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Original Article

Changes in skinfolds and mid-upper arm circumference during pregnancy in Argentine women

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Abstract

This investigation describes the pattern of changes in mid-upper arm circumference (MUAC), triceps, biceps and subscapular skinfold thicknesses during the course of pregnancy, and its relationship with maternal and newborn outcomes. A prospective cohort of 1066 pregnant women were selected in seven different urban regions in Argentina. Measurements of MUAC were carried out at 16, 28 and 36 gestational weeks. In a subsample of 488 women, triceps, biceps and subscapular skinfold thicknesses were measured. Mean total increase in subscapular, tricipital and bicipital skinfolds from 16 to 36 weeks of gestation were 4.5, 3.6 and 2.6 mm, respectively. MUAC showed a mean increase of 1.7 cm in the same period. Overweight or obese women at the start of pregnancy had lower increases in all measurements compared with women with normal or low body mass index. Maternal anthropometry was related to birthweight; women who gave birth to infants of less than 3000 g had lower average values in all measurements than those who had normal birthweight infants. LMS curves for MUAC and skinfolds by gestational age are presented, which can be used as a reference to assess maternal nutrition status during pregnancy. MUAC, tricipital and subscapular skinfold for gestational age curves are proposed for monitoring maternal nutritional status during pregnancy. MUAC cut-off points of 24.5, 25.5 and 26.5 cm for 16, 28 and 36 weeks of gestation, respectively, are also proposed as a proxy to detect low birthweight.

Keywords: maternal anthropometry assessment, MUAC, skinfold thicknesses.

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Introduction

Anthropometric assessment has many advantages for nutritional evaluation: it is relatively simple, non-invasive and causes minimal discomfort to the patient. During pregnancy, maternal anthropometry assessment helps to identify women at risk of malnutrition and adverse pregnancy outcomes. Prepregnancy body mass index (BMI) and gestational weight gain are the most used anthropometric indicators because they are closely related to neonatal birthweight, and many charts have been generated for prenatal use in order to identify low or excessive weight gain. Nevertheless, in developing countries, prepregnancy weight may be frequently unknown and thus total weight gain cannot be calculated. In these cases, mid-upper arm circumference (MUAC) is recognized as an effective tool for screening purposes because of its strong correlation with body weight, but knowledge about its changes during the course of pregnancy is still limited (James *et al.* 1994; Pelletier *et al.* 1995; Kelly *et al.* 1996).

Skinfold thicknesses reflect subcutaneous fat stores that are used to meet the energy needs of the fetus and the mother during pregnancy and lactation. Changes in these measurements could also be used to assess maternal nutritional status, but as in the case of MUAC, few studies have evaluated its variation at different gestational ages (Licitra *et al.* 1998; Zekan *et al.* 1998; Araújo *et al.* 2009).

In late pregnancy, abnormal body weight gain can be related to clinical oedema; in such cases, both MUAC and skinfold measurements are alternative parameters to be used for nutritional assessment as they are not so influenced by leg oedema (Davison 1997; Reynolds 2003).

In this study, we describe the pattern of changes in MUAC, triceps, biceps and subscapular skinfold thicknesses during the course of pregnancy, and its relationship with maternal weight gain and newborn outcomes.

Population and methods

Subjects

Data were collected as part of a larger project designed to evaluate maternal weight gain during the course of pregnancy (Calvo *et al.* 2009). A prospective cohort of 1066 pregnant women was selected from antenatal clinics in seven different urban regions in Argentina with the aim of taking geographical variability into account, but without probabilistic sampling procedures. Data were collected from May 2005 to December 2006.

The study protocol was conducted pursuant to local ethical standards according to the Helsinki Declaration and was approved by the National Commission 'Salud Investiga' from the Ministry of Health. All the subjects involved signed an informed consent form.

Eligibility criteria included women aged 19–49 years with singleton pregnancies and a gestational age of less than 12 weeks at entry (or less than 16 weeks if prepregnancy weight was remembered), without clinical symptoms of any concomitant pathology at entry, parity 0–5, non-smokers or smoking less than five cigarettes per day and non-alcohol consumers or drinking less than 20 g of ethanol per day.

