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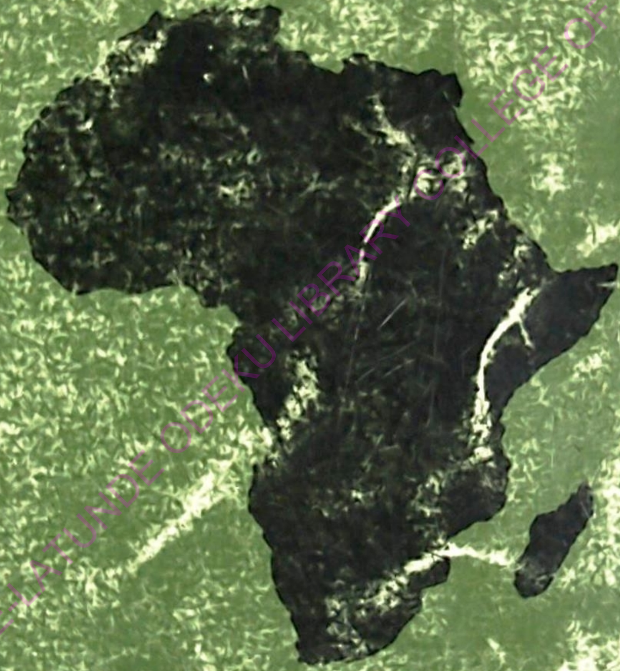

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Maternal weight and weight gain during pregnancy — can the arm circumference be used as surrogate?

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Summary

A survey among pregnant Nigerian women attending an antenatal clinic showed a strong correlation between the arm circumference and weight. The sensitivity and positive predictive value of mid-arm circumference <23 cm for first trimester weight of <45 kg was 85.7% and 54.5% respectively. In the second trimester, these values for mid-arm circumference of <24 cm and weight <50 kg were 55.6% and 32.3% respectively. The specificity was high, ranging up to 99.4%. The value of the screening was found to be higher amongst primigravidas. Mid-arm circumference was however found to be insensitive for monitoring of weight gain during pregnancy. Strips based on this principle may be useful as a screening tool especially for low cadre health workers to identify pregnant women considered nutritionally at risk.

Résumé

Une enquête auprès des femmes Nigérianes en grossesse, consultantes dans une clinique prénatale, montre une forte corrélation entre la circonférence du bras et le poids. La sensibilité et la valeur prédictive positive d'une circonférence du bras à mi-hauteur de <23 cm pour un poids au premier trimestre de <45 kg étaient de 85.7% et de 54.5% respectivement. Au deuxiéme trimestre, ces valeurs pour une circonférence du bras à mi-hauteur de <24 cm et pour un poids de <50 kg étaient de 55.6% et de 32.3% respectivement. La spécificité était élevée, remontant jusqu'à 99.4%. La valeur du contrôle se trouva plus élevée chez les primigravides. La circonférence du bras à mi-hauteur se révéla insensible en ce qui concerne le contrôle de l'accroissement du poids au cours de la grossesse. De bandes, fonctionnant selon ce principe, peuvent servir comme outil de contrôle, surtout pour les travailleurs de la santé de bas niveau, pour identifier les femmes en grossesse à risque nutritionnel.

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Introduction

The nutritional status of pregnant women is generally believed to be closely linked to perinatal outcome [1]. Increased incidence of premature births and preeclampsia has been reported in extremely underweight women [2,3]. Studies have found a higher incidence of hyperemesis gravidarum, instrumental delivery and prematurity in underweight women than controls of normal weight [4–6]. This is also supported by a study which found fewer preterm deliveries in women whose nutrition was improved by supplementation [7]. One study using multivariate analysis, showed that low pregnancy weight is associated with premature rupture of the membranes [8]. Poor maternal nutrition has also been linked to spontaneous abortions, stillbirths and congenital malformations [9].

The product of pregnancy is not spared: it has been found that maternal weight, (one of the measures of maternal nutritional status), specifically the pre-pregnancy weight, and the gestational weight gain [10], is linked to the birthweight of the infant.

One study demonstrated that women weighing more, had higher subscapular skinfolds, and that birth weights of offspring were higher in such women [11]. Another study also found that significant changes in the measurements of the upper arm circumference, triceps and subscapular skinfolds occur during pregnancy [12]. A previous study in Nigeria found that the arm circumference could be used to identify underweight non-pregnant women with a fairly good sensitivity and positive predictive value [13].

