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Original Article

Body composition and newborn birthweight in pregnancies of adolescent and mature women

María Elena Contreras Campos*†, Nora Rodríguez-Cervantes†, Sandra Reza-López‡, Marina Ávila-Esparza‡§, Dora Virginia Chávez-Corral‡ and Margarita Levario-Carrillo‡

Unidad de Investigación Médica en Epidemiología Clínica, Instituto Mexicano del Seguro Social (IMSS), Chihuahua, México, †Programa de Especialidad en Medicina Familiar Universidad Nacional Autónoma de México/IMSS, Unidad de Medicina Familiar Plus 33, Chihuahua, México, ‡Facultad de Medicina, Universidad Autónoma de Chihuahua, Circuito Universitario Campus II, Chihuahua, México, and §Hospital de Ginecología y Obstetricia Número 15, IMSS, Chihuahua, México

Abstract

Teenage pregnancy has been associated with adverse effects for the mother and the newborn (NB). In order to compare body composition (BC) between adolescents (Ad) and mature women (MW) during pregnancy and to determine the difference in birthweight and perinatal morbidity, pregnant Ad ($n = 40$) and MW ($n = 227$) were studied. BC changes between the second and third trimesters were determined by multifrequency bioelectrical impedance analysis, and birthweight and NB morbidity were evaluated. During the second and third trimesters of the pregnancy, fat mass was lower in the Ad group [16 kg (13–19)] than in the MW group [22 kg (17–27)] ($P < 0.01$; median and quartiles 1–3). Fat-free mass increased by 3.09 kg (2.29–4.20) and 2.20 kg (1.0–3.59) ($P \leq 0.01$), and total body water increased by 2.77 L (0.84–4.49) vs. 2.04 L (0.55–3.89) ($P = 0.36$), in the Ad and MW groups, respectively (median and quartiles 1–3). Birthweight was not significantly different between NBs of Ad (3223 ± 399 g) and NBs of MW (3312 ± 427 g, $P = 0.22$). The youngest Ad (<18 year old, $n = 8$) had NB with lower birthweight than MW (3031 ± 503 g, $P = 0.06$). NBs of Ad mothers showed a non-significant trend towards a higher rate of morbidity relative to the NBs of MW. In conclusion, the BC of Ad differs from that of MW during pregnancy. In addition, the NB infants of Ad mothers tended to have a lower birthweight than those from MW, a result that suggests that the Ad should be in strict prenatal control.

Keywords: adolescent pregnancy, body composition, low birthweight, birthweight, bioelectrical impedance, pregnancy.

Correspondencence: Dr Margarita Levario-Carrillo, Facultad de Medicina, Universidad Autónoma de Chihuahua, Circuito Universitario Campus II, CP 31109 Chihuahua, México. E-mail: mlevarioc@uach.mx

Introduction

Adolescence in Mexico, as in other countries, is a time of gradual transition from childhood to adulthood during which young individuals must build a foundation of knowledge and skills to assume future roles as adults (Díaz-Sánchez 2003). However, for a great portion of Mexican adolescents (Ad), this stage is very short. Although the fertility rate declined between 1997 and 2006 from 82 to 63 births per 1000 Ad girls, in 2006, births to Ad mothers accounted for 16% of all births in Mexico (Juárez *et al*. 2010).

Teen pregnancy has been associated with adverse maternal and perinatal outcomes. For the mother, teen pregnancy has shown to increase the risk of maternal death and preterm delivery. For the infant, teen pregnancy increases the risk of perinatal morbidity and mortality, small for gestational age size, and low birthweight (Conde-Agudelo *et al*. 2005; Chen *et al*. 2007). The reasons for the increased risk of adverse outcomes are still unclear. However, maternal body composition (MBC) before and during pregnancy, as a proxy of her nutritional status, may be a factor.

Birthweight is associated with MBC before and during pregnancy (Levario-Carrillo *et al*. 2009). Newborns from mothers with low pregestational body mass index (BMI) have increased risk of being small for gestational age (Bolzan & Guimarey 2001). Furthermore, maternal weight gain and changes in body composition during pregnancy are associated with birthweight (Levario-Carrillo *et al*. 2009). During pregnancy, MBC undergoes profound adaptive changes (i.e. increased extra- and intracellular water and fat mass) (Larciprete *et al*. 2003). These changes in MBC are associated with pregestational nutritional status, energy expenditure, nutrient metabolism, adaptation, and expansion of plasma volume, among other factors (Brown *et al*. 1992; Leis-Marquez & Guzman-Huerta 1999). However, little is known about the variation of MBC during pregnancy due to the age of the mother.

