Anthropometric Characteristics of Pregnant Women in Cali, Colombia and Relationship to Birth Weight

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ABSTRACT Anthropometric dimensions were collected from 46 pregnant women living in Cali, Colombia to gain a better understanding of how poor, urban women deal with the demands of pregnancy and to identify relationships between maternal characteristics and infant birth weight. Height, weight, skinfold thicknesses (subscapular, suprailiac, thigh, calf, and triceps), and circumferences (hip, thigh, calf, and mid-upper arm) were measured on all women. Infant measurements were weight and length. The women were measured in the second and third trimesters, and a subsample ($n = 16$) was measured twice in the third trimester. Mean birth weight was $3{,}137.6 \pm 488.5$ g ($n = 44$), and mean length was 49.8 ± 3.0 cm. All but three of the infants were full-term, and the incidence of low birth weight (LBW) was 9%. The 46 women showed a significant increase in weight ($P < 0.001$); subscapular, suprailiac, and mid-thigh skinfold thicknesses ($P \leq 0.01$) and in hip, thigh, and calf circumferences ($P \leq 0.01$) between trimesters 2 and 3. Women who gave birth to both normal birth weight (NBW) and LBW infants showed significant increases in weight ($P < 0.001$ and $P = 0.02$, respectively), but only women who had NBW infants showed significant increases in the suprailiac skinfold and hip circumference ($P < 0.001$). In the third trimester, attained weight, skinfold thicknesses, and circumferences tended to be greater in women who had NBW infants. In general, this group of women gained less weight and had a greater incidence of LBW infants compared with women in developed countries, but changes in skinfold thicknesses over the course of pregnancy were similar compared with other studies. Am. J. Hum. Biol. 14:29−38, 2002.

Understanding how women deal with the energetic stress of pregnancy and, at the same time, prepare for the more energetically demanding period of lactation (Butte et al., 1997) is of interest because successful reproduction is a most basic aspect of adaptation. The majority of anthropometric studies of pregnancy have focused on weight gain and have been conducted in developed countries (Adair and Bisgrove, 1991; Brown et al., 1981, 1986; Hytten, 1991; Kleinman, 1990; Naeye, 1979, 1990; Niswander et al., 1969; Seidman et al., 1989; Seiga-Riz et al., 1996; Winikoff and Debrovner, 1981). Less is known about changes in skinfold thicknesses and circumferences during pregnancy and their impact on infant birth weight among women in developing countries.

Weight gain during pregnancy is associated with the growing fetus, development of maternal reproductive tissues, increased blood volume and extra-cellular fluid, and an increase in maternal energy stores. Maternal fat stores are thought to be important energy reserves for the latter stages of pregnancy when the fetus is growing rapidly and during lactation (Norgan, 1997; Prentice et al., 1996). Decreases in some skinfold thicknesses in the latter stages of pregnancy support the idea that the maternal energy stores laid down earlier are used during the latter stages when energy demands are higher (Taggart et al., 1967).

It is well known that inadequate maternal weight gain during pregnancy is associated with low infant birth weight (Lubchenco et al., 1972) and that infant birth weight tends to follow socioeconomic gradients with poorer women giving birth to smaller sized infants (Jansen et al., 1984). It is also clear that the majority (95%) of low birth weight (LBW) infants are born in

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TABLE 1. Anthropometric and socioeconomic variables of 46 pregnant women included in this study and 136 non-pregnant, non-lactating (NPNL) women living in the same neighborhoods

Parameters	Pregnant women Mean	Pregnant women SD	NPNL women Mean	NPNL women SD	P^b
Age (yrs)	25.5	5.1	28.3	6.1	0.005
Height (cm)	156.9	6.3	156.5	6.1	ns
Weight (kg)	61.5	9.7	55.8	8.2	<0.001
MUAC[a] (cm)	25.2	2.4	25.4	2.2	ns
Parity	1.6	1.4	2.5	1.6	<0.001
Education (yrs)	6.1	0.4	6.3	0.2	ns

[a]MUAC, Mid-upper arm circumference.
[b]ns, not significant.

developing countries (Lechtig, 1988). In addition, maternal stature influences birth weight with taller women giving birth to heavier infants (Adair and Bisgrove, 1991; Rosso, 1985; Dougherty and Jones, 1982). This relationship may be a function of the positive association between maternal height and weight gain during pregnancy (Kleinman, 1990).