In Nigeria, coverage of the population with modern health care services is estimated to be no more than 35%, resulting in relatively small proportion of women receiving antenatal care, or delivery by trained personnel [14]. The maternal mortality ratio has been found to be very high, at 1500 per 100,000 live births, with values up to 1800 per 100,000 live births in some rural areas [15]. There is thus no gainsaying that appropriate technology has to be developed to improve maternal health services, especially for women in rural areas, patronizing non-medical workers in order to improve on quality and increase health care coverage in the spirit of primary health care.

This study was performed to find out if the arm circumference could be useful in screening and monitoring women during pregnancy in order to identify those who are deemed to be underweight or who have poor weight gain, so that appropriate nutritional and other interventions could be instituted by lower cadre health workers.

Materials and methods

The sample consisted of 1256 pregnant women attending the Antenatal Clinic at the Lagos University Teaching Hospital. Lagos is the commercial capital of Nigeria, and the Teaching Hospital caters mostly for upper lower class/middle class patients. The sample size reflects at least 40% of the women attending the clinic in a year. The sample was further stratified to reflect women in the three trimesters of pregnancy.

Another cohort of 200 women was followed from the first or early second trimester until delivery. At each visit, the gestational age (from the last menstrual period — LMP) was calculated, as well as measurements of weight and left arm circumference. The arm circumference was taken at a point 15 cm above the left olecranon, with the arm flexed at 90° and relaxed, using a non-stretchable tape measure. All measurements were taken by the same trained health worker using the same weighing scales and tape measure. The weights were measured with only the underclothes on. The heights were measured against a flat vertical surface without any shoes on. The reverse side of the tape was used before taking the actual reading in order to minimize bias. Women who had toxaemia, multiple pregnancies or overt oedema were excluded from the analysis. Ten percent of the sample measurements and other data were verified by one of the authors.

Results

In all, 1256 women were recruited into the study. The analysis reflects women whose data were complete for the various analyses, with the exception of the women whose data were dropped on account of toxaemia, multiple pregnancies or overt oedema. Besides these variables, there did not seem to be any other special characteristics that could be ascribed to women whose cases were dropped.

The characteristics of the women are shown in Table 1. The largest proportion of women (47.1%) were in the 25–29 year age group. There was a fairly even distribution of women between the three trimesters. Primigravidas made up 16.3% of the sample, and 10.4% of the women had had six or more pregnancies; 34.3% of the sample consisted of nulliparous women.

Some anthropometric measurements are shown in Table 1. The mean weight for the whole sample was 67.9 ± 12.6 (s.d.) kg. The mean weight for women in the first trimester was 64.3 ± 13.1 kg, second trimester 67.0 ± 11.3 kg and 72.4 ± 12.3 kg in the third trimester. The differences between the means were all significant at $P < 0.001$. The heights of the women varied from 1.42 m to 1.84 m. The mean height was 1.63 ± 0.05 m. Only 1.2% of the women had heights below 1.5 m. The left arm circumference (LAC) ranged from 19.4 cm to 44.0 cm, with a mean of 27.9 ± 3.5 cm.

Digital preference

Further analysis carried out on the data to determine digital preference showed a strong tendency for measurements to be recorded in

Table 1. Characteristics of the pregnant women

	No.	%
Age (years)		
15–19	12	1.0
20–24	181	15.2
25–29	650	47.1
30–34	322	27.1
35–39	101	8.5
40–44	14	1.2
Gestation (trimester)		
1st	344	29.7
2nd	426	36.8
3rd	388	33.5
Gravidity		
1	194	16.3
2–3	518	43.5
4–5	313	26.3
6–7	124	10.4
8–9	31	2.6
≥10	12	1.0
Parity		
0	409	34.3
1–2	511	42.9
3–4	211	17.7
5–6	53	4.4
7–8	6	0.5
≥9	2	0.[illegible]
Weight (kg)		
<50 kg	48	3.9
≥100 kg	14	1.1

	Mean weight (kg)		
	Whole sample	Primigravidas	Multigravidas
Gestation (trimester)			
All	67.9 ± 12.6	64.1 ± 12.1	68.7 ± 12.7
1st	64.3 ± 13.1	63.8 ± 17.1	64.4 ± 12.5
2nd	67.0 ± 11.3	62.3 ± 9.3	68.1 ± 11.4
3rd	72.4 ± 12.3	67.7 ± 9.9	73.4 ± 12.7

round kilograms, or whole centimetres — 73% of the weight, 49% of the arm circumferences and virtually all the height measurements.