Changes on MBC during pregnancy may vary between teenagers and mature women (MW). This is suggested by the lower body weight, fat and fat-free mass observed in pregnant teenagers than in MW (Scholl *et al*. 1997; Thame *et al*. 2007). However, data on the body composition of Ad girls during pregnancy and the changes that occur between the second and third trimesters are scarce. Hence, the objectives of this study were twofold: (1) to compare MBC between Ad and MW during pregnancy; and (2) to determine the difference in newborn birthweight and perinatal morbidity in these two cohorts.

Materials and methods

Study participants

Participants in their second trimester of pregnancy were recruited for this study. Cases in antenatal care at the Family Medicine Unit 33 of the Mexican Institute of Social Insurance (IMSS) in Chihuahua, Mexico were invited to participate. The groups were classified according to their age. The Ad group included teenagers 14–19 years of age ($n = 40$) and the MW group included women that were ≥21 years of age ($n = 227$).

MBC changes between the second and third trimesters of pregnancy were assessed. The study was performed between February 2005 and December 2010. The project was approved by the ethics committee of the IMSS and all participants signed a letter of informed consent. Individuals with systemic diseases such as hypertension, diabetes mellitus, hyperthyroidism, hypothyroidism, autoimmune disease or multiples pregnancy were excluded. In addition, any participants recruited during the second trimester that subsequently developed gestational diabetes (MW, $n = 3$) or hypertensive complications (Ad, $n = 1$; and MW, $n = 19$) were excluded. Women who were 20 years of age were excluded, because they could have started their pregnancy as a teenager.

The following maternal variables were obtained through an informational interview: education, obstetric history [number of pregnancies, stillbirths, history of intrauterine growth retardation (IUGR)], smoking status, alcohol consumption, occupation and pre-pregnancy body weight [confirmed in the clinical record when available (26%)]. Maternal height was measured and pre-pregnancy BMI was estimated. Gestational age was initially determined based on the last menstrual period and subsequently confirmed by obstetric ultrasound in 98% of participants.

Body composition analysis

The body composition assessment methodology used in this study has been described in detail elsewhere (Levario-Carrillo *et al*. 2009). Briefly, we performed measurements of body composition by bioelectrical impedance analysis (BIA) in pregnant women in their

Key messages

- The body composition of adolescent (Ad) girls is different than that of mature women (MW) during pregnancy, and their nutritional status should be monitored.
- The newborn infants of Ad mothers tended to have a lower birthweight than those from MW.
- Further research is warranted to identify the mechanisms underlying these associations and to implement strategies for improving neonatal and maternal health.

second trimester, and later during the third trimester with a composition and body fluid measuring device (QuadScan Bodystat model 4000, Tampa, FL, USA). The range of bioresistance was 20–1000 Ω with a 1 Ω resolution. The frequency range was 5–50–100 and 200 kHz and the test current was 200 μA. Assessment of body composition was performed in the morning and patients were asked not to drink any alcohol in the preceding 24 h and not to exercise 4 h before the test.

Body weight (kg), was measured using a mechanic scale (Nuevo León, with a range of 160 ± 0.01 kg), height (cm) with a Nuevo León stadiometer (75–192 cm of range) and abdominal circumference (cm) was measured at the level of the umbilical scare with a plastic tape. Each participant was then asked to lie in a supine position with sensor pads in her right hand, forearm, foot and ankle, situated according to the instructions provided by the manufacturer. The analysis of body composition included assessments of body fat and fat-free mass. Total body water was estimated from the values of bioresistance (at 50 kHz) and reactance, using the regression equation suggested by Lukaski *et al*. (Lukaski *et al*. 1994): height^2/bioresistance (cm^2/Ω) × 0.700 + abdominal circumference (cm) × 0.051 − weight (kg) × 0.069 − reactance × 0.029 − haematocrit × 0.043 + 2.833. Haematocrit values were determined in the second and third trimesters by spectrophotometry using an automatic haematology analyser system (Cell-Dyn 3700 SL, Abbott, Abbott Park, IL, USA).

Newborn weight, length and circumferences of the head, chest and abdomen were measured following the delivery using a paediatric mechanic scale "Nuevo León" (0–10 kg of range) and a plastic tape, respectively. We also identified newborn morbidity (according to the International Classification of Diseases, version 10) and recorded Apgar scores.