Study design

At the first visit, a questionnaire on social characteristics and a medical history were completed, and weight and height were measured according to standardized techniques; prepregnancy BMI (kg m^2) was calculated and classified according to the Institute of Medicine (1990). Gestational age was determined by dating the last menstrual period at the time of registration and was corrected by first trimester ultrasonographic examinations if the difference exceeded 5 days.

Serial measurements of MUAC were carried out with a flexible steel tape (Rosscraft Innovations Inc., Surray, Canada) at less than 16, 28 $\pm$ 2 and 36 $\pm$ 2 gestational weeks. In a subsample of 488 women, triceps, biceps and subscapular skinfold thicknesseses were measured by trained nutritionists using a Lange skinfold caliper according to standardized methods. The average of three measurements was recorded at each site.

Before data collection, a standardization procedure was carried out to homogenize anthropometric results among investigators; intra- and inter-observer errors

Key messages

- MUAC cut-off points of 24.5 cm at less than 16 weeks of gestation, 25.5 cm at week 28 and 26.5 cm at week 36 can be used as a proxy to detect both low maternal BMI and low birthweight when maternal weight gain cannot be calculated.
- Average MUAC of mothers of normal-birthweight infants was almost 2 cm higher during the whole course of pregnancy than that of mothers of low-birthweight newborns.
- MUAC increase was lower in overweight and obese women, compared with normal-weight or underweight mothers.
- Subscapular and tricipital skinfolds could also be used as a proxy to detect low-birthweight newborns and can be applied as complementary measurements to assess maternal nutritional status.

for skinfolds and circumference were calculated. Only three nutritionists with the highest precision were selected to perform skinfold measurements in a subsample of pregnant women. Neonatal sex, weight and height were obtained from hospital records.

Statistical analysis

Summary statistics (means and 95% confidence intervals) were calculated using Epi-Info software, version 3.2 [Center for Disease Control and Prevention (CDC), Atlanta, GA, USA]. Quantitative data were analysed by contrasting means using *t*-test or analysis of variance, and qualitative data were analysed by using the chi-square test. A significance level of $P < 0.05$ was used in all tests. Centile curves of MUAC and skinfolds by gestational age were developed for those pregnant women who delivered neonates with birthweights between 2500 and 4000 g. The LMS method, which summarizes the distribution by three curves representing the median (M), coefficient of variation (S), and skewness expressed as a Box–Cox power transform (L) (Cole 1990), was used to fit the smoothed curves (lmsChartMaker, The Institute of Child Health, London, UK).

Changes in MUAC and skinfolds were analysed as a function of initial maternal BMI and categories of birthweight.

The receiver operating characteristic (ROC) curves were applied to obtain cut-off points of MUAC at different gestational ages, based on the current data set plus data on BMI of the same women (Calvo *et al.* 2009). We intended to find the best cut-off point of MUAC in the different trimesters to predict low maternal BMI and/or risk of low birthweight [Epidat 3.1 (2006), Xunta de Galicia – PAHO/WHO, Washington DC, USA].

Results

Maternal and newborn characteristics for the whole population and the subsample with skinfolds measurements are summarized in Table 1. There were no differences in age, parity, educational level and prepregnancy weight between women in both samples. Although women from the subsample with skinfold measurements were taller, there were no differences in prepregnancy BMI classification with the whole population. There were minor differences in birthweight (58 g) and length (1.6 cm), but these are not conditions associated with sampling procedures, could not be prevented and are not likely to affect the interpretation of data.

According to the selection criteria, only 10.65% of women smoked (less than five cigarettes per day), and 1.97% developed diabetes and 2.62% developed pre-eclampsia during the follow-up.

Means and 95% confidence intervals for MUAC and skinfold measurements at 16, 28 and 36 weeks of gestation are shown in Table 2. The total number of subjects in the MUAC sample was 1066, 910 and 905 at weeks 16, 28 and 36, respectively. The subsample for skinfold measurements included 488 women at week 16; 431 women at week 28; and 415 at week 36.

Maternal anthropometry was related to birthweight; women who gave birth to infants of less than 3000 g presented lower average values for all measurements at 16, 28 and 36 weeks of gestation than mothers of normal birthweight infants. Total change in MUAC and skinfolds is shown in Table 3. The largest absolute gain in skinfold thickness from the first trimester (<16 weeks) to week 36 of gestation was in the subscapular area, with a mean increase of 4.5 mm; tricipital and bicipital skinfolds increased 3.6 mm and 2.6 mm, respectively.

