Biological determinants of pregnancy weight gain in a Filipino population[1-3]

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ABSTRACT Patterns of pregnancy weight gain and predictors of first trimester and total weight gain were investigated in a sample of 1367 women from Cebu, Philippines, with pregnancy intervals of < 2 y. The mean total weight gain based on actual measurements of prepregnant weight was 8.4 kg. Controlling for gestational week when weight was measured, multivariate-regression models predicted higher first trimester weight gain with higher parity, lower prepregnant body mass index (BMI), and longer nonpregnant intervals. Higher total weight gain was associated with longer nonpregnant intervals, lower prepregnant BMI, taller maternal stature, and relatively high dietary energy intakes. Lactation into the third trimester of pregnancy and maternal age over 35 y had significant negative effects on total weight gain. Given the importance of maternal weight gain in predicting birth outcome, this study provides information on modifiable risk factors that should be considered when developing maternal-infant health policy and programs. *Am J Clin Nutr* 1993;57:365–72.

KEY WORDS Determinants, weight gain, pregnancy, less-developed countries, lactation, anthropometry, nutrition, first trimester

Introduction

Weight gain is well recognized as an important determinant of pregnancy outcome. In Europe and the United States numerous studies show the most favorable birth outcome with weight gains in the range of 10–15 kg (1). Among poorly nourished women of developing countries, weight gains rarely fall in this range. Instead, mean total weight gains range from 4.8 kg in Bangladesh (K Krasovec, ScD dissertation, Johns Hopkins University School of Hygiene and Public Health, 1989) to 8.9 kg in Thailand (2). We summarize weight gain data from studies in less-developed countries (LDCs) in **Table 1.** Such low gains are likely to be a major contributor to the high prevalence of low birth weight (LBW) found in these settings.

The vast majority of studies, including those done in Europe and the United States, focus on total weight gain and provide us with little information on patterns of change by trimester. The few studies involving patterns of weight gain appropriately controlled for gestational age demonstrate that inadequate weight gain after 20–24 wk of pregnancy increases the risk of preterm delivery (9, 10; H Kalkwarf, unpublished observations, 1992). Given the important effects of weight gain on pregnancy outcome, it is clear that more information is needed about patterns and determinants of weight gain, particularly among women who are nutritionally at risk. The combination of low prepregnancy weight status and low weight gain during pregnancy substantially increases the risk of poor birth outcomes, especially LBW.

Studies on the determinants of weight gain from developed countries show that prepregnancy weight, parity, gestational duration, and mother's height are significant predictors (11–15). However, only a small amount of the variance can be accounted for by these variables (2–12%) leaving many of the determinants of weight gain unknown. Information from LDCs is sparse because there are few well-designed prospective studies and data from maternity clinics are often inadequate because women are less likely to attend regularly for weight monitoring and prenatal care. Lack of regular measurements throughout pregnancy prohibits adequate descriptions of patterns of weight gain. Furthermore, studies are hindered by a lack of good prepregnancy weight data. Investigators often rely on a woman's report of her prepregnancy weight or use weight measured early in pregnancy as a proxy. Thus, there is almost no information from LDCs about first trimester weight gains. Finally, recent reports note that many women in LDCs may continue to breast-feed while they are pregnant (15). This practice is likely to place additional nutritional demands on the mother and affect her weight gain. However, to date no study has evaluated the effect of lactation on pregnancy weight gain.

The present study can help fill these gaps in our knowledge in several ways. First, subjects are from a community-based (rather than hospital- or clinic-based) sample of women in metropolitan Cebu, Philippines. Maternal weight was measured prospectively from birth of a previous infant. Thus, true pre-

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TABLE 1
Mean pregnancy weight gain among women in developing countries

Country	Sample size	Mean total wt gain	Period covered*	Reference
		kg		
Bangladesh	1700	4.8		Krasovec†
East Java	NA‡	6.0	1–3 and 7–9 mo	Hull (3)
Gambia	52	7.3	10 wk to term	Durnin (2)
Guatemala	NA	7.0		Lechtig (4)
India	69	7.0		Tripathi (5)
India				
Maharashtra	514	5.7		Anderson§
Gujarat	559	6.1		Anderson§
Kenya	190	4.1	3.1–7.6 mo	Jansen (6)
Taiwan	125	7.6		Adair (7)
Thailand	44	8.9	10 wk to term	Durnin (2)
Philippines	51	8.5	10 wk to term	Tuazon (8)

* Covers the entire period unless otherwise noted.