Statistical analysis

We performed a comparative analysis between the study groups. Data are presented as means ± standard deviation, 95% confidence interval (CI), median and quartiles (Q 1–3), or frequency and percent. Student's *t*-test was used for variables measured in a ratio scale with a normal distribution. The Mann–Whitney test was used to compare the difference between Ad and MW groups in fat mass, fat-free mass, and total body water, and Height^2/bioresistance index. To evaluate the difference in proportions, a Chi-squared or the Fisher's exact test was used. Birthweight was adjusted for maternal age (Ad or MW), gestational age, weight gain, fat-free mass, newborn gender, IUGR in previous gestation and newborn morbidity by multiple linear regression. Risk ratios were calculated to compare adverse perinatal outcomes between the groups. Statistical analysis was performed using STATA 9.0 software for Windows (Stata Corp., College Station, TX, USA). Data was considered statistically significant when the P-value was <0.05.

Results

Gestational assessments

The clinical characteristics of the study subjects are summarised in Table 1. The initial clinical assessments and body composition measurements were performed during the second trimester of pregnancy at 22 ± 2 weeks, on average. The second evaluation was performed during the third trimester, between 34 and 35 weeks of gestation.

Significant differences were found between the two groups in pre-pregnancy BMI, and second- and third-trimester body weight.

Pre-pregnancy BMI was <18.5 kg/m^2 in $n = 2$ (5%) vs. $n = 9$ (4%); between 18.5–24.99 kg/m^2 in $n = 34$ (85%) vs. $n = 109$ (48%); between 25.0–29.99 kg/m^2 $n = 3$ (8%) vs. $n = 74$ (32%) and ≥30.0 kg/m^2 $n = 1$ (3%) vs. $n = 35$ (15%) in Ad and MW, respectively.

With respect to patient habits and others maternal characteristics (Table 2), smoking prior to pregnancy was similar in MW (9%) and Ad (8%). However, during pregnancy, the smoking rate was reduced in the MW group (to 3%) while remaining constant (at 8%) among Ad ($P = 0.13$). Five per cent of Ad admitted to drink alcohol during pregnancy compared with 2% of MW. There were a significantly higher proportion of participants who were primigravidas in the Ad group (70%) than in the MW group (28%) $P < 0.01$.

Table 1. Clinical maternal characteristics

Variable	Adolescents	Mature women	Difference (95% CI)	P
	$n = 40$	$n = 227$		
	$\bar{X} \pm$ SD	$\bar{X} \pm$ SD		
Maternal age (year)	18 ± 1	28 ± 5	–10 (–10.8, –7.8)	<0.01
Maternal education (year)	10 ± 2	11 ± 3	–1.6 (–2.71, –0.49)	<0.01
Pregestational body mass index (kg/m^2)	22 ± 3	25 ± 4	–3.43 (–4.87, –1.99)	<0.01
Height (cm)	158.23 ± 7	157.62 ± 6	0.60 (–1.58, 2.79)	0.58
Weight (kg) second trimester	59 ± 9	69 ± 11	–7.65 (–11.42, –3.88)	<0.01
Weight (kg) third trimester	66 ± 9	72 ± 11	–6.50 (–10.20, –2.80)	<0.01

CI, confidence interval; SD, standard deviation.

Table 2. Patient's habits studied and maternal antecedents

Variable	Adolescents	Mature women	Difference (95% CI)	P*
	$n = 40$	$n = 227$		
	n (proportion)	n (proportion)		
Smoking prior to pregnancy				
Present	3 (0.08)	21 (0.09)	0.01 (–0.10, 0.08)	0.50
Absent	37 (0.92)	206 (0.91)		
Smoking during pregnancy				
Present	3 (0.08)	6 (0.03)	0.05 (–0.03, 0.13)	0.13
Absent	36 (0.92)	221 (0.97)		
Alcohol consumption during pregnancy				
Present	2 (0.05)	4 (0.02)	0.03 (–0.03, 0.09)	0.22
Absent	38 (0.95)	222 (0.98)		
Maternal occupation				
At home	21 (0.52)	97 (0.43)	0.09 (–0.07, 0.25)	0.21
Outside home	19 (0.48)	130 (0.57)		
Parity				
Primiparous	28 (0.70)	63 (0.28)	0.42 (0.26, 0.57)	<0.01
Multiparous	12 (0.30)	164 (0.72)		
Fetal death antecedent				
Present	1 (0.03)	5 (0.02)	–0.01 (–0.05, 0.03)	0.62
Absent	39 (0.97)	221 (0.98)		
Intrauterine growth retardation in previous gestation				
Present	3 (0.08)	33 (0.15)	–0.07 (–0.16, 0.02)	0.16
Absent	37 (0.92)	192 (0.85)		

*P-value of chi-squared test or exact Fisher's test.