MUAC showed a total average increase of 1.7 cm: the largest increase of 1.1 cm (95% confidence interval: 1.0–1.2 cm) was observed from the first trimester to 28 weeks, while the variation from week 28 to the end of pregnancy was only 0.6 cm (95% confidence interval: 0.5–0.7 cm).

MUAC and maternal weight were significantly associated as could be expected; the correlation coefficient was strongest in the first trimester ($r = 0.735$, $P < 0.001$), with a decrease throughout the course of pregnancy ($r = 0.718$ at 28 weeks and $r = 0.638$ at 36 weeks, $P < 0.001$). The association between increase in MUAC and total maternal weight gain was weaker ($r = 0.165$, $P < 0.001$).

In a previous publication, we generated and proposed the use of maternal BMI curves by gestational

Table 1. Sample characteristics

Maternal characteristics	MUAC sample ($n = 1066$)	Skinfolds sample ($n = 488$)	P-value
Age [years, mean (SD)]	27.0 (5.8)	27.6 (6.0)	0.060
Parity [mean (SD)]	1.04 (1.2)	1.06 (1.2)	0.760
Completed secondary school [n (%)]	795 (74.9)	385 (79.2)	0.065
Prepregnancy weight [kg, mean (SD)]	60.1 (12.5)	60.1 (12.0)	1
Height [cm, mean (SD)]	159.6 (6.7)	160.6 (7.0)	0.004
Prepregnancy BMI [kg m^2, mean (SD)]	23.3 (4.3)	23.1 (4.1)	0.270
Prepregnancy BMI classification [n (%)]			0.540
Underweight (BMI < 19.8)	160 (15.0)	84 (17.2)	
Normal weight (BMI 19.8–25.9)	682 (64.0)	314 (64.3)	
Overweight (BMI 26–29)	120 (11.3)	49 (10.0)	
Obese (BMI > 29)	104 (9.8)	41 (8.4)	
Total weight gain [mean (SD)]	11.9 (4.4)	11.7 (3.9)	
Newborn characteristics			
Mean birthweight (g)	3239.0 ± 492.4	3180.8 ± 474.9	0.030
Mean birth length (cm)	47.4 ± 3.8	45.8 ± 4.4	0.000
Birthweight classification [n (%)]			0.073
Low birthweight (<2500 g)	55 (5.16)	27 (5.53)	
Insufficient birthweight (2500–2999 g)	224 (21.01)	131 (26.84)	
Normal birthweight (3000–4000 g)	736 (69.04)	307 (62.91)	
High birthweight (>4000 g)	51 (4.78)	23 (4.71)	
Prematurity (less than 37 weeks)	61 (5.7)	23 (4.7)	
Infant gender, male (%)	48.8	47.5	0.630

MUAC, mid-upper arm circumference; SD, standard deviation; BMI, body mass index.

Table 2. MUAC and skinfolds at 16, 28 and 36 weeks of gestation according to neonatal birthweight (means and 95% confidence intervals)

	Gestational age <16 weeks	Gestational age 28 weeks	Gestational age 36 weeks
MUAC (cm)	25.7 (25.5–26)	26.9 (26.6–27.2)	27.5 (27.2–27.8)
Neonatal weight <3000 g ($n = 279$)	24.4 (23.9–24.9)*	25.5 (25.0–26.1)*	26.4 (25.7–27.0)*
Neonatal weight >3000 g ($n = 787$)	26.2 (25.9–26.5)*	27.4 (27.1–27.7)*	28.0 (27.6–28.3)*
Bicipital skinfold (mm)	10.1 (9.7–10.6)	11.7 (11.3–12.2)	12.8 (12.4–13.3)
Neonatal weight <3000 g ($n = 158$)	8.3 (7.7–8.9)*	10.1 (9.4–10.7)*	11.3 (10.6–11.9)*
Neonatal weight >3000 g ($n = 330$)	11.0 (10.5–11.5)*	12.5 (11.9–13.1)*	13.5 (12.9–14.1)*
Tricipital skinfold (mm)	19.2 (18.5–19.8)	21.5 (20.8–22.1)	23.0 (22.3–23.7)
Neonatal weight <3000 g ($n = 158$)	16.1 (15.0–17.3)*	18.6 (17.5–19.8)*	19.9 (18.8–20.9)*
Neonatal weight >3000 g ($n = 330$)	20.6 (19.8–21.4)*	22.8 (22.0–23.6)*	24.4 (23.6–25.1)*
Subscapular skinfold (mm)	19.4 (18.8–20.1)	22.4 (21.7–23.1)	24.2 (23.5–24.9)
Neonatal weight <3000 g ($n = 158$)	16.9 (15.8–17.9)*	19.9 (18.8–21.0)*	21.9 (20.9–22.9)*
Neonatal weight >3000 g ($n = 330$)	20.7 (19.9–21.5)*	23.6 (22.7–24.4)*	25.2 (24.3–26.1)*