This paper focuses on changes in maternal anthropometry over the course of pregnancy and its relationship with infant outcome in a group of 46 pregnant women living in poverty in a developing nation where access to food and medical care were sub-optimal. The 46 women were measured in the second and third trimesters, and a sub-sample (n = 16) was measured twice in the third trimester. Based on current understanding of the relationships among maternal weight gain, poverty, and birth weight, increases in body weight, skinfold thicknesses, and circumferences were expected over the course of pregnancy with achieved values lower than those in developed countries. It was anticipated that women who delivered LBW infants would have lower achieved weight, skinfold thicknesses, and circumferences than women who gave birth to normal weight infants.

MATERIALS AND METHODS

Subjects

The data were collected as part of a larger project designed to look at the health and nutritional status of poor, urban women and children living in Cali, Colombia. Cali is the capital of the Colombian state of Valle del Cauca and at the time of the study had an estimated population of 2.2 million people. Cali is located 976 meters above sea level.

The women lived in one of two *barrios* (neighborhoods) located in the Aguablanca district on the periphery of Cali, and were part of the city's lowest socioeconomic level. At the time of data collection, the first *barrio* consisted of approximately 660 homes (Staten et al., 1998), the majority of which were made of wood, cement, or brick and, in some instances, recycled materials. Most homes had access to water and electricity through connections engineered by the *barrio* residents, but most lacked adequate sewerage, and many people used the nearby lagoon for waste disposal.

The second *barrio* was considerably larger and had approximately 2,100 homes, which were mostly made primarily of brick, the preferred building material (Staten et al., 1998). This *barrio* was connected to city electricity, water, and sewage disposal and had a functioning health post, community center, and multi-room school. While the two *barrios* differed markedly in appearance, the anthropometry of women was very similar (Staten et al., 1998).

Subjects were recruited by technicians who worked for the project and lived in the same two *barrios,* by doctors and health care workers working at *barrio* health posts, and via word of mouth. Only those recruits judged healthy by a routine medical exam participated in the study. All subjects were compensated for their participation. Based on a comparison of anthropometric dimensions and socioeconomic variables between these women and other non-pregnant, non-lactating women living in the same neighborhoods, this sample of 46 women was representative of the general population of women living in the area (Table 1). The project was approved by the Medical College of Wisconsin and the Universidad del Valle prior to data collection.

Data were available for a total of 63 pregnant women. Of these, 46 met the criterion of this study: They were measured at least once in the second and third trimester of pregnancy. Of the 46 women, 16 were measured twice in the third trimester and are used to estimate changes in late pregnancy. Infant birth weights and lengths, as well as estimates of gestational age were available for 44 of the 46 women. In a previous report, Dufour et al. (1999) compared a slightly different subset of the 63 pregnant subjects with non-pregnant, non-lactating women. However, the cross-sectional nature of the analysis in that paper limited the understanding of changes in anthropometric characteristics over time and how they might be related to birth weight.

Data collection

Anthropometric dimensions were taken by two experienced technicians following the protocols of Lohman et al. (1988). Height was measured in centimeters using a Harpenden stadiometer. Weight was measured with the women dressed lightly using a portable Homs beam balance accurate to ± 25 g. Skinfold thicknesses (subscapular, suprailiac, mid-thigh, medial-calf, and triceps) were taken with a Lange skinfold caliper. Circumferences (hip, mid-thigh, medial-calf, and mid-upper-arm) were measured with a flexible steel tape. All skinfolds and circumferences were taken on the left side of the body in triplicate and the average value was used. Intra-observer error for skinfolds and circumferences was calculated for the one technician who took the vast majority of measurements. Correlation coefficients between the duplicate measurements ($n = 80$ on 2 successive days) and coefficients of reliability (Marks et al., 1989) are reported in Table 2. Pearson correlations were 0.90 or greater for all measurements and in most cases were above 0.95. Coefficients of reliability for most measurements are above 0.90.