MBC data are shown in Table 3. Only fat mass was found to be lower in Ad than in MW in both the second (median 16 vs. 22 kg) and third trimester of pregnancy (median 19 vs. 25 kg, $P < 0.01$). Fat-free mass and body water did not differ significantly between the two groups. Changes in body components were (median, Q1–Q3): fat mass increased from the second to the third trimester by 3.09 kg (1.9–4.55), in the Ad group and 2.90 kg (1.5–4.79) in MW ($P = 0.69$); fat-free mass increased by 3.09 kg (2.29–4.20) and 2.20 kg (1.0–3.59) ($P < 0.01$); and total body water increased by 2.77 L (0.84–4.49) vs. 2.04 L (0.55–3.89) ($P = 0.36$), in the Ad and MW, respectively. Height^2/resistance index was lower in Ad than in MW in second trimester. However, in women with BMI between 18.5 and 24.99 kg/m, this index was not

Table 3. Comparison of maternal body composition during the second and third trimester of gestation

Variable	Adolescents		Mature women	
	$n = 40$		$n = 227$	
Trimester	Second Median (Q1–Q3)*	Third Median (Q1–Q3)	Second Median (Q1–Q3)	Third Median (Q1–Q3)
Fat mass (kg)	16 (13–19)	19 (17–22)	22 (17–27)‡	25 (21–30)‡
Fat-free mass (kg)	42 (38–47)	45 (41–50)	44 (41–47)	46 (43–50)
Total body water (L)†	28 (26–30)	31 (28–35)	29 (27–32)	32 (32–35)
Bioresistence 50 kHz (Ω)	630 (587–663)	571 (531–613)	577 (540–638)‡	550 (499–596)‡
Reactance 50 kHz (Ω)	64 (60–67)	60 (53–70)	63 (59–69)	61 (56–67)
Height²/bioresistance index (cm²/Ω)	40 (36–44)	44 (40–48)	42 (40–47)‡	45 (41–50)

*Q1–Q3 = quartiles (1–3). †Total body water was estimated from the regression equation suggested by Lukaski *et al.* 1994: Height²/bioresistance (50 KHz) (cm²/Ω) × 0.700 + abdominal circumference × 0.051 − weight × 0.069 − reactance × 0.029 − haematocrit × 0.043 + 2.833 (18). ‡$P < 0.05$ between adolescent and mature women.

significantly different between Ad and MW, when measured during the second ($P = 0.24$) and third trimesters ($P = 0.32$). Gestational weight gain of the groups tended to be higher in the Ad group than in MW (10.71 ± 4 kg vs. 9.26 ± 5 kg, difference = 1.44 and 95% CI –0.16, 3.06; $P = 0.07$).

Neonatal assessments

Neonates from Ad mothers had lower birthweight (3223 ± 399 g) than those born to MW mothers (3312 ± 427 g), but this difference did not reach statistical significance (difference = –89 g; 95% CI –232, 54, $P = 0.22$). Adjusting by gestational age, weight gain, fat-free mass on the third trimester, gender of newborn, maternal antecedent of IUGR in previous gestation, and newborn morbidity, did not modify the relationship ($\beta = 71.77$, 95% CI –61.36, 204.91; $P = 0.28$).

Further analyses revealed that Ad (<18 years of age, $n = 8$) had newborns with lower birthweight than MW (3031 ± 503 g vs. 3312 ± 427 g, respectively). The difference of means was –281 g (95% CI –585, 23). Adolescents between 18 and 19 years ($n = 32$) had a mean birthweight of 3271 ± 363 g, [41 g lower than the birthweight of newborns from MW (95% CI –197, 115)].

Fat-free mass was positively associated with birthweight in both Ad and MW groups, in which 1 kg of fat-free mass during the third trimester accounted for an increase of ~15 g in birthweight, in the multivariate model ($\beta = 15.03$ 95% CI 6.43, 24.17; $P < 0.01$). Fat mass did not show significant relation with birthweight.