MUAC, mid-upper arm circumference; **P-value less than 0.000* (t-test between neonatal weight <3000 g and ≥3000 g).

age to evaluate nutritional status during pregnancy (Calvo *et al.* 2009). According to this study, maternal BMI by gestational age lower than –1 standard deviation (SD) was related to low-birthweight infants.

MUAC cut-off points of 24.5 cm at gestational age of less than 16 weeks, 25.5 cm at 28 weeks and 26.5 cm at 36 weeks of gestation were selected after applying ROC. Sensitivity of these values in relation to a

Table 3. Increase in MUAC and skinfold thickness by maternal prepregnancy BMI classification (mean, 95% confidence interval)

Prepregnancy weight classification* (BMI kg m^2)	Increase in MUAC† (cm)	Increase in bicipital skinfold† (mm)	Increase in tricipital skinfold† (mm)	Increase in subscapular skinfold† (mm)
Total sample	1.7 (1.5–1.8)	2.6 (2.3–2.8)	3.6 (3.2–4.0)	4.5 (4.1–4.9)
Underweight	2.4 (2.1–2.7)	3.1 (2.7–3.5)	5.0 (4.3–5.7)	6.4 (5.6–7.2)
Normal weight	1.9 (1.7–2.1)	2.7 (2.4–3.0)	3.8 (3.3–4.3)	4.7 (4.3–5.2)
Overweight	0.9 (0.4–1.3)	2.0 (1.0–3.1)	1.8 (0.4–3.1)	2.2 (0.8–3.6)
Obese	0.6 (0.05–1.1)	0.6 (−1.1–2.3)	0.4 (−1.5–2.2)	0.6 (−1.0–2.3)

MUAC, mid-upper arm circumference; BMI, body mass index; *Underweight: BMI < 19.8, normal weight: BMI 19.8–25.9, overweight: BMI 26–29, Obese: BMI > 29. †P-value less than 0.000 (analysis of variance between categories of prepregnancy weight classification).

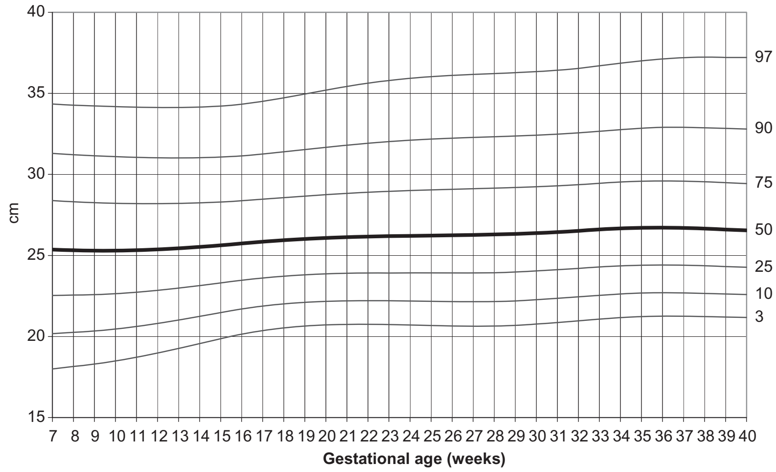

Fig. 1. Mid-upper arm circumference centiles according to gestational age.

maternal BMI < −1 SD was 88.0%, 81.3% and 85.4%, respectively. Specificity was higher for the cut-off at the beginning of pregnancy (71.3%) and decreased at the second and third trimesters (69.8% and 63.5%, respectively). These cut-off points were also a proxy to predict neonatal birthweight lower than 3000 g with sensitivity in the range of 48%–56%. Areas under the ROC curves varied from 60% to 62% for birthweight lowe than 3000 g and from 82% to 87% for prediction of a maternal BMI < −1 SD at different gestational ages.

