Anthropometrical measurements and maternal visceral fat during first half of pregnancy: a cross-sectional survey

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Abstract

Background Prenatal care is fundamental for achieving good results in the outcome of pregnancy, however, the coverage in Brazil is still low. In the impossibility of pre-gestational weight measure and subsequent body mass index (BMI) values, the others anthropometric measurements are useful and may be ideal for measuring the nutritional status of pregnant women, especially in low- and middle-income countries. The aim of this study was to assess the anthropometrical measurements during pregnancy and compared it to maternal ultrasound visceral adipose tissue.

Methods A cross-sectional study was conducted with pregnant women from the city of Porto Alegre (city), capital of Rio Grande do Sul (state), southern Brazil, from October 2016 until January 2018. Anthropometrical variables (weight, height, mid-upper arm circumference (MUAC), circumferences of calf and neck and triceps skin folds – TSF and subscapular skin folds – SBSF), and ultrasound variables (visceral adipose tissue – VAT and total adipose tissue – TAT) were collected. To verify the correlation of anthropometric and ultrasound measurements, non-adjusted and adjusted Spearman correlation was used. The study was approved by the ethics committees.

Results Among the 149 pregnant women, 54.8% (n=80) were white race. The age median was 25 years [21 - 31], pre-pregnancy BMI was 26.22kg/m 2 [22.16 – 31.21] and gestational age was 16.2 weeks [13.05 – 18.10]. The best measurements correlated with VAT and TAT were MUAC and SBSF, being anthropometric measurements with a higher correlation than pre-pregnancy BMI.

Conclusion It is possible to provide a practical and reliable estimate of VAT and TAT from anthropometric evaluation (MUAC or SBSF) that is low cost, efficient and replicable in outpatient clinic environment, especially in low- and middle-income countries.

Background

Prenatal care is characterized by a preventive practice recommended during pregnancy that provides a platform for important health-care functions, including health promotion, screening and diagnosis, and disease prevention (1). Complementary, it is shown that prenatal care visits are an essential component of services to improving maternal and newborn outcomes health (2). In Brazil, there are a significant regional disparities in the prevalence of women with prenatal visits (3). A research about pregnant users of the health services found that appropriateness of such care is still low; the most of women (75.8%) began prenatal care before the 16th gestational week. Specifically, in the South Region, the main related reasons for late booking of the first prenatal visit was did not know she was pregnant (4).

About mother’s anthropometry, the pre-pregnancy body mass index (BMI) is considered a reflection of maternal nutritional status, a currently the gold standard for measuring body fatness, while gestational weight gain is the aggregate change of mother’s, child’s and placental mass in the physiologic state (5, 6). A limitation of using the pre-pregnancy BMI is a pregnancy-associated weight gain and oedema, as well as late booking into antenatal care in population setting (6). The assessment of the amount of maternal fat deposits during pregnancy is limited by the impossibility of using ionizing radiation in computerized tomography and dual-energy x-ray absorptiometry, high cost and maintenance of nuclear magnetic resonance and low accuracy of bioelectric impedance analysis. Thereafter, the most commonly used method to measure maternal body composition changes in pregnancy is anthropometry, particularly use of skinfolds and circumferences (7, 8).

The use of ultrasound to measure distribution of maternal visceral adipose tissue (VAT) and total adipose tissue (TAT) is becoming useful because widely available in hospital-based settings and to predict risk to mother, with a higher risk of preeclampsia (9), insulin resistance, with alterations in HOMA-IR (Homeostasis Model Assessment) index (10, 11), higher chance of developing gestational diabetes mellitus (12), and metabolic diseases (13) and child, with a higher risk of preterm birth (9) and predicts newborn weight (14). It is worth mentioning that ultrasound is an easy, quick, safe, non-invasive, precise and reliable method to identify patients with adverse metabolic profiles (15). However, due to the easiness of execution and low cost, anthropometrical measurements, like mid-upper arm circumference (MUAC), may become alternative to the use of ultrasound devices (6, 16–18).