Other anthropometric variables (length, head, chest, abdominal circumferences) in newborns showed non-significant trends towards being lower in the Ad mothers group. The Apgar scores were similar in the two groups (8 at 1 min and 9 at 5 min).

Newborn morbidity was present in 4/40 babies (10%) born to Ad and 17/227 babies (7%) born to MW (RR = 1.30; 95% CI 0.51–3.30). Respiratory and cardiovascular disorders specific to the perinatal period were the most frequent diagnosis of disease in both groups. Birth defects were found in 2/40 babies (5%) born to Ad and 34/227 babies (1.32%) born to MW (RR = 2.75; 95% CI 0.90–8.39).

Discussion

The present results show that the body composition of Ad girls during pregnancy differs from that of MW. Fat mass was lower in the second trimester in the Ad group than in the MW group, and continued to be lower in Ad than in the MW group until the end of gestation. Fat-free mass increased more in the Ad group than in the MW group between the second and third trimesters of pregnancy. Our results also show that birthweight of newborns from Ad tended to be lower than in newborns from MW, but this difference was not significant.

Similar results with respect to body composition in young mothers during pregnancy were reported by

Thame *et al*. in a study with a Jamaican population (Thame *et al*. 2007). Teenage girls had a mean fat mass in the second trimester of 19.1 kg, whereas that in MW was 24.5 kg. In our population, Ad and MW had a median of fat mass in the second trimester of 16 and 22 kg, respectively. The variation in the absolute values of fat mass may be due to the ethnic background of the participants or to the different technique used to estimate body composition (i.e. anthropometry vs. BIA).

Changes in body composition between the second and third trimesters of pregnancy were observed in both Ad and MW groups. However, Ad girls gained more fat-free mass than MW, but fat mass gain was not significantly different. Other studies have reported greater increases in both fat mass and lean mass in Ad than in MW from the first antenatal visit (<15 weeks) to the 35th week of gestation. Their results also showed that lean mass increased approximately 2.9 and 2.3 kg in Ad and MW, respectively, between the second and third trimesters of pregnancy (25–35 weeks) (Thame *et al*. 2007). Similarly, in our study, fat-free mass increased 3.1 and 2.2 kg in Ad and MW, respectively (~22–35 gestational weeks). The non-significant difference in fat mass gain maybe explained by the gestational period in which these measurements were taken, because fat accretion during pregnancy occurs at a greater rate during the first half of pregnancy (Butte & King 2005), which we did not assess.

MBC has been identified as an important predictor of birthweight. We have previously shown that maternal fat-free mass and body water are positively associated with birthweight (Sanin Aguirre *et al*. 2004; Levario-Carrillo *et al*. 2009). Consistent with previous results, fat-free mass in this study was positively associated with birthweight in both Ad and MW groups, in which 1 kg of fat-free mass during the third trimester accounted for an increase of ~15 g in birthweight, after adjusting for several predictors ($P < 0.01$). In contrast, fat-free mass gain between the second and third trimesters of pregnancy, was not associated with birthweight. Our results are also in agreement with those reported by Farah *et al*., who analysed maternal body composition using bioelectrical impedance. They found a positive correlation of birthweight with maternal fat-free mass, but not with fat mass at 28 and 37 weeks of gestation, or fat mass and fat-free mass gain during that period (Farah *et al*. 2011).

Competition for nutrients between mother and fetus may occur in pregnant Ad, because they are growing themselves. Then, maternal tissue reserves are not mobilised to support fetal growth; instead those reserves are used to continue their own growth (Scholl & Hediger 1993). Although we did not estimate maternal growth in the Ad group, the greater increase in fat-free mass ($P < 0.01$) observed in the Ad group than in MW, may suggest that tissue accretion may be occurring at increased rate in Ad. In the Camden study (Scholl *et al*. 1997), infants born to growing Ad mothers were in average 139 g lighter at birth than the infants of Ad mothers who had completed their growth; the neonates of Ad mothers who had completed their growth had a mean birthweight (3188.9 g) similar to that of the neonates of adult women (3158.0 g). In our study, the youngest teenagers, most likely to be still growing (<18 years of age), had newborns with lower birthweight (281 g on average) than MW, whereas newborns from Ad between 18 and 19 years were only 41 g lighter at birth than those born to MW.

Women with antecedent of IUGR have a high risk of an adverse fetal outcome in the subsequent pregnancy (Hossain & Paidas 2007); in this study, the antecedent of IUGR was more frequent in MW (15%) than in Ad (8). Although the difference was not significant ($P = 0.16$), this could be related to the frequency of primiparity (Ad group 70% vs. 28% in MW). In the multivariate model, the antecedent of having a newborn with IUGR was an important predictor of birthweight ($\beta = -147$ in Ad group and $\beta = -152$ in MW, data not shown).