Relationship between maternal weight (MW), age, height (H) and left arm circumference (LAC) in the sample

Product moment correlation coefficients were calculated for the various anthropometric and other variables (Table 2). On the whole, the strongest correlation was between the LAC and MW. The correlation coefficients ranged from 0.74 to 0.81 in all three trimesters, and were all significant at $P < 0.001$. The effect of maternal height on LAC/MW was also examined. The LAC/MW correlation coefficients were all quite high, ranging from 0.78 to 0.84, and significant at $P < 0.001$.

Table 2. Relationship between age, weight (MW), height (H) and left arm circumference (LAC) in the sample

	Gestation (trimester)											
	All			1st			2nd			3rd		
	No.	r	sig	No.	r	sig	No.	r	sig	No.	r	sig
MW/H	1181	0.34	0.001	343	0.34	0.001	421	0.36	0.001	378	0.38	0.001
MW/Age	1188	0.19	0.001	342	0.16	0.01	420	0.23	0.001	386	0.18	0.001
Age/H	1173	−0.11	0.001	342	−0.06	NS	417	−0.11	NS	376	−0.13	0.01
Age/LAC	1188	0.24	0.001	342	0.24	0.001	422	0.24	0.001	385	0.25	0.001
H/LAC	1179	0.09	0.01	343	0.06	NS	421	0.05	NS	377	0.13	0.01
MW/LAC												
Whole sample	1227	0.76	0.001	344	0.81	0.001	424	0.77	0.001	387	0.78	0.001
Primigravidas	192	0.75	0.001	46	0.83	0.00	74	0.76	0.001	67	0.74	0.001
Multigravidas	997	0.76	0.001	297	0.81	0.001	348	0.76	0.001	319	0.78	0.001

sig = level of significance; r = Pearson's coefficient of correlation.

Prediction of weight from LAC

A fairly strong relationship was demonstrated between LAC and MW. The cut-off for MW was set at three different levels — 45, 50 and 55 kg. A previous study on non-pregnant women gave a regression equation for LAC as 119.60 + 0.253 (MW), which gave an LAC of about 23 cm for MW cut-off at 45 kg. The LAC cut-offs were thus chosen as 23, 24, 25 and 26 cm. The specificity was high, ranging up to 99.4%. The sensitivities and predictive positive values are shown in Tables 3–5. When the MW cut-off was chosen at 45 kg, LAC cut-off at 23 cm seemed optimum, especially in the first trimester, with sensitivities ranging from 80 to 100% and positive predictive values ranging from 50.0% to 66.7%, the predictive positivity being best on primigravidas (Table 3).

At 50 kg cut-off for MW, the optimum cut-off for LAC appears to be at 24 cm. The sensitivities ranged from 46.1% to 100%, and positive predictive values from 21.9% to 66.7%. Again, this cut-off seemed to be of best use in the first trimester. The sensitivity drops from 100% in primigravidas to 65% in multigravidas, but the positive predictive values double from 33.3% to 66.7% (Table 4). LAC cut-offs of 25 cm and 26 cm raise the sensitivities, but concurrently, the predictive positive values decrease.

At 55 kg cut-off for MW (Table 5), the LAC cut-off seems optimum at 25 cm. The sensitivities ranged from 58.3% to 83.3% with positive predictive values of 23.1–77.8%. Again, use in the first trimester seems to yield the best compromise between sensitivity and positive predictive values, and the sensitivities seem better with primigravidas than multigravidas.

Use of LAC for weight monitoring

Of the cohort of 200 women who were followed from the first trimester and early second trimester to delivery, 171 records were found suitable for analysis. From these, the weight changes and corresponding arm circumference changes were calculated. Correlation coefficients between weight changes and arm circumference

Table 3. Test sensitivities (%) and positive predictive values (%) using cut-off for wei[illegible] by, left arm circumference (LAC)

Gestation (trimester)	LAC (cm) < 23 Sens	< 23 Pred pos	< 24 Sens	< 24 Pred pos	< 25 Sens	< 25 Pred pos	< 26 Sens	< 26 Pred pos
Whole sample								
All	85.7	17.1	85.7	6.5	85.7	3.0	100	2.2
1st	85.7	54.5	85.7	22.2	85.7	10.9	100	7.6
2nd	NC	NC	NC	NC	NC	NC	NC	NC
3rd	NC	NC	NC	NC	NC	NC	NC	NC
Primigravidas								
All	100	16.7	100	6.3	100	4.2	100	2.9
1st	100	66.7	100	33.3	100	20.0	100	14.3
2nd	NC	NC	NC	NC	NC	NC	NC	NC
3rd	NC	NC	NC	NC	NC	NC	NC	NC
Multigravidas								
All	80	19.0	80	7.4	80	2.8	100	2.0
1st	80	50.0	80	19.0	80	8.9	10	6.4
2nd	NC	NC	NC	NC	NC	NC	NC	NC
3rd	NC	NC	NC	NC	NC	NC	NC	NC

Sens = sensitivity; Pred pos = predictive positive value; NC = not calculable.