LMS curves of MUAC, tricipital and subscapular skinfolds for gestational age were calculated using measurements throughout pregnancy of only those women who delivered newborns with birthweights between 2500 and 4000 g (Figs 1–3). LMS curves were based on the serial measurements of 948 women for MUAC, having a total of 3412 individual measurements and 436 women for skinfolds, with 1266 individual points. The programme considers each individual point as cross-sectional, and even if points are clustered around 4-week intervals, there is some spread over the entire period. Specifications of the model that provided the best fit to generate the curves were: no age power transformation; degree of freedom (d.f.) (M) = 7; d.f. (S) = 3, and d.f. (L) = 3.

Discussion

In developing countries, pregnant women usually initiate their prenatal care after the first months of pregnancy and thus prepregnancy weight can be unknown; in such cases, total weight gain is difficult to determine. Therefore, the value of MUAC has been evaluated in many studies as an alternative or complementary measurement during prenatal care (Pelletier *et al.* 1995; Ogbonna *et al.* 2007; Thame *et al.* 2007). Khadivzadeh studied 2000 healthy women at

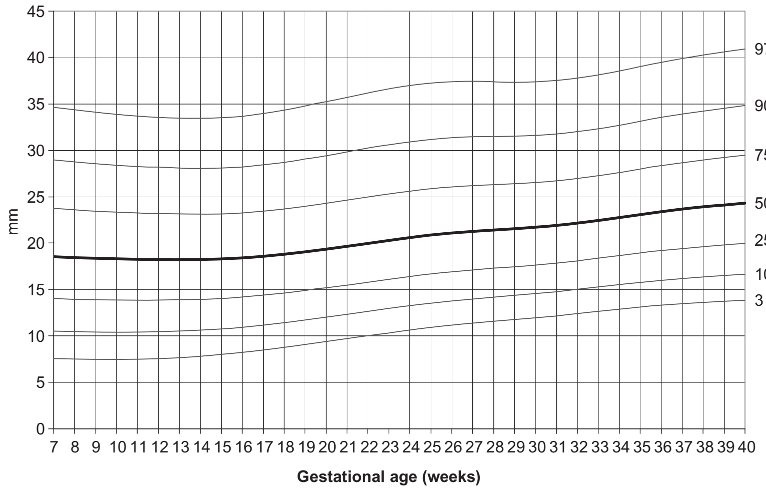

Fig. 2. Subscapular skinfold centiles according to gestational age.

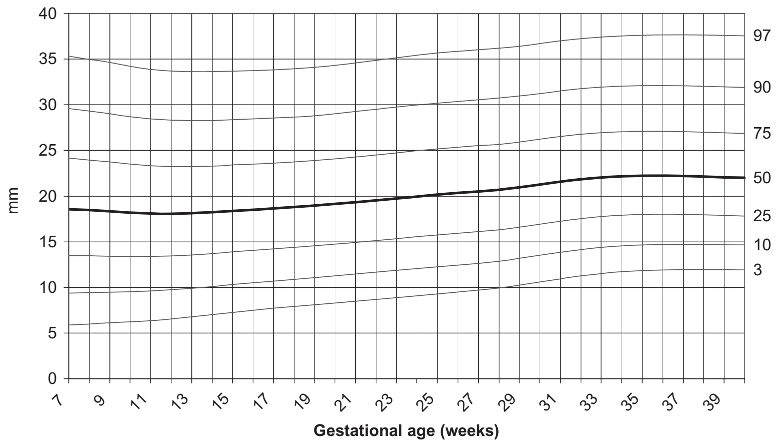

Fig. 3. Tricipital skinfold centiles according to gestational age.

reproductive age in Iran and found a strong correlation of MUAC with maternal weight and BMI (Khadivzadeh 2002). Olukoya *et al.* studied the correlation between MUAC and women's weight in Nigeria; they found that a value of MUAC lower than 23 cm had a sensitivity of 85.7% and a positive predictive value of 54.5% for a first trimester weight under 45 kg (Olukoya 1990; Olukoya & Giwa-Osagie 1991).