† Krasovec K. An investigation into the use of maternal arm circumference for nutritional monitoring of pregnant women. ScD dissertation, Johns Hopkins University, School of Hygiene and Public Health, 1989.

‡ NA, not available.

§ Anderson MA. The relationship between maternal nutrition and child growth in rural India. PhD dissertation, Tufts University, April 1989.

pregnancy weight and first trimester weight gain data are available. Second, information was collected on a wide range of individual, household, and community-level factors that may affect weight gains. Shortcomings of the study include the lack of complete birth-outcome data and the short pregnancy intervals of sample women. The latter limits generalizing from the results. Despite these shortcomings, data are particularly valuable because they allow us to focus on the first trimester and on determinants of weight gain. Furthermore, because detailed data on infant-feeding practices were collected, this study provides an important opportunity to investigate the effect of lactation on pregnancy weight gain.

Methods

Design and sample size

This study is part of the Cebu Longitudinal Health and Nutrition Survey (CLHNS) that took place in central Philippines from 1983 to 1987. The initial sample consisted of 3327 pregnant women who were drawn from randomly selected communities in the metropolitan Cebu area. Women and their families were followed from pregnancy through birth of the index child and for 2 y postpartum. During that time, subsequent pregnancies were identified in 1367 women. These women form the sample for the present analysis. It was not the intent of the initial study to follow subsequent pregnancies. Thus, data collection ends 2 y after birth of the index infant. **Figure 1** presents information on the timing of subsequent pregnancies in relation to the index birth in the CLHNS. The difference in timing of these pregnancies explains the varying amount of data available for each woman. First trimester-weight change data are available from 1192 women. Data into the third trimester are available for 877 women. Because all of these women have pregnancy intervals < 24 mo, results may not be generalized to women with longer pregnancy intervals.

Women who became pregnant within the 2-y study period were less educated, younger, of lower parity, and came from more traditional lower income families than those who did not become pregnant in that time period. Furthermore, of those women who became pregnant during the study period, women with short pregnancy intervals (< 12 mo) were of higher income, heavier (prepregnant weight 46.1 vs 44.8 kg), of lower parity (2 vs 3), more educated (7.4 vs 6.4 y of education), and less likely to have breast-fed or breast-fed for a shorter period of time compared with women with intervals of 12–24 mo.

Data collection and definition of variables

A baseline survey was conducted when women were pregnant with the CLHNS index child. Baseline data consisted of extensive information on socioeconomic, demographic, household, nutritional, anthropometric, and maternal biological factors collected during in-home interviews. Then bimonthly anthropometric, infant-feeding, health status, and socioeconomic data were collected [further details of the study have been published elsewhere (16–18)]. The study was approved by the Institutional Review Board at the University of North Carolina at Chapel Hill School of Public Health.

Ascertainment of the subsequent pregnancy came from two sources of information: in the majority of cases from date of birth or pregnancy termination of the second child obtained during a separate pregnancy follow-up survey conducted in 1986–1987 and in the few cases when date of birth was unknown, we relied on the woman's own report of being pregnant. For live birth outcomes and stillbirths, a date of conception was estimated by using the sample mean gestational age (39 wk) determined from all CLHNS index births. For pregnancies ending in recognized miscarriages, a mean gestational duration of 12 wk was assumed. In general we found a good correspondence between estimated dates of conception and the woman's own perception that she was pregnant. However, this method of determining the date of conception may cause errors in the estimates of first trimester weight gain for preterm and postterm deliveries. Based on CLHNS index birth data, 12.5% of the births occurred before 37 wk and 9% after 41 wk.

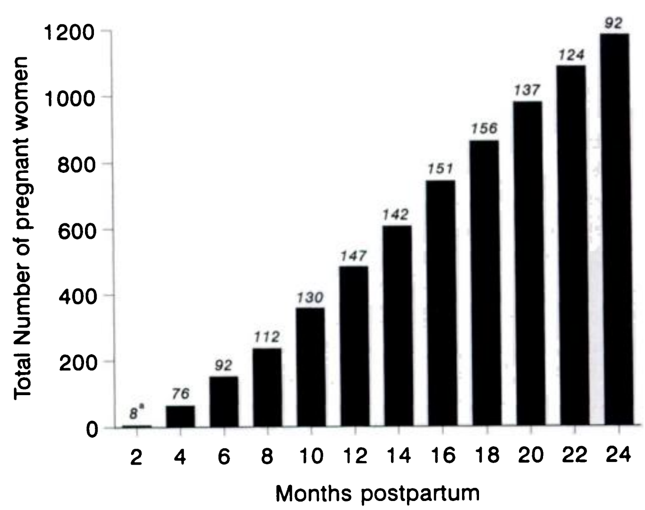

FIG 1. Combined sample sizes for urban and rural women 2–24 mo postpartum. [a]Number of women that became pregnant during the survey month.