The body mass index was calculated as weight/height (kg/m^2). Rates of change in weight, skinfolds, and circumferences were estimated by dividing the difference in the measurements by the amount of time between the two observations. Infant birth weight and length were extracted from hospital records. Gestational age at birth was calculated from the mother's recall of her last menstrual period, which was obtained by interview at the time of the first measurement. Ponderal indices (weight (g) × 100/recumbent length (cm^3)) were calculated for all full-term infants for which birth weight and length data were available.

TABLE 2. Correlations between duplicate measurements and coefficients of reliability for anthropometric dimensions

Anthropometric measure	Correlation coefficient	Coefficient of reliability[a]
Skinfolds		
Triceps	0.97*	0.97
Subscapular	0.98*	0.93
Suprailiac	0.96*	0.86
Thigh	0.93*	0.90
Calf	0.92*	0.85
Circumferences		
Mid-upper arm	0.99*	0.99
Hip	0.99*	0.99
Thigh	0.98*	0.99
Calf	0.99*	0.99

*$P < 0.05$

[a]Coefficient of reliability was calculated following Marks et al. (1989); $R = s^2 - S_r^2/s^2$, in which s^2 is the inter-individual variance and S_r^2 is the intra-subject variance.

The first trimester was defined as conception through week 13 of pregnancy; the second trimester was defined as weeks 14 through 26; and the third trimester was defined as week 27 to term. LBW was defined as less than 2,500 g based on the World Health Organizations definition (WHO, 1995a), and normal birth weight (NBW) as equal to or greater than 2,500 g. Pre-term birth was defined as less than 37 weeks of gestation (WHO, 1995a). Infants with ponderal indices ≥2.5 and recumbent length z-scores below −2 were considered stunted, and infants with ponderal indices <2.5 and recumbent length z-scores ≥−2 were considered wasted (Ashworth et al., 1997).

Statistical analyses

Two hypotheses were tested. The first hypothesis was that the women would increase in anthropometric dimensions during the course of pregnancy. Paired-sample Student's t tests were used to evaluate changes from the second to third trimesters in the total sample of 46 women and within the third trimester in the sub-sample of 16 women. The second hypothesis was that women who gave birth to LBW infants would have smaller anthropometric values than those who had NBW infants. A two-way, repeated-measures ANOVA in the time dimension was used. Significant changes over time were followed-up with paired

TABLE 3. Anthropometric characteristics of 46 women by trimester

	Trimester 2			Trimester 3			2^{nd} to 3^{rd} Trimester
Variable	Mean	Median	SD	Mean	Median	SD	P^a
Weeks of gestation	19.4	19.0	3.1	32.0	32.0	3.8	–
Age (yr)	25.6	24.5	5.0	–	–	–	–
Height (cm)	156.9	156.0	6.7	157.1	156.0	6.7	ns
Weight (kg)	57.5	57.0	9.6	62.1	62.0	9.4	<0.001
BMI (kg/m^2)	23.3	22.7	3.3	25.2	24.9	3.2	<0.001
Skinfolds (mm)							
Triceps	18.1	18.0	6.2	18.4	18.0	6.0	ns
Subscapular	20.3	19.0	6.1	22.4	21.0	7.2	0.003
Suprailiac	20.2	20.0	8.3	24.3	24.5	8.3	<0.001
Thigh	31.6	30.0	8.5	34.8	34.5	8.7	0.001
Calf	21.7	20.0	6.8	21.7	22.0	5.7	ns
Circumferences (cm)							
Mid-upper arm	25.1	25.0	2.7	25.2	25.0	2.4	ns
Hip	91.6	91.0	7.2	94.4	93.5	6.8	<0.001
Thigh	48.5	48.0	4.7	49.5	49.0	4.6	0.014
Calf	33.1	33.0	2.4	33.7	33.5	2.2	0.002

[a]Paired-sample student's *t* tests.