Factors related to birthweight are complex and interdependent (Sacks 2004; Muthayya 2009). Early diagnosis of IUGR and small-for-gestational-age neonate (Gardosi 2006) in risk groups, such as pregnant Ad, would be very useful. However, only 25% of IUGR cases are diagnosed prenatally (Gardosi 2011). Higher perinatal morbidity rates (i.e. higher proportion of small for gestational age newborns), as well as a higher rate of birth asphyxia and death within the first 48 h of life have been reported in infants of Ad girls vs. in infants of adult women (Mukhopadhyay *et al*. 2010). We observed a non-significant trend towards a higher risk of perinatal morbidity and birth defects in the Ad group than in the MW group, perhaps because of the low incidence observed in these outcomes.

Pre-pregnancy nutritional status, gestational weight gain and antenatal control influence birthweight and adverse pregnancy outcomes (Arcos Griffiths *et al*. 1995; Raatikainen *et al*. 2007; Ay *et al*. 2009). A poor nutritional status has been associated with low birthweight (Shirima & Kinabo 2005) and maternal pre-pregnancy BMI and gestational weight gain are lower in low birthweight neonates than in those with normal weight (Santos *et al*. 2012). In our study, more than 80% of Ad was in the category of normal pre-pregnancy BMI, 12.5% showed a BMI suggestive of overweight/obesity and 5% were underweight. In contrast, 48% of MW had a BMI suggestive of overweight/obesity, which tended to have heavier newborns. However, our limited sample size and the low frequency of under and overweight in Ad, did not allow us to fully explore these relationships. On the other hand, gestational weight gain was marginally different between Ad and MW and it was associated with birthweight in the multivariate analysis.

The association between adverse outcomes in adolescence has been found to be modified by an adequate antenatal care (Santos *et al*. 2012; Vieira *et al*. 2012). Under-attendance to antenatal care has been observed in young mothers, and it has been associated with a high risk of low birthweight and perinatal mortality (Raatikainen *et al*. 2007). In population from the IMSS, Mexico, 47% of Ad girls enter to antenatal care on their third trimester of gestation (Sanchez-Nuncio *et al*. 2005). Because we recruited the subjects during the second trimester of pregnancy, it is possible that they differ on their pregnancy outcomes from those that enter in antenatal care later in their gestation.

Body composition was assessed using bioelectrical impedance and total body water was estimated using the Lukaski's regression equation (Lukaski *et al*. 1994). This equation was validated in a group of pregnant women, but not specifically for pregnant Hispanic teenagers, which is a limitation of this study. However, the main predictor of total body water is the Height^2/resistance index, which was not significantly different between Ad and MW in the second or third trimesters in women with a pre-pregnancy BMI between 18.5–24.99 kg/m^2 ($P = 0.24$ and $P = 0.32$, respectively). Further research is necessary to generate a predictive equation specific for pregnant women by age and ethnic group.

Our study included $n = 40$ Ad and $n = 227$ MW. This sample size allowed us to detect differences in MBC. However, we found some non-significant, but marginal differences ($P < 0.10$) between Ad and MW (i.e. antecedent of IUGR, smoking during pregnancy, gestational weight gain, perinatal morbidity, among others), suggesting that the study was underpowered for these variables. Thus, results on the relationship of birthweight and adolescence require to be confirmed in a study with larger sample size, in particular of young teenagers (<18 years old).

In conclusion, the body composition of Ad girls is different than that of MW during pregnancy. In addition, the newborn infants of Ad mothers tended to have a lower birthweight than those from MW, a result that suggests that the Ad should be in strict prenatal control. Particular attention should be given to the youngest women, which are the most likely to be in higher risk for adverse results of pregnancy.

Further research is warranted to confirm these associations and to implement strategies for improving neonatal and maternal health.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Contributions

ML-C, SR-L wrote the paper. MECC, NR-C, MA-E recruited participants and collected the data, performed body composition analyses and assisted with the interviews and clinical records from the mother and assisted with data collection of the newborn. ML-C, SR-L, DVC-C analysed and interpreted the data. ML-C provided methodological (technical or statistical) guidance. All co-authors participated in the preparation of the paper and critically reviewed all sections of the text for important intellectual content.

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