Prepregnancy weight is the woman's weight measured at the survey before the estimated date of conception. Weight was measured in the respondent's home by using frequently calibrated spring-balance scales. In the 57 cases when data from that survey were missing, we used weight measured at the next prior survey or at a subsequent survey occurring < 8 wk after conception was used in its place. Of these subjects with estimated prepregnancy weight, only 37 were eligible for the study of first trimester weight gain. Weight gain in the first trimester is the difference between prepregnancy weight and weight measured at the survey closest to 13 wk gestation. Total weight gain refers to weight gain up to the last survey before delivery. For the majority of sample women this corresponds to 32–37 wk gestation. This calculation may slightly underestimate total weight gain, because women are likely to continue gaining weight until delivery. In multivariate models we include the variable, gestational week, to control for differing lengths of gestation at the time weight was measured.

The body mass index (BMI; in kg/m^2) was used to categorize prepregnant weight status. Underweight was defined as a BMI < 18.5, the value recommended by James et al (19) to suggest chronic energy deficiency in LDC populations. Normal weight and overweight were defined as a BMI between 18.5 and 25 or > 25, respectively.

Information on dietary intake was obtained at 2, 6, and 14 mo after birth of the index child by using the 24-h recall method. Food models were used to improve the accuracy of the recall. Data from a 24-h recall taken during the sample woman's subsequent pregnancy were used to rank energy intakes into tertiles. Classification of the women into tertiles is considered to be valid for three reasons. First, there is relatively little variability in diets, particularly in poor rural women who tend to have the lowest intakes. Second, energy intakes tend to be consistent over time. About one-fourth of the women were classified in the same energy intake tertile at all three surveys and an additional 53% were in the same tertile for two surveys and an adjacent tertile for the third survey. Third, there is a highly significant correlation of energy intake with a socioeconomic status index based on household income, assets, and parental education ($r = 0.33$, $P < 0.0001$ at 6 mo postpartum). Energy expenditure was estimated based on the woman's report of time spent in specific home and work activities and average energy expenditure values for those activities based on data from other Filipino women (*see* reference 20 for details). Our estimates of expenditure are likely to be overestimates because of the overlap of numerous tasks and a tendency to overestimate the intensity with which tasks are performed (because calculations of energy expenditure were based on the assumption

TABLE 2
Characteristics of women from CLHNS who became pregnant during the survey*

	Entire population (n = 1367)	Subpopulation† (n = 877)
Age (y)	24.6 ± 0.14 (14–43)	24.1 ± 0.18 (15–45)
Prepregnancy weight (kg)	45.33 ± 0.19 (30–74.5)	45.67 ± 0.23 (30.5–73.5)
Height (cm)	150.4 ± 0.13 (132.5–169.2)	150.4 ± 0.17 (132.5–165.7)
Body mass index‡	20.0 ± 0.07 (14.4–34.38)	20.1 ± 0.09 (14.4–34.38)
Energy expenditure (kJ · kg^{-1} · d^{-1})§	151.8 ± 0.29 (95.6–216.1)	151.1 ± 0.33 (131.7–184.4)
Energy intake (kJ/d)	5443 ± 69 (669–17 686)	5581 ± 84 (669–17 436)
Parity	3.0 ± 0.05 (1–14)	2.8 ± 0.07 (1–14)
Nonpregnant interval (d)	410 ± 3.85 (42–738)	321 ± 4.58 (42–548)
Lactation overlap‖ (wk)	11.9 ± 0.35 (0.14–37)	12.6 ± 0.43 (0.14–37)
Breast-feeding intensity (min/d)	45.5 ± 2.48 (1–900)	46.9 ± 2.45 (1–360)
Birth weight of index child (g)	2951 ± 12.3 (907–4195)	2929 ± 15.9 (907–4195)
Gestational age of index child (wk)	39 ± 0.07 (27–48)	39 ± 0.09 (27–48)
Household income¶ (pesos/wk)	184 ± 6.2 (0–2799)	190 ± 7.6 (0–2358)
Education (y)	6.8 ± 0.1 (0–16)	6.9 ± 0.1 (0–16)
Electricity in the home (%)	44.6	47.8
Own a refrigerator (%)	5.3	5.0
Gas or kerosene stove (%)	23.9	24.2
Smoker (%)**	13.9	12.1
Underweight (%)††	28.0	25.6
Lactation overlap (%)‡‡	46.0	50.1
Urban (%)	74.8	76.3
Low birth weight infant (%)	14.2	15.5
Preterm infant	14.3	15.4