Student's *t* tests, and significant differences between groups (NBW and LBW) were followed by independent sample Student's *t* tests. In both cases, the Bonferroni correction was used to control for type-I errors across the pair-wise comparisons.

Correlations were calculated between maternal and infant anthropometry and between gestational age at birth and birth outcome. All statistical analyses were performed using SPSS version 10.0 for Windows and statistical significance was set at $P \leq 0.05$.

RESULTS

Infant anthropometry

The infants ($n = 44$) had an average birth weight of $3{,}138.0 \pm 488.5$ g, length of 49.8 ± 3.0 cm, and gestational age of 40.1 ± 2.3 weeks. Four (9%) of the infants were classified as LBW, one of which was also classified as pre-term (<37 weeks). Two NBW infants were also classified as preterm. Birth weight was not correlated with gestational age ($r = 0.09$, $P = 0.59$). The mean ponderal index for sexes combined was 2.56 ± 0.40 and ranged between 1.65 and 3.29. The mean ponderal index for boys was 2.45 ± 0.41 and for girls was 2.70 ± 0.34. Based on definitions of intrauterine stunting and intra-uterine wasting used by Ashworth et al. (1997), one infant was classified as stunted (girl) and nine were classified as wasted (six boys and three girls).

Maternal anthropometry

Mean stature for the 46 women was 157.1 ± 5.8 cm. There was no significant change in stature during the course of pregnancy in these women ($t = 1.96$, $P = 0.06$). Maternal stature was significantly correlated with attained weight in both the second and third trimesters ($r = 0.54$, $P < 0.001$ and $r = 0.52$, $P < 0.001$, respectively), but not with weight gain between the second and third trimesters ($r = -0.10$, $P = 0.51$).

With one exception, all women gained weight from the second to third trimesters (Table 3). The exception was a woman who lost 1.0 kg and later gave birth to a 2,640-g baby, one of the smallest infants in the sample (but not LBW). The average weight gain from the second to third trimesters was 4.6 kg ($t = 12.07$, $P < 0.001$), an average of 0.38 kg/week. The sub-sample ($n = 16$) of women weighed twice in the third trimester showed a significant weight gain of 2.2 kg ($t = 6.59$, $P < 0.001$) in 6.6 weeks, or 0.36 kg/week.

Skinfold thickness increased significantly at the subscapular ($t = 3.20$, $P < 0.001$), suprailiac ($t = 5.81$, $P < 0.001$), and mid-thigh ($t = 3.52$, $P = 0.001$) sites from the second to third trimesters (Table 2). In contrast to these centralized sites, skinfold thickness at peripheral sites (triceps and medial calf) showed no significant changes over time. For the 16 women measured twice in the third trimester, only the calf skinfold increased significantly ($t = 3.45$, $P = 0.004$).

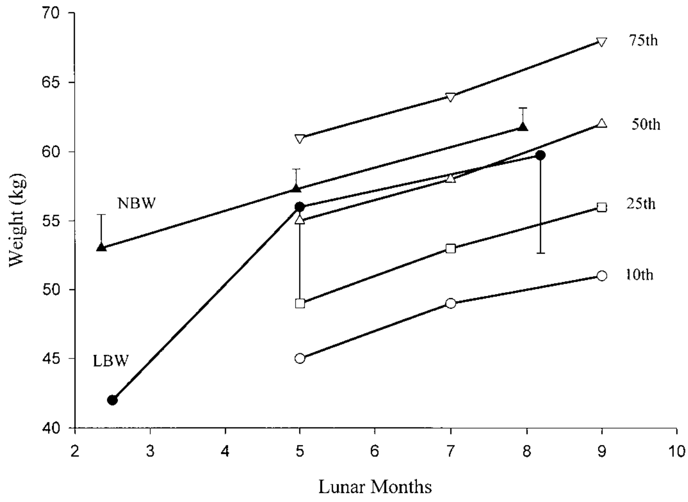

Fig. 1. Attained weight by lunar month for the total sample of 46 women compared with WHO (1995a) reference percentiles for Colombia. Error bars are standard errors.

