88	30.23±4.03	30.15±3.85	0.31	0.74
CC (cm)	36.81±3.49	36.81±3.49	37.06±3.81	0.29	0.75
WC (cm)	92.06±10.28	97.57±10.78	106.46±12.00	79.16	0.001
HC (cm)	105.31±9.10	105.97±8.79	108.65±9.27	7.60	0.001
W/Hip Ratio	0.87±0.05	0.92±0.06	0.98±0.08	117.64	0.001
Remark	**Significant**	**Significant**	**Significant**		

BMI = Body Mass Index, MUAC = Mid Upper Arm Circumference, CC =Calf Circumference, W = Waist, WC = Waist Circumference, and HC = Hip Circumference

Values are expressed as mean ±Standard deviation of sampled groups (Trimesters) for obtained Anthropometric parameter. Between groups, ANOVA proved significant with mean ± SD values of 72.48±13.59kg (weight for 1st Trim), 75.92±13.60kg (weight for 2nd Trim), and 81.15±14.35 (weight for 3rd Trim) at f < f-crit. =p=0.08, p=0.41, and p=0.001 respectively

Table 5a. Correlations of various anthropometric parameters for group A (1st trimester)

Anthropometric parameter	First trimester					
	BMI	**MUAC**	**CC**	**WC**	**HC**	**W/Hip ratio**
BMI	1	.869(*)	.765(*)	.868(*)	.877(*)	.358(*)
MUAC	.867(*)	1	.686(*)	.778(*)	.822(*)	.272(*)
CC	.765(*)	.686(*)	1	.623(*)	.661(*)	.222(*)
WC	.868(*)	.778(*)	.623(*)	1	.839(*)	.657(*)
HC	.877(*)	.822(*)	.661(*)	.839(*)	1	.144
W/Hip Ratio	.358(*)	.272(*)	.222(*)	.657(*)	.144	1
Remark	*Correlation was significant at 0.01 level (2-tailed)					

BMI = Body Mass Index, MUAC = Mid Upper Arm Circumference, CC =Calf Circumference, W = Waist, WC = Waist Circumference, and HC = Hip Circumference

Values are expressed in decimals (Approx. to 3DP) as returned by Pearson Product Moment Correlation Coefficient

Table 5b. Correlations of various anthropometric parameters for group B (2nd trimester)

Anthropometric parameter	Second trimester					
	BMI	**MUAC**	**CC**	**WC**	**HC**	**W/Hip ratio**
BMI	1	.777(*)	.708(*)	.843(*)	.830(*)	.371(*)
MUAC	.799(*)	1	.710(*)	.781(*)	.774(*)	.338(*)
CC	.708(*)	.710(*)	1	.644(*)	.664(*)	.237(*)
WC	.843(*)	.781(*)	.644(*)	1	.829(*)	.652(*)
HC	.830(*)	.774(*)	.664(*)	.829(*)	1	.119
W/Hip Ratio	.371(*)	.338(*)	.237(*)	.652(*)	.206	1
Remark	*Correlation was significant at 0.01 level (2-tailed)					

BMI = Body Mass Index, MUAC = Mid Upper Arm Circumference, CC =Calf Circumference, W = Waist, WC = Waist Circumference, and HC = Hip Circumference

Values are expressed in decimals (Approx. to 3DP) as returned by Pearson Product Moment Correlation Coefficient

Table 5c. Correlations of various anthropometric parameters for group C (3rd trimester)

Anthropometric parameter	Third trimester					
	BMI	MUAC	CC	WC	HC	W/Hip ratio
BMI	1	.833(*)	.689(*)	.701(*)	.872(*)	.057
MUAC	.833(*)	1	.643(*)	.622(*)	.786(*)	.037
CC	.689(*)	.643(*)	1	.472(*)	.696(*)	-.074
WC	.701(*)	.622(*)	.472(*)	1	.641(*)	.658(*)
HC	.872(*)	.786(*)	.696(*)	.641(*)	1	-.153(**)
W/Hip Ratio	.057	.037	-.074(*)	.658(*)	-.153(**)	1
Remark	*Correlation was significant at 0.01 level (2-tailed) **Correlation was significant at 0.05 level (2-tailed)					

BMI = Body Mass Index, MUAC = Mid Upper Arm Circumference, CC =Calf Circumference, W = Waist, WC = Waist Circumference, and HC = Hip Circumference
Values are expressed in decimals (Approx. to 3DP) as returned by Pearson Product Moment Correlation Coefficient

Again, Table 4 showed the mid upper arm circumference result (in centimetres) of subjects as measured. Here, obtained values; 30.47±3.88, 30.23±23, and 30.15±4.81 were each higher than those reported by Ricalde et al. [5] for 1st, 2nd, and 3rd Trimesters respectively. This difference may be accounted for by the fact that their study involved a smaller group of women (97), or that our women are predisposed to having larger arms than Brazilian women. It could also be that the current trend of obesity in pregnancy has affected women in Enugu since their study was carried out over a decade ago.

From this study, MUAC showed an excellent correlation with maternal weight. However, there was no significant difference in the three study groups; suggesting that it is independent of gestational age. This is in line with those of Ricalde et al., 1998. Hence, MUAC is relevant in the identification of changes in size at pregnancy.

Haven been studied less extensively than MUAC, Tables 5a, 5b, and 5c shows a correlation between calf Circumference and MUAC. While Piperetta et al. (2002) found a significant difference between calf Circumference and MUAC in their longitudinal study amongst pregnant women in Columbia, this study found no significant difference between both, following correlation. The reason for this may be traced to the development of Oedema in late pregnancy since women with such ailment (oedema) where exempted from this study. Calf circumference may therefore be a pointer to the pre-pregnancy weight of a woman in the absence of oedematous swelling of the legs.

5. CONCLUSION

This study has shown that non-BMI indices like Mid upper arm circumference, Calf Circumference, waist Circumference, and Waist/hip Circumference have positive correlation with weight, which may prove helpful than BMI measurements in the bid to ascertain the onset of obesity, during pregnancy.

6. PROSPECT FOR FURTHER STUDY

Further studies can be done with a much larger sample size to identify more effective cut off points for obesity in pregnancy. Longitudinal studies can also be done to identify how these indices change in individuals during pregnancy. Studies that show the possible outcome of pregnancy at different cut off points of indices can also be done. These women can also be followed up to 6 weeks after delivery to ascertain the degree of pregnancy weight gain that was shed.

CONSENT

As per international standard or university standard, patient's written consent has been collected and preserved by the authors.

ETHICAL APPROVAL

As per international standard or university standard, written approval of Ethics committee has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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