There were no found studies that assessed the association between predictive capacities of anthropometrical measurements against a reference method, like VAT and TAT obtained by ultrasound. The aim of this research is assessed the anthropometrical measurements complementary to pre-pregnancy BMI, comparing to findings of maternal VAT and TAT measured by ultrasound.

Methods

Design

The cross-sectional study included patients from 2016 to 2018 at the Ultrasound Department of Murialdo Health Center School that provides services of fetal medicine to Brazil's Unified Health System at the city of Porto Alegre, Rio Grande do Sul, Brazil.

Participants

For this study, single pregnancies, below twenty gestational weeks, with no evident fetal malformations, with no scars in abdominal cavity or in sites to use adipometer that hide the measurements and in course of routine scheduled appointments in Brazil's Unified Health System were included. The pregnant women who met the inclusion criteria were invited to participate and, after informed consent, were included with the completion of the maternal, clinical and epidemiological questionnaire.

Measures

The maternal anthropometric evaluation included assessment of anthropometric measures (weight and height) and evaluation of body composition. The participants were encouraged to use minimal clothing and no shoes and accessories like watches, bracelets and earrings. The body weight was measured in kilograms with portable electronic digital scale Marte® LC200-PP (São Paulo, São Paulo, Brazil) accurate to 50g. The height was measured in meters with extensible portable stadiometer Alturexata®(Belo Horizonte, Minas Gerais, Brazil). Maternal pre-pregnancy weight was collected from the prenatal pregnant chart or, in the absence of this information, was reported by the mother in the interview. The BMI (in kg/m^2) was calculated through the formula current weight divided by the current height squared. The classification used was pre-pregnancy BMI in underweight (BMI < 18.50 kg/m^2), adequate weight (BMI between 18.50 and 24.99 kg/m^2), overweight (BMI between 25.00 and 29.99 kg/m^2) and obese (BMI ≥ 30.00 kg/m^2), according to categories defined by World Health Organization (19).

Perimeters were measured with an anthropometric tape on the right trunk, arm and leg. Calf perimeter was measured at the greater circumference. The neck perimeter was measured at the midpoint between the clavicle bone and chin. MUAC was measured at the midpoint between the acromion and olecranon bones. Triceps (TSF) and subscapular skin folds (SBSF) were evaluated using a caliper (Lange®). The TSF was measured at the same levels as those of arm perimeter. The SBSF was measured two centimeters below the lower angle of the scapula bone. Anthropometric data were measured in duplicate by nutritionists, considering the arithmetic mean value among the measurements.

Measurement of maternal abdominal fat space was done with ultrasound device Toshiba Xario XG® with 3.5 mHz multi-frequency convex probe placed above the maternal umbilical scar, with low pressure, and automatic calipers were positioned from anterior aortic wall to linea alba performing the measurement of maternal abdominal depth. Two measurements were performed by only one specialist medical researcher, first during maternal inspiration and after during maternal expiration. The arithmetic mean of measurements was used for this research. The measurement of maternal subcutaneous adipose tissue (SAT) was made in the same position as that of VAT measurement, with the automatic caliper positioned from linea alba to dermal edge on the surface of maternal abdomen. The sum of VAT and SAT was used to estimate the total adipose tissue (TAT) during the evaluation.

Statistical analysis

Statistical analyses were performed through Statistical Package for Social Sciences (SPSS) 21.0. The level of significance was set at $p < 0.05$. Clinical, epidemiological and ultrasonographic data were presented as quantitative and categorical variables. The test of normality of variables distribution was made. Quantitative variables with asymmetric distributions were described as median and interquartile range. Categorical variables were reported as absolute frequency and percentage. In perform the associations between anthropometrical measurements and VAT and TAT measurements non-adjusted Spearman correlation (ρ) was used. After that, Spearman correlation was adjusted for factors associated to maternal adipose accumulation during pregnancy: number of children, pregnant age and gestational age.