* $\bar{x}$ ± SEM (range). CLHNS, Cebu Longitudinal Health and Nutrition Study.
† Women with weight gain data into the third trimester.
‡ In kg/m^2.
§4.184 kJ = 1.0 kcal.
‖ Mean for women with overlap of pregnancy and lactation > 0; entire population, n = 651; subpopulation, n = 457.
¶ Mean of total household income reported at baseline and 12 mo postpartum.
** Based on information reported during the baseline survey.
†† Based on prepregnancy BMI (<18.5).
‡‡ Women who were pregnant and reported breast-feeding at the time of conception.

that a task was performed at full intensity throughout the reported time spent in that activity).

The lactation status of women was determined based on detailed infant-feeding data (18, 21). The duration of overlap of pregnancy and lactation was calculated from the date of conception and the date when the woman stopped breast-feeding. Intensity of breast-feeding was defined as the frequency of breast-feeding in the past 24 h multiplied by the number of minutes of active sucking on the breast for the same time period. An average breast-feeding intensity during the overlap period was calculated. Seasonality was taken into consideration as the number of pregnant days occurring during the wet season (May–October).

Statistical methods

For the descriptive analysis of weight gain by gestational age, data were used in a cross-sectional manner with each woman contributing a varying amount of information. Mean changes in weight gain by lactation and prepregnancy weight status were calculated for the entire group (n = 1367) and for a subpopulation (n = 877) with data into the third trimester. Mean weekly rate of weight gain by lactation and weight status was calculated for each trimester. Comparisons between groups within each trimester were done by using Student's t test. Comparisons are made only for the underweight and normal-weight groups because of the small number of overweight women in this population.

Multivariate-regression techniques (ordinary least squares) were used to estimate the determinants of first trimester and total weight gain. In developing regression models we focused on biological determinants of weight gain. Bivariate analysis was used to help define the form of the variables to be used in the models: gestational week, BMI, parity, seasonality, and mother's height are continuous, whereas age (< 18, 18–35, and > 35 y of age), nonpregnant interval (< 6, 6–12, and > 12 mo), energy expenditure (low < 146, medium 146–155, and high > 155 $kJ \cdot kg^{-1} \cdot d^{-1}$), energy intake (low < 4180, middle 4180–5950, and high > 5950 kJ), and overlap (0, 1–12, 13–28, and > 28 wk gestation) are categorical. Breast-feeding intensity (high > 53 min of active sucking per day) is dichotomous. Variables were dropped from the final models if their coefficients were not statistically significant ($P < 0.05$) in either the first trimester or total weight gain models. Variables tested and dropped include those representing energy expenditure, low energy intake, seasonality, and intensity of breast-feeding. To sort out independent age and parity effects, maternal age was retained in all the models regardless of its statistical significance. To determine whether the effect of BMI differed according to energy intake, energy expenditure, and duration of overlap, interaction terms were tested in the models. Interaction terms were kept in the final model if $P < 0.05$. Models for first trimester and total weight gain were identically specified with the exception of the variable overlap so that results could be compared. The *SAS* statistical software package was used for all the analyses (22).

Results

We present descriptive information on maternal socioeconomic and demographic characteristics and previous pregnancy outcomes in **Table 2.** Significant differences between the entire sample (all women with pregnancy weight data) and the subpopulation (women with weight data in the third trimester) are seen only in parity, and as would be expected, in length of the nonpregnant interval. Approximately 28% of the sample women were underweight before pregnancy. For women who were breast-feeding and pregnant, the mean number of weeks of overlap was ($\bar{x} \pm$ SEM) 11.9 ± 0.35 for the entire sample and 12.6 ± 0.43 for the subpopulation. The amount of active sucking on the breast for these women was 45.5 ± 2.48 and 46.9 ± 2.45 min/d for the entire and subpopulations, respectively. Mean energy intake for both groups was ≈5439 kJ/d (1300 kcal/d).