The women increased in hip (t = 7.64, P < 0.001), thigh (t = 2.55, P = 0.014), and medial calf (t = 3.32, P = 0.002) circumferences from the second to third trimesters (Table 3). Only the mid-upper arm circumference did not change significantly. The group of 16 women measured twice in the third trimester increased significantly in hip (t = 3.04, P = 0.009) and calf (t = 3.00, P = 0.01) circumferences.

Maternal and infant anthropometry

Infant birth weight was not correlated with maternal stature (r = –0.15, P = 0.36), but infant length was correlated with maternal stature (r = 0.39, P = 0.01). Attained weight for women who gave birth to NBW infants (n = 40) and those who had LBW babies (N = 4) was close to the Colombian median (WHO, 1995a) (Fig. 1). Both groups showed significant increases in weight from the second to third trimesters (t = 11.42, P < 0.001 and t = 4.39, P = 0.02, respectively). Women who gave birth to the NBW infants tended to have higher achieved weights in both the second and third trimesters but differences between groups were not significant (Table 4). Women who gave birth to NBW infants tended to gain more weight than women who gave birth to LBW infants (4.72 and 3.75 kg, respectively), but this difference also was not significant (t = 0.71, P = 0.30). Finally, women who gave birth to NBW infants tended to have higher rates of weight gain between the second and third trimesters compared with women who gave birth to LBW infants (0.39 and 0.29 kg/week, respectively); however, the difference was not significant (t = 0.91, P = 0.30).

Women who gave birth to NBW infants showed a significant increase in the suprailiac skinfold (t = 5.77, P < 0.001) from the second to third trimester, whereas women who had LBW infants did not (Table 4). Women who had NBW infants also tended to have higher achieved suprailiac, midthigh, and medial calf skinfolds in the third trimester compared with women who gave birth to LBW infants, but the differences were not significant. Women who gave birth to NBW infants showed a significant increase in hip circumference from the second to third trimester (t = 7.15, P < 0.001), whereas women who had LBW infants did not (Table 4). By the third trimester, women who gave birth to NBW infants tended to have higher achieved circumferences at all sites compared with women who gave birth to LBW infants, but the differences were not significant.

DISCUSSION

Infant outcomes

The average birth weight of infants born to women in this study was 3,138 g, which is slightly higher than the average birth weight (3,015 g) calculated for a larger

TABLE 4. Mothers of low birth weight (LBW) vs normal birth weight (NBW) infants: attained weight, skinfold thicknesses and circumferences in the 2nd and 3rd trimesters

Characteristic	Group	*n*	Trimester 2 Mean	Trimester 2 SD	Trimester 3 Mean	Trimester 3 SD	ANOVA *P*-values Time	ANOVA *P*-values Group	ANOVA *P*-values Time by group
Weight (kg)	LBW	4	56.0	14.1	59.8	14.2	<0.001[a]	ns	ns
	NBW	39	57.0	9.2	62.0	9.0			
Skinfolds (mm)									
Triceps	LBW	4	16.3	5.6	15.8	3.4	ns	ns	ns
	NBW	39	18.2	6.5	18.6	6.4			
Subscapular	LBW	4	18.5	3.3	18.8	4.5	ns	ns	ns
	NBW	39	20.5	6.4	22.6	7.5			
Suprailiac	LBW	4	15.0	5.2	16.8	5.7	0.02[b]	ns	ns
	NBW	39	21.0	8.7	25.2	8.1			
Thigh	LBW	4	26.8	7.3	26.5	7.3	ns	ns	ns
	NBW	39	32.4	8.8	35.5	8.6			
Calf	LBW	4	18.0	1.8	15.5	2.6	ns	ns	ns
	NBW	39	22.4	7.1	22.5	5.6			
Circumferences (cm)									
Mid-upper arm	LBW	4	24.8	2.8	24.0	2.6	ns	ns	ns
	NBW	39	25.1	2.8	25.3	2.4			
Hip	LBW	4	91.5	10.7	95.8	9.8	<0.001[c]	ns	ns
	NBW	39	91.5	7.1	94.2	6.7			
Thigh	LBW	4	46.0	4.2	45.0	4.9	ns	ns	ns
	NBW	39	48.8	4.6	50.0	4.4			
Calf	LBW	4	31.5	3.5	32.0	2.4	ns	ns	ns
	NBW	39	33.3	2.2	33.9	2.1			