Ethical Aspects

The study was approved in the Research Ethics Committees by Healthy Department of Porto Alegre under number 2.132.090 and in the Presidente Vargas Hospital under number 1.758.959. A written informed consent was obtained from pregnancies.

Results

The sample comprised 149 pregnant women with up to 20 weeks of pregnancy, with average age of 25 years [21 - 31], most of them white race (54.8%, n = 80), pre-pregnancy BMI of 26.22 kg/m² [22.16—31.21], with two children, on average [1 - 3] and gestational age average of 16.2 weeks [13.05—18.10]. The anthropometric measurements showed that the MUAC median was of 31.0 cm [28.0—35.0], calf perimeter median was 37.0 cm [35.0—41.0] and neck perimeter was 34.0 cm [32.0—36.0]. TSF and SBSF showed median of 31.5 mm [25.0—40.5] and 30.0 mm [21.0—40.5], respectively. The median VAT was 41.7 mm [34.5—52.8] and TAT was 61.1 mm [50.72—71.42], as shown in Table 1.

Table 2 shows the non-adjusted correlation across anthropometrical measurements and pre-pregnancy BMI values with ultrasound measurements of the maternal abdomen. We can observe that all body perimeters and skin folds showed to be statistically correlated to VAT and TAT. When analyzed individually, calf and neck perimeters and TSF indicate weaker correlations to detect VAT and TAT, when compared to pre-pregnancy BMI. However, MUAC and SBSF presented greater correlations with VAT and TAT, when compared to pre-pregnancy BMI.

Table 3 presents the adjusted correlation between anthropometric measurements, pre-pregnancy BMI with ultrasound measurements of the maternal abdomen. It is worth mentioning that even with the adjustment for variables associated to maternal adipose accumulation during pregnancy (number of children, maternal age and gestational age), the measurements of MUAC, TSF and SBSF maintained statistical significance (p<0.05), showing values higher than pre-pregnancy BMI.

Discussion

The study found that the MUAC and SBSF measures presented greater correlations with distribution of VAT and TAT, during the first 20 weeks of pregnancy, with a higher correlation than pre-pregnancy BMI value. It is important to emphasize that these anthropometric measurements are considered low cost, efficient and replicable in in under-resourced settings.

We consider that these findings are an advantage in case of unknown pregnancy or if the pregnant does not accurately remember the pre-gestational weight in clinical practice, making it difficult to correctly estimate pre-pregnancy BMI. Currently, pre-pregnancy BMI is the anthropometrical indicator of nutritional state most used as metabolic risk marker, because women who were overweight or obese were at increases the relative risk of preeclampsia (20, 21), cesarean section delivery (20), gestational diabetes (21), elevates the relative risk of intrauterine death (21) and more likely to be macrosomic (20). However, this index is limited with regard to the differentiation of adipose content (8), particularly in the central region, focus of the present study.

Reviews shown that the use of circumferences and skinfolds in the assessment of maternal nutritional state during the first weeks of pregnancy to detect associated metabolic risk (7, 8). A study made in Nigeria with 578 consecutive consenting pregnant showed that MUAC has a strong positive correlation with maternal weight, and could be used to identify obesity in women regardless of the age of pregnancy. The authors found that MUAC values of 33cm might be reliable cut off points for diagnoses of obesity throughout pregnancy (18). Another study in Central Malaysia with 498 pregnant women found that MUAC was inversely associated with an inadequate rate of gestational weight gain, as compared to normal gestational weight gain (16). Besides that, a cross-sectional study conducted in South Africa with 164 women showed a strong correlation between MUAC and pre-pregnancy BMI in pregnant women up to 30 weeks' gestation. The authors found that the MUAC cut-offs for obesity and malnutrition were calculated as 30.57 cm and 22.8 cm, respectively (6).