Weight gain curves for the entire population and subpopulation appear in **Figure 2.** The two samples do not differ significantly in patterns of weight gain during the early weeks of pregnancy when weight data are available for both groups. Accordingly, subsequent comparisons focus on the subpopulation with more complete weight data.

Total weight gain was 8.4 ± 1.2 kg. Compared with women in developed countries, the United States and Europe (**Figure 3**), Cebu women began gaining weight more slowly and then caught up until 22–24 wk gestation. Thereafter, their rate of weight gain was markedly lower than women in developed countries. However, compared with women in Gujarat or Maharashtra, India, Cebu women gained more weight in the second half of pregnancy (**Fig 4**).

Comparisons of trimester-specific patterns of weight gain by prepregnancy weight status can be seen graphically in **Figure 5.** To better illustrate the differences in these groups, regression lines were fitted to the data. Underweight women consistently gained more weight than normal-weight or overweight women. During the first trimester as shown by the divergence in the regression lines, underweight women also gained weight at a higher rate. This is also shown by the comparison of mean weekly rates of weight gain (**Table 3**). Underweight women gained 0.07 ± 0.49 kg/wk (± SD), whereas normal weight women actually tended to lose weight (−0.08 ± 0.50 kg/wk) in the first trimester.

Weight gain according to lactation status is shown in **Figure 6.** Women who reported lactating at conception, irrespective of the duration of overlap, were compared with women who did not lactate while pregnant. There are no consistent differences between these two groups in the overall weight gain curve. How-

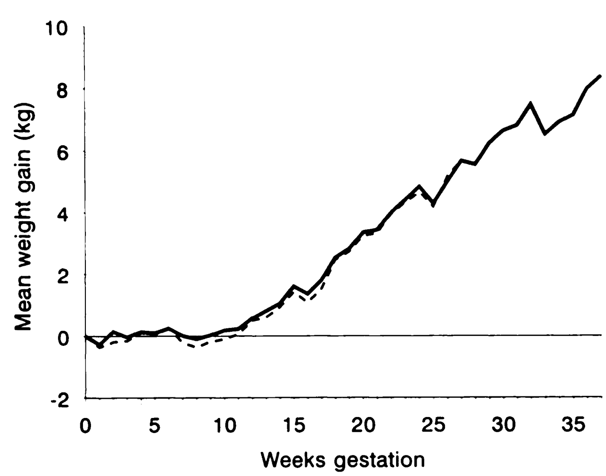

FIG 2. Weight gain curve for the Cebu population. ---, entire population, n = 1367. —, subpopulation of women with weight gain into third trimester, n = 877.

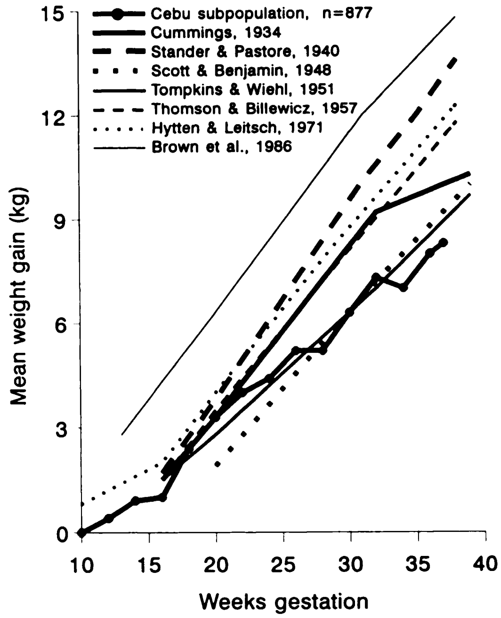

FIG 3. Pattern of maternal weight gain in developed countries compared with the Cebu subpopulation. Reprinted with permission from National Academy of Sciences (24).

ever, when mean weekly weight gains are compared (Table 3), women with any overlap of pregnancy and lactation gained weight at a significantly higher rate during the third trimester (0.31 ± 0.22 vs 0.22 ± 0.28 kg/wk among women with no overlap).