[a]Significant increase in weight in women with LBW and NBW infants (*t* test, $P = 0.02$ and $P < 0.001$, respectively).
[b]Significant increase at the suprailiac site in women who gave birth to NBW infants (*t* test, $P < 0.001$).
[c]Significant increase in hip circumference in women who gave birth to NBW infants (*t* test, $P < 0.001$).

sample of 4,598 Colombian women (WHO, 1995a). The incidence of LBW was 9%, which is similar to the Colombian average of 10% (UNICEF, 1997). Whereas the incidence of LBW in Colombia is similar to other Latin American countries (9.7%), this average is almost twice as high as that seen in developed nations of Western Europe, the United States, and Canada (5.2%) (UNICEF, 1997).

The fact that the incidence of LBW was just under 10% in this sample was surprising. A higher prevalence was expected since the study focused on the poorest Cali women. In addition, although conditions have improved among the rural poor in Colombia over the past 10 years, conditions of the urban poor have remained relatively unchanged (World Bank, 1994). What makes these results less surprising, however, is that maternal anthropometry (height and weight) is on average similar to Colombian women as a whole (WHO, 1995a). Therefore, while these women live in poverty they appear to be meeting the demands of pregnancy as measured by the fact that they gave birth to average-size infants.

The fact that infant birth weight was not correlated with gestational age in this sample was also surprising as there is typically a strong correlation between these variables. According to Jacobsen (1975), gestational age is the best predictor of infant birth weight. The lack of correlation between these two variables in this study is probably due to the small sample size and the greater variability in birth weight than in gestational age in the sample.

Whereas only one infant was classified as stunted, nine were classified as wasted. Of the nine, two-thirds ($n = 6$) were male. According to the timing hypothesis, stunting is caused by fetal insults early in gestation because the majority of linear growth occurs before the 28th week of gestation. On the other hand, wasting is due to fetal insults later in gestation because that is when most weight and fat deposition occur (Falkner et al., 1994). The fact that more infants in the sample were wasted than stunted suggests that fetal growth was constrained during the latter stages of gestation. The women in this sample gained more weight per week between the second and third trimesters of pregnancy than within the third trimester. These women also gained, on average, less weight from the second to the third trimester (0.38 kg/week) than Hispanic women in developed countries. Hispanic women living in San Francisco, California, showed an average weight gain of 0.54 kg/week within the second and third trimesters (Abrams et al., 1995). In a population of pregnant Hispanic women in Los Angeles, California, average weight gain was 0.45 and 0.49 kg/week in the second and third trimesters, respectively (Seiga-Riz et al., 1994). The women in the present study did not show an increased weight gain during the later stages of pregnancy and showed lower estimated rates of gain than seen among Hispanic women living in the U.S. The lower rate of gain and thus lower total weight gain over the last two trimesters may partially explain the incidence of wasting in the sample. Most of the wasted infants were boys, and boys tend to be longer at birth than girls (Bogin, 1988), whereas girls tend to have a greater amount of body fat than boys (Forbes, 1987). Insults to growth during the latter stages of pregnancy may, therefore, have a greater impact on the ponderal indices of boys than girls.