Along with the use of MUAC to determine maternal metabolic risk, SBSF proved to be used for detection of low weight newborns in prospective study made in Argentina that assessed 488 pregnant women. The authors found that low increase of skinfolds during pregnancy can indicate low birthweight, demonstrating significant consequences to the offspring health (22, 23).

On the other hand, the measurement of the different compartments of abdominal fat can be made with ultrasound that is a method with good accuracy to assess central adiposity (24), but the assessment of maternal central fat is not routinely performed in obstetric ultrasounds. The risk of adverse conditions caused by excess of fat, particularly visceral fat, to the pregnant woman and fetus health is clearly consolidated in the literature (9, 13, 20, 25, 26), therefore, the analysis precocious and low cost of the different fat compartments is highly important to the population (27).

Aligned with the Ministry of Health (Brazil) recommendations on resolute prenatal care (3) and in addition to the isolated capacity of MUAC and SBSF to detect the increase in amounts of maternal central fat, the inclusion of clinical anthropometry during the first 20 weeks of pregnancy can contribute to diagnose accuracy of maternal metabolic risk. Thus, their complementary use in clinical practice is justified, as well as their possible inclusion in protocols, for nutritional assessment during pregnancy. MUAC, particularly, become an alternative tool in screening of patients with metabolic risk in developing countries where monitoring of weight gain is not feasible due to limitations involving equipment (adipometer, for example), team or prenatal coverage.

It is well known that the early diagnosis of metabolic risk during the first half of pregnancy can bring benefit involving the suspicion of prevailing conditions associated to adipose tissue and that the early initiation of preventive and therapeutic measures can positively impact on maternal and fetal health, because morbidities from diagnosis delay are avoided (28). On the other hand, cases where maternal central fat estimate is appropriate, according to the suggested anthropometry, even among obese women, the high cost of following patients without metabolic risk and high risk prenatal could be avoided.

Strengths And Limitations

The study was conducted in low risk environment of primary health care and in a natural way without intervention with the sample. The data were obtained from routine follow-up of patients, which suggests that the findings can be easily transferred to the clinical practice. The most important aspect of the research was that the study's population comprised pregnant women at where the anthropometrical measurements can be become tools for decision making in clinical practice both in low and high obstetric risk environments. The low number of researchers involved in data collection minimizes possible mistakes of measurement. To this research, one researcher was in charge of ultrasound collections and two researchers were in charge of the general questionnaire and nutritional assessment. The aspects that may confer fragility to the study are the cross-sectional design that makes impossible the verification of the pregnancy outcome among those women with large amounts of central fat followed by the absence of blood sampling that allowed the serum diagnosis of metabolic risk in pregnancy, which is HOMA-IR added to fasting insulinemia, added to fasting glucose.

Conclusions

The study found that the greater anthropometric measurements correlated with VAT and TAT were MUAC and SBSF, being measurements with a higher correlation than pre-pregnancy BMI. It is possible to provide a practical, reliable and low-cost clinical estimate of ultrasound measurements of maternal central fat, which will help to identify women with high amounts of central fat, and, therefore, with high metabolic risk, during pregnancy, based on efficient and replicable anthropometrical examination. In the impossibility of pre-gestational weight measurement and subsequent BMI values, the anthropometric measurements found, MUAC and SBSF, are useful and may be ideal for measuring the nutritional status of pregnant women, especially in low- and middle-income countries.