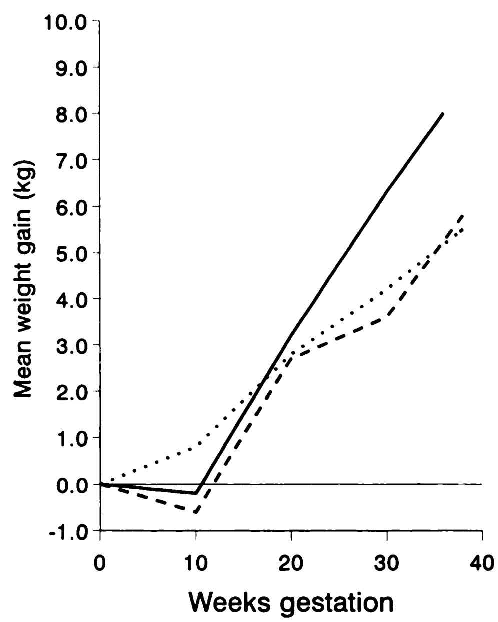

FIG 4. Pattern of maternal weight gain in India compared with the Cebu subpopulation. ---, Maharashtra, n = 514. ---, Gujarat, n = 559. —, Cebu, n = 877. (Five-point rolling mean for Maharashtra and Gujarat.) Reprinted with permission from Anderson MA. The relationship between maternal nutrition and child growth in rural India. PhD dissertation, Tufts University, April 1989: 30.

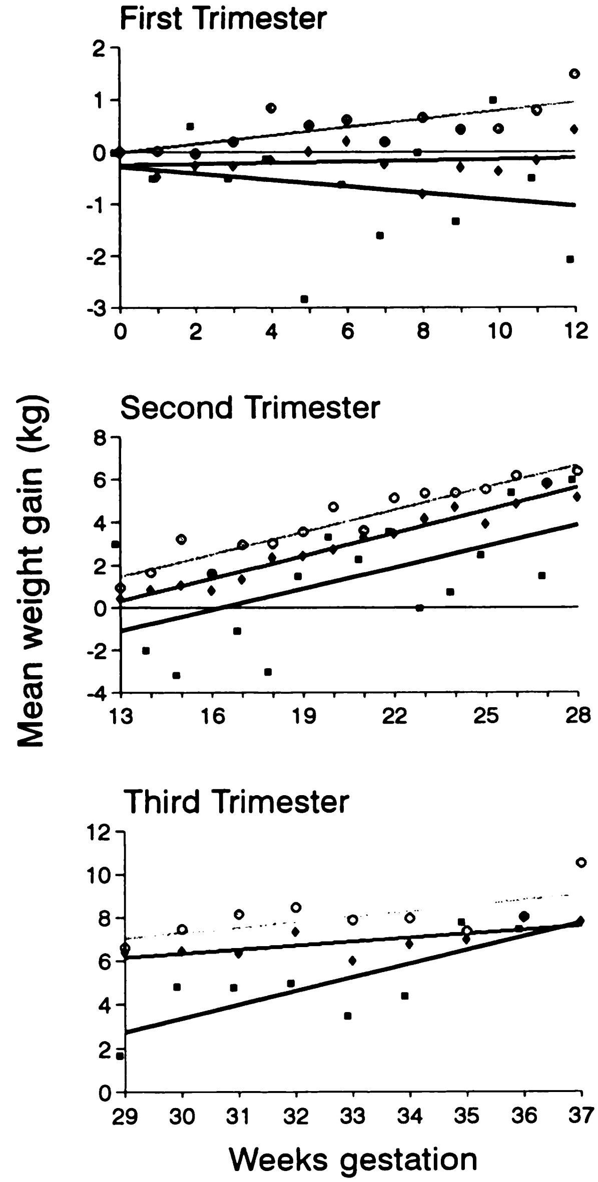

FIG 5. Pattern of weight gain for the Cebu subpopulation by weight status and by trimester of pregnancy. Regression lines fitted to the data. Weight status based on body mass index values; ○ = < 18.5, ♦ = normal, 18.5–25, ■ = > 25.