Although a positive relationship between MUAC and birthweight has also been reported in many studies (Pelletier *et al.* 1995; Ricalde *et al.* 1998; Janjua *et al.* 2008), there is no consensus about the cut-off point that can be associated with an increased risk of low or insufficient birthweight, prematurity or inadequate maternal weight gain. In Mozambican pregnant women, MUAC below 25 cm has been proposed as a warning of malnutrition and below 23 cm as a strong indicator of malnutrition. Researchers suggest that, particularly during early pregnancy, MUAC can be a better predictor of prematurity than weight or BMI (Liljestrand & Bergström 1991). Ojha & Malla (2007) found that low birthweight was twice more common in Nepalese pregnant women with MUAC lower than 22 cm, and the same figure has been proposed to identify pregnant women in South Africa who can be at risk of adverse pregnancy outcomes (Kruger 2005).

In our research, we suggest MUAC cut-off points from 24.5 cm at the first weeks of pregnancy to

26.5 cm at the end of gestation as a proxy to identify both maternal BMI lower than −1 SD and neonatal weight lower than 3000 g. These values were rounded to the next 0.5 cm of the selected point in the ROC curves in order to be easily remembered. Although these figures are higher than those proposed by other researchers based on populations from Africa or Asia, our cut-off points could be more appropriate to identify low maternal BMI and newborns with insufficient weight in Latin American pregnant women. We have selected a neonatal birthweight lower than 3000 g as an outcome because many studies indicate that birthweights lower than 3000 g are a possible risk factor for developing both undernutrition in late childhood and cardiovascular diseases in adult life (Eriksson *et al.* 2004; Varela-Silva *et al.* 2009). Moreover, our study included only 55 women whose newborns weighed less than 2500 g, making our comparisons less reliable.

Changes in MUAC during pregnancy have been less investigated. In the present study, we observed a mean increase of 1.7 cm in MUAC from <16 to 36 weeks of gestation, this value being higher than the 0.8 cm reported by Mahaba *et al.* (2001) in pregnant women from Egypt. Other researchers have not found variations in MUAC during gestation and even suggest that MUAC is independent of gestational age (Piperata *et al.* 2002). Moreover, Krasovec & Anderson (1991) have stated that in developing countries, where pregnancy weight gain is scarce, a consistent decrease in MUAC can be observed, with 70% of women experiencing a loss in MUAC over pregnancy.

In the study by Piperata *et al.* (2002), which evaluated the anthropometric characteristics of pregnant women in Colombia, mothers of normal-birthweight newborns (3000 g or more) had a higher MUAC than mothers of low-birthweight newborns. In our study, average MUAC of mothers of normal-birthweight infants was almost 2 cm higher during the whole course of pregnancy than that of mothers of low-birthweight newborns.

There is no published information related to MUAC changes during pregnancy and its relationship with prepregnancy weight or BMI. In our study, the MUAC increase was lower in overweight and obese women, compared with normal-weight or underweight mothers. In a previous publication (Calvo *et al.* 2009), we observed that there were no differences in weight gain among women who enter pregnancy with low weight, normal weight or overweight; only those women with a prepregnancy BMI in the range of obesity showed a significantly lower weight gain. A similar pattern of change in MUAC measurements was observed in this study: women who presented overweight or obesity at the start of pregnancy (BMI > 26 kg m^2) had lower increases in MUAC compared with women with normal or low BMI.

In our study, we classified women according to early pregnancy BMI (instead of any of the measurements under study), and repeated measurements were made on the whole population. However, in the interpretation of changes in MUAC or skinfolds throughout pregnancy, the phenomenon of regression towards the mean cannot be ruled out.

LMS values from 7 to 40 weeks of gestation for MUAC are presented and can be used as a guide to monitor maternal nutritional status. Nevertheless, although the statistical model applied allows the generation of the proposed smooth curves, only three measurements have been made in each pregnant women, and therefore, more extensive surveys are required before generalization for clinical purposes. Taking into account these limitations, we also propose to use cut-off points of 24.5 cm at less than 16 weeks of gestation, 25.5 cm at week 28 and 26.5 cm at week 36 as predictive figures to detect both low maternal BMI and low birthweight, pointing out the usefulness of MUAC as an alternative measure when maternal weight gain cannot be calculated. As could be expected, we found that MUAC had a greater association with maternal attained BMI than with neonatal low birthweight, with a sensitivity higher than 85% for maternal BMI below −1 SD and in the range of 48%–56% for insufficient birthweight. Although maternal weight gain and neonatal weight are influenced by many other determinants, the strong relationship between MUAC and maternal weight gain has already been established (Krasovec & Anderson 1991). Therefore, MUAC is still a valuable anthropometric tool for nutritional evaluation, particularly for screening purposes in areas where adequate scales are not available. It is customary in the literature to use measurements in each trimester for evaluating pregnant women nutritional gains; a more detailed schedule could be more sensitive, but changes in MUAC are not of great magnitude to overcome measurement errors in repeated measurements.