Abbreviations

BMI - body mass index

HOMA-IR - Homeostasis Model Assessment

MUAC - mid-upper arm circumference

SAT - subcutaneous adipose tissue

SBSF - subscapular skin folds

SPSS - Statistical Package for Social Sciences

TAT - total adipose tissue

TSF - triceps skin folds

VAT - visceral adipose tissue

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Tables

Table 1. Maternal demographic, gestational and clinical characteristics

Variables	n (%)*	Median (IQ)
Age (years)	149	25.00 [21.00 – 31.00]
Number of pregnancies	143	02 [01 - 03]
Gestational age (weeks)	149	16.20 [13.05 – 18.10]
Race	146	
White	80 (54.80)	
Black	42 (28.80)	
Dark-skinned	24 (16.40)	
Body Mass Index (kg/m^2)	144	26.22 [22.16 – 31.21]
Arm circumference (cm)	147	31.00 [28.00 – 35.00]
Neck circumference (cm)	147	34.00 [32.00 – 36.00]
Calf circumference (cm)	146	37.00 [35.00 – 41.00]
Triceps Skinfold (mm)	147	31.50 [25.00 – 40.50]
Subscapular Skinfold (mm)	147	30.00 [21.00 – 40.50]
Central Visceral Fat (mm)	149	41.70 [34.50 – 52.80]
Total Central Fat (mm)	142	61.10 [50.72 – 71.42]

Descriptive table with medians [interquartile interval] and frequency (%).

Totals may not add up to 149 because of missing values.

Table 2. Non-adjusted correlation of anthropometrical measurements and pre-pregnancy body mass index values with ultrasound measurements of maternal abdomen

Variables		Mid-upper arm circumference (cm)	Calf circumference (cm)	Neck circumference (cm)	Triceps Skinfold (mm)	Subscapular Skinfold (mm)	Pre-pregnancy BMI (Kg/m²)
Central Visceral Fat (mm)	ρ	0.603*	0.498*	0.500*	0.541*	0.597*	0.546*
	n	147	146	147	147	147	144
Total Central Fat (mm)	ρ	0.792*	0.677*	0.656*	0.698*	0.740*	0.725*
	n	140	139	140	140	140	137

BMI - body mass index

Spearman correlation; *p value <0.05.

Totals may not add up to 149 because of missing values.

Table 3. Adjusted correlation of anthropometrical measurements and pre-pregnancy body mass index values with ultrasound measurements of maternal abdomen

Variables		Control Variables	Mid-upper arm circumference (cm)	Triceps Skinfold (mm)	Subscapular Skinfold (mm)	Pre-pregnancy BMI (Kg/m²)
***Central Visceral Fat* (mm)**	Coef. ρ	Without adjustment	0.603*	0.541*	0.597*	0.546*
	n=130	Number of children + Maternal age (years) + Gestational age (weeks)	0.598*	0.598*	0.602*	0.543*
***Total Central Fat* (mm)**	Coef. ρ	Without adjustment	0.792*	0.698*	0.740*	0.725*
	n=130	Number of children + Maternal age (years) + Gestational age (weeks)	0.752	0.712	0.719	0.691*

BMI - body mass index

Spearman correlation adjusted to number of children, maternal age and gestational age. **p* value <0.05.

Totals may not add up to 149 because of missing values.

Declarations

Ethics approval and consent to participate

The study was approved in the Research Ethics Committees by Healthy Department of Porto Alegre under number 2.132.090 and in the Presidente Vargas Hospital under number 1.758.959. A written informed consent was obtained from pregnancies.

Consent for publication

All participants have consented for publication of the result of this study. This was a written consent which was obtained during the same time of consent to participate.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to patient confidentiality reasons and as these data are being used in the development of other manuscripts.

Competing interests

The authors declare there was no personal or commercial conflict of interest in the performance of the present study.

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Authors' contributions

DCK: Substantial contributions to the conception and design of the research. Acquisition, analysis and interpretation of data for the research.

SM: Substantial contributions to the conception and design of the research. Reviewed the paper critically with important intellectual contribution.

LVD: Statistical evaluations and interpretation of results that enabled the achievement of the research.

JA de AM: Study conception and design.

A da SR: Substantial contributions to the conception and design of the research. Reviewed the paper critically with important intellectual contribution.

JRB: Substantial contributions to the conception and design of the research. Reviewed the paper critically with important intellectual contribution.

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