Results of the multivariate regressions are found in **Tables 4** and **5.** Regression analyses for the first trimester with either the entire population or subpopulation were compared to test the effects of including women with a wider range of nonpregnant intervals. Similar results were obtained, suggesting that determinants of weight gain are similar over the full range of intervals represented in the sample. For consistency we present the results based on the subpopulation only. Controlling for gestational week when weight was measured, higher first trimester weight gains were significantly associated with low prepregnant BMI, a nonpregnant interval > 6 mo, and higher parity. Together, these variables accounted for 11% of the variability in weight gain. The significant effect of BMI is consistent with the descriptive results showing that underweight women gain more rapidly in

TABLE 3
Weekly weight gain (kg/wk) by trimester for Cebu women with data into the third trimester*

Trimester	Subpopulation (n = 877)	Lactating (n = 457)	Nonlactating (n = 413)	Underweight (n = 199)	Normal weight (n = 543)
First	−0.04 ± 0.50	−0.05 ± 0.50	−0.03 ± 0.51	0.07 ± 0.49†	−0.08 ± 0.50
Second	0.35 ± 0.21	0.35 ± 0.21	0.35 ± 0.20	0.36 ± 0.18	0.36 ± 0.20
Third	0.27 ± 0.25	0.31 ± 0.22‡	0.22 ± 0.28	0.24 ± 0.29	0.29 ± 0.23

* $\bar{x}$ ± SD.
† Significantly different from normal weight, $P < 0.05$.
‡ Significantly different from nonlactating women, $P < 0.05$.

the first trimester. Lactation had a negative effect that was not statistically significant (P = 0.16).

The model of total weight gain accounted for 15% of the variation. Controlling for gestational week when weight was measured, higher total weight gain was significantly associated with low prepregnant BMI, a longer nonpregnant interval, greater maternal stature, and energy intake in the highest tertile. In addition, lactation into the third trimester of pregnancy and maternal age > 35 y had a significantly negative effect on weight gain. The interaction terms testing a differential effect of BMI according to energy intake and duration of lactation overlap on weight gain were not significant. Based on the beta coefficients, a woman with overlap into the third trimester would gain ≈1.84 kg less than a woman with overlap only in the first trimester. Compared with a woman with the sample average BMI (20.1), a woman with a BMI of 18 would be expected to gain ≈0.7 kg more. The effect of the nonpregnant interval is biologically important as well. A woman with a 6-mo pregnancy interval would gain ≈1.27 kg less than a woman with an 18-mo pregnancy interval.

Finally, a comparison of determinants of total and first trimester weight gain shows that parity has a significant effect on first trimester but not on total weight gain. In contrast, mother's height, duration of overlap of pregnancy and lactation, advanced maternal age, and high energy intake affect total but not first trimester weight gain.

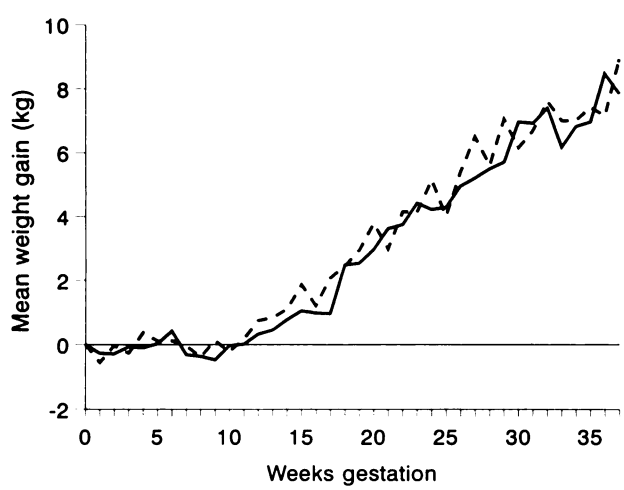

FIG 6. Weight-gain curve according to lactation status at the beginning of the pregnancy. Cebu subpopulation: —, lactating, n = 457, – – –, nonlactating, n = 413.

Discussion

This study describes patterns and determinants of pregnancy weight gain in a sample of women from the Philippines who are nutritionally at risk. Some results from the study are consistent with previous research, whereas others provide new insights on pregnancy weight gain.

The mean total weight gain of 8.4 kg from this study is at the higher end of the range reported for women in developing countries (*see* Table 1) but consistent with the value of 8.5 kg in the socioeconomically similar Filipino sample studied by Tuazon et al (8). However, it is lower than the means found in developed countries. This most likely represents an effect of the numerous constraints faced by the sample women, including poor diets, stressful work, and other risk factors typical of the poor environments encountered in developing countries.

There is very little information on determinants of pregnancy weight gain in women from LDCs. As in studies in the United States, we also found positive effects of maternal height and prepregnancy BMI on total weight gain (11–14). The presence of a maternal age effect for women > 35 y is contrary to research done by Scholl et al (13) and Kleinman