Maternal anthropometry

Maternal stature influences birth weight with taller women giving birth to larger infants (Adair and Bisgrove, 1991; Rosso, 1985; Dougherty and Jones, 1982). The women in this sample were short by international standards but of average size for Colombian women (WHO, 1995a). According to the WHO (1995b, p. 42), "environmental conditions that lead to poor maternal linear growth may also result in poor growth and sub-optimal development of the anatomical and physiological systems that sustain optimal fetal growth or maximize maternal health." In this sample of women, maternal height was correlated with birth length but not with birth weight. Whereas lack of significance may be due to small sample size, the WHO collaborative study on "Maternal Anthropometry and Pregnancy Outcomes," found that maternal height showed a low odds ratio (1.7) for predicting the risk of giving birth to a LBW infant (WHO, 1995a). In addition, a study of 8,870 women noted that maternal height was positively correlated with infant birth weight in Asians, Blacks, and Whites but not in Hispanics (Pickett et al., 2000). The reason for this difference is not understood.

Assessment of weight gain in pregnancy is contingent on knowledge of pre-pregnancy body weight, which is typically determined by recall, although there is a great deal of error associated the ability to recall pre-pregnancy weight (WHO, 1995a). Given that most women in this sample did not appear to know their current or pre-pregnant body weight, attention was focused on achieved maternal weight at different points during pregnancy.

In this sample of 46 Colombian women the greatest weight increase occurred between weeks 19 to 32 (mid-second to mid-third trimesters). Over this period, the women gained an average of 4.6 ± 2.6 kg at an estimated rate of 0.37 ± 0.20 kg/week or 1.4 kg per month. This estimate is greater than that observed during the latter stages of the third trimester. These results are similar to other studies. The WHO (1995a) reported a mean weight gain of 1.4 kg per month over a similar period of time for a group of women from developing countries, including Colombian women. Naeye (1990) suggests that a weight gain of 0.8 kg per month is sub-optimal after the first trimester. Therefore, these women show average weight gain patterns compared with other women living in developing nations and exceed the 0.8 kg per month suggested by Naeye (1990).

Although the women who gave birth to LBW infants did not differ significantly from those who had NBW infants in attained weight or estimated rate of gain, their absolute values were lower in all trimesters. The difference in achieved weight in the third trimester was 2.2 kg, which is a non-trivial difference from a biological point of view. Failure to demonstrate statistically significant between group differences is probably due to the relatively low power of the test as a result of small sample sizes and high standard deviations. A power of 0.80 requires sample sizes of 459 for both groups. The women with LBW infants gained an average of 1.1 kg/month between the mid-second and mid-third trimesters compared with 1.54 kg/month gained by the women who had NBW infants. This places the women who had LBW infants close to the cut-off of 1.0 kg/month set by the WHO (1995b).

The women showed significant increases in skinfold thicknesses at more centralized sites (subscapular, suprailiac, and mid-thigh) between the second and third trimesters whereas peripheral sites showed little change. Studies in samples from developed nations have also reported significant increases in the central skinfolds (Clapp et al., 1988; Forsum et al., 1989; Pipe et al., 1979; Ridzon et al., 1998; Taggart et al., 1967). The study of Clapp et al. (1988) is particularly interesting since it demonstrated that even women in their first trimester showed significant site-specific (abdominal and suprailiac) increases in subcutaneous fat deposition.

Only one other study in a developing country reported changes in skinfold thicknesses during the course of pregnancy. In a study of African women, Jansen et al. (1984) found significant decreases at the triceps and subscapular skinfold sites as pregnancy progressed. This contrasting finding may have been due to the fact that the African women were rural agricultural-workers, whereas the women in the present study lived in a less physically demanding, urban environment.