Table 4. Test sensitivities (%) and positive predictive values (%) using cut-off for weight 50 kg by left arm circumference (LAC)

	LAC (cm)							
	< 23		< 24		< 25		< 26	
Gestation (trimester)	Sens	Pred pos	Sens	Pred pos	Sens	Pred pos	Sens	Pred pos
Whole sample								
All	31.3	42.9	60.4	31.2	79.2	18.8	91.7	31.2
1st	25.9	63.6	59.3	59.3	74.1	36.4	88.9	26.1
2nd	33.3	66.7	55.6	32.3	83.3	19.7	94.4	14.0
3rd	NC	NC	NC	NC	NC	NC	NC	NC
Primigravidas								
All	50	33.3	87.5	21.9	87.5	14.6	87.5	10.0
1st	100	66.7	100.0	33.3	100.0	20.0	100.0	14.3
2nd	40	66.7	80.0	30.8	80.0	21.1	80.0	14.8
3rd	NC	NC	NC	NC	NC	NC	NC	NC
Multigravidas								
All	23.7	42.9	52.6	37.0	76.3	20.6	92.1	14.2
1st	20.0	62.5	65.0	66.7	72	40.0	88.0	28.2
2nd	30.8	66.7	46.1	33.3	84.6	20.0	100.0	14.1
3rd	NC	NC	NC	NC	NC	NC	NC	NC

Sens = sensitivity; Pred pos = predictive positive value; NC = not calculable.

Table 5. Test sensitivity (%) and positive predictive values (%) using cut-off for weight 55 kg by left arm circumference (LAC)

	LAC (cm)							
	< 23		< 24		< 25		< 26	
Gestation (trimester)	Sens	Pred pos	Sens	Pred pos	Sens	Pred pos	Sens	Pred pos
Whole sample								
All	19.2	82.9	40.4	65.6	64.2	48.0	78.8	35.7
1st	15.3	100.0	33.3	88.9	58.3	76.4	76.4	59.8
2nd	16.3	88.9	42.9	67.7	67.3	43.4	81.6	33.1
3rd	38.9	58.3	61.1	42.3	77.8	25.5	88.9	16.2
Primigravidas								
All	33.3	83.3	63.3	59.4	76.7	47.9	80.0	34.3
1st	33.3	100	44.4	66.7	66.7	60.0	66.7	42.9
2nd	25.0	100	75.0	69.2	75.0	47.4	83.3	37.0
3rd	50.0	60.0	66.7	36.4	83.3	31.3	83.3	23.8
Multigravidas								
All	14.9	81.0	34.2	72.2	59.6	48.2	78.1	36.0
1st	12.7	100.0	31.7	57.1	80.0	77.8	77.8	62.8
2nd	14.3	83.3	34.3	66.7	62.9	40.0	80.0	30.4
3rd	33.3	57.1	58.3	46.7	75.0	23.1	91.7	15.1

changes were also calculated. The results showed no significant correlation between weight change and arm circumference changes.

Discussion

It is generally assumed that gestational weight gain has four main components: laying down of fat stores, growth of breast and uterine tissue, increased plasma volume, and growth of the foetus, placenta and amniotic fluid [16]. Weight gain can thus be expected to increase subcutaneous fat and, therefore, arm circumference.

This study showed a fairly high correlation coefficient between LAC and MW. Coefficients were in the range of 0.74–0.83 and significant at $P < 0.001$ (Table 2). The coefficients decreased from the first to the third trimester, probably due to increases in weight in other organs that do not lead to increase in subcutaneous fat. Also, it is generally believed that the baby gains the most weight during the third trimester, and it can be assumed that maternal subcutaneous fat decreases during the third trimester (contributing to the increase in the baby's weight) in the presence of total gross body weight gain. This is supported by another study which showed that women gained subscapular fat during the first two trimesters and lost fat in the last trimester [11].

Whilst it is generally assumed that a pregnant woman should gain some weight during pregnancy, consensus has not been reached on the amount of weight, although a report stated a relative risk for intra-uterine growth retardation of 1.98 for gestational weight gains of less than 7 kg [10]. Using the WHO standard of weight (in non-pregnant women) of less than 45 kg as underweight [17], it can be assumed that a weight in the third trimester of 50 kg or less is underweight. Pregnancy weight cut-offs were chosen at 45, 50 and 55 kg. The corresponding sensitivities and predictive positive values are shown in Tables 3–5. The specificity for the method was high, ranging up to 99.4%.