Skinfolds are good indirect indicators of subcutaneous body fat, and their measurement can be used to describe the patterns of fat change during pregnancy (Huston Presley *et al.* 2000). In our study, bicipital, tricipital and subscapular skinfolds were evaluated. A mean increase of 3.6 mm was observed in tricipital skinfold from early pregnancy to 36 weeks of gestation; this figure is higher than the values reported by other researchers who observed changes in the range of 1.1 mm–1.9 mm (Paxton *et al.* 1998; Mahaba *et al.* 2001; Sidebottom *et al.* 2001). Differences could be explained by socio-economic and demographic characteristics of the populations, and because measurements were performed at different gestational ages.

However, average subscapular skinfold increase in our research (4.5 mm) was similar to that found by Sidebottom *et al.* (2001) (4.2 mm) and smaller than the 5.9 mm observed by Forsum *et al.* (1989). In all three studies, the largest increase was observed in subscapular skinfold. These findings support the idea that during pregnancy, central skinfold thicknesses increase more than those at peripheral sites and also that the pattern of changes shows a peak increase at the end of the third trimester.

In this study, all measurements (at 16, 28 and 36 weeks of gestational age) of bicipital, tricipital and subscapular skinfolds from mothers who delivered infants with a birthweight below 3000 g had a lower average than measurements from mothers of normal-weight newborns; similar findings have been reported by Piperata *et al.* (2002).

Soltani & Fraser (2000) have postulated that skinfolds increase according to women prepregnancy body weight. In their study, at 6 months post-partum, obese women had a higher increase in fat mass compared with normal-weight women. Although they could not find a significant difference in maternal fat mass during pregnancy, probably because of the small sample size, their findings suggest a different pattern of skinfold variation for overweight and obese women compared with normal-weight women. In our survey, we have observed that in normal-weight women, the increase in subscapular skinfold from 16 to 36 weeks of gestation was around 2.5 mm higher than in obese women. These findings are again related to our population having a lower than average weight gain in the obese group, with a mean increase of 10.2 kg in contrast with 12.2 kg in normal-weight women (Calvo *et al.* 2009).

As opposed to MUAC, in the literature there are no skinfold thickness cut-off points to be applied during prenatal control. Our data suggest that subscapular and tricipital skinfolds could be used as a proxy to detect low-birthweight newborns and can be applied as complementary measurements to evaluate maternal nutritional status. As there are no published data from Latin American countries about MUAC or skinfold changes during the course of pregnancy, the LMS values from 7 to 40 weeks of gestation for MUAC, tricipital and subscapular skinfolds, as well as the MUAC cut-off points obtained from a healthy cohort of pregnant women, are proposed to be used in the region as complementary measurements during prenatal control.

Over the last few years, there has been a notable shift in the demographic and epidemiologic profiles of childbearing women in developed countries. Overweight and obesity prior to pregnancy, and excess gestational weight gain are common nutritional problems. Prepregnancy weight and weight gain during the course of pregnancy are the most reliable anthropometric indicators to monitor nutritional status. In such cases, MUAC can add little information and could be used as a complementary measure.

Skinfold measurements are difficult to standardize and lack the precision required to estimate changes in fat mass accurately. Nevertheless, in this context of preventing post-partum weight retention, skinfold measurements become an appropriate complementary tool for nutritional assessment besides weight gain. In addition, low skinfold increase during the course of pregnancy could be a proxy of insufficient birthweight.

In developing countries where weight gain monitoring is not feasible because of limitations in facilities, staff and/or coverage of prenatal care, MUAC becomes an alternative tool for anthropometric evaluation. Alternatively, MUAC can be used as a first screen in order to refer women to facilities for a more complete assessment of nutritional risk. As different patterns of MUAC change have been described in diverse settings, MUAC is not recommended for monitoring, but it is a useful tool for screening.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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