The finding of subcutaneous fat deposition at the suprailiac and thigh sites is logical from a physiological perspective because these are major female fat depots. Lipoprotein lipase (LPL) activity is elevated and lipid mobilization is low in the femoral depot compared with other fat depots in the body, and this pattern is accentuated during pregnancy when LPL activity is even further elevated (Rebuffé-Scrive et al., 1985). However, during the more energetically demanding period of lactation, LPL activity decreases at the femoral depot leading to greater lipid mobilization, which allows women to draw on these reserves, if necessary, to meet energetic demands. Fat deposition at the subscapular site is more difficult to explain.

Whereas the absolute values for skinfold thicknesses at most sites continued to increase through the third trimester, only the medial calf skinfold showed a statistically significant increase. This suggests that while the women continued to gain weight in the third trimester, less of the weight was deposited as body fat. Maternal weight gain may reflect fetal growth, which is rapid during the latter stages of gestation. This continued weight increase throughout the third trimester may also reflect changes in hydration, which could explain the increased medial calf skinfold in association with an increased tendency toward edema in the lower limbs in late gestation. The results are similar to those of Pipe et al. (1979) and Ridzon et al. (1998), who also found peak skinfold thicknesses at the end of the third trimester. Taggart et al. (1967) also noted significant increases in skinfold thicknesses, but only to the 30th week of gestation. Thereafter, skinfold thicknesses either remained constant or decreased slightly. The only exception was the thigh skinfold, which showed a continued increase until the 38th week.

Women who gave birth to NBW infants had greater absolute values for achieved skinfold thicknesses at all sites in both the second and third trimesters than women who had LBW infants, but the differences were not significant. This is probably a function of the low power of the tests. Studies that have looked at differences in infant birth weight and its relationship to maternal skinfold thicknesses are apparently not available. Lederman et al. (1999) reported increases in maternal body water (fluid and lean tissues) but not body fat, which was positively associated with infant birth weight in 200 healthy U.S. women. The results of Lederman et al. (1999) emphasize the need to understand the relationship between maternal weight gain and body composition and their implication for infant birth weight. Lederman et al. (1999) focused on a group of healthy women living in a developed country where weight gain during pregnancy and energy reserves are typically sufficient if not overly high. It would be interesting to see if this same pattern exists among more nutritionally marginalized populations.

Hip and thigh circumferences showed significant increases from the second to third trimesters, which paralleled skinfold thicknesses at these same sites. The calf circumference also increased over this period of time, which was not expected and may be due to edema. With the exception of mid-upper arm circumference, other studies are not available for comparison because serial measurements of circumferences during pregnancy have not been reported. Both Olukoya (1990) and Tibrewala and Shah (1978) found a significant, positive relationship between maternal body weight and mid-upper arm circumference, and have used it as a proxy measurement for pre-pregnancy and early maternal weight. According to these two studies, a mid-upper arm circumference below 23.0 cm may be indicative of nutritional stress. Three women in this sample had mid-upper arm circumferences under 23.0 cm during the second and third trimesters of pregnancy. Of these three women, one gave birth to a LBW infant (2,200 g).

Overall, the women in this study appeared to meet the demands of pregnancy, as measured by achieved weight and birth outcome, despite their poor living conditions. Continued weight gain through the third trimester of pregnancy along with the absence of decreases in skinfold thicknesses, indicates that these women accommodated their pregnancies without using their own energy stores. However, the number of wasted infants may be indicative of some type of insult during the latter stages of pregnancy. Women who gave birth to NBW infants and those who had LBW infants tended to differ from one another in the suprailiac skinfold and hip and thigh circumferences, which may be useful in identifying women at risk. As seen in this study, and as noted by both Prentice et al. (1996) and Norgan (1992), skinfold thicknesses at the suprailiac and thigh depots show greater increases during pregnancy than do other sites. These two sites are not usually measured in pregnant women, but future studies should include them. Based on the small sample size in this study, the authors recognize the limitations of these data for making recommendations regarding maternal anthropometry and birth outcome. However, given that many of the trends in the data are similar to those reported in other larger studies, they provide potentially valuable information. More studies of pregnancy among poor, urban women in developing countries are needed because these populations continue to expand due to both internal growth and immigration from rural areas.

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