It would appear that, in general, 23 cm would be a good cut-off to detect women whose weights are less than 45 kg during the first trimester of pregnancy. This would yield at the worst 80% sensitivity — that is, 20% of cases will be missed, and predictive positive value of 50% — that is, every other woman testing positive will be a false positive. There would be more false positives among multigravidas. This might not be entirely undesirable as multigravidas are more likely to take things for granted, based on 'previous experience', especially in this environment, and it would be good to identify those at possible risk for better care. On the other hand, the better sensitivities and predictive positive values amongst primigravidas would lead to better screening among this group during a pregnancy normally considered as 'high risk'.

For the second trimester, the weight cut-off ideally should be 50 kg. The optimum LAC cut-off for this appears to be 24 cm; with this, at the worst, about 50% of the women will be missed, and two out of every three women screening positive could be false positives. This may not be a cost too high for the individual and the community to bear, as there would still be time for the woman to increase her nutritional intake and adopt other appropriate measures to improve on her perinatal outcome. It would appear that for the 3rd trimester, LAC of 25 cm would miss 25% of women weighing less than 55 kg, with a very low positive predictive value. These values should of course be seen in the context of the health care delivery system. Where supervision of lower cadre workers is good, there would not be a great cost for being a false positive, since the supervisor can provide prompt back-up and reassurance where appropriate. Where supervision is not so good, a trip to the nearest health centre for palpation, weighing and other antenatal care services would in any case be beneficial to the woman, and is better than no service at all.

Monitoring of weight gain using the arm circumference does not appear very promising in this study. The correlations between weight changes and LAC changes were very poor and insignificant. The digital preference for the arm circumference was 49%; that is, there was a strong tendency to recording of lengths in whole centimetres. This could make the LAC even less sensitive for detecting changes in weight. Besides, changes in weight do not all result in changes in subcutaneous fat during pregnancy. It thus seems that LAC is better for screening than for monitoring. More field research needs to be done on the usefulness of this as a screening tool in the hand cadre health workers.

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References

1. Lechtig A, Klein R, Daza C, Kahn S. Effects of maternal nutrition on infant health: implications for action. J Trop Paediat 1982;28:273–86.
2. Roopnarinesingh S, Morris D, Chang E. The underweight Jamaican parturient. J Obstet Gynaecol Br Commonw 1971;78:379–82.
3. Tompkins TT, Wiehl D, Mitchell BN. The underweight hazard. Am J Obstet Gynaecol 1955;69:114–23.
4. Effiong EI. Outcome of pregnancy in the underweight Nigerian. Nig Med J 1979;9:727–9.
5. Lister U. Obstructed labour. J Obstet Gynaecol Br Emp 1960;67:188–98.
6. Harrison K. Childbearing, health and social priorities: a survey of 22,774 consecutive hospital births in Zaria, Northern Nigeria. Br J Obstet Gynaecol 1985;92:Suppl. 5:23–31.
7. Rush D, Kristal A, Navarro C *et al*. The effects of dietary supplementation during pregnancy on placental morphology, pathology and histophometry. Am J Clin Nut 1984;39:863–71.
8. Flood B, Naeye RL. Factors that predispose to premature rupture of the foetal membranes. JOGN-Nurs 1984;13:119–22.
9. Worthington-Roberts B. The role of nutrition in pregnancy course and outcome. J Environ Pathol Toxicol Oncol 1985;5:1–80.
10. Kramer MS. Determinants of low birth weight: methodological assessment and meta-analysis. Bull WHO 1987;65:663–737.
11. Adair LS, Pollitt E. Maternal anthropometric changes during pregnancy and lactation in rural Taiwanese population. Hum Biol 1983;55:771–87.
12. Jansen AA, Kusin JA, Thiuri B, Lakhani SA, 't-Mannetje W. Anthropometric changes during pregnancy in rural African women. Trop Geograph Med 1984;36:91–7.
13. Olukoya A. Identification of underweight women by measurement of the arm circumference. Int J Gynaecol Obstet 1990;31:231–5.
14. Federal Republic of Nigeria. National Health Policy and Strategy to achieve Health for all Nigerians. Lagos: Federal Ministry of Health, 1988.
15. Federal Republic of Nigeria. Health Profile. Lagos: Federal Ministry of Health, 1987.
16. Hytten F, Chamberlain G. Clinical Physiology in Obstetrics. Oxford: Blackwell Scientific Publications, 1980.
17. World Health Organisation. Rapid Community Health and Nutrition Survey. WHO Regional Office for Africa. AFR/NUT/84:1984;Rev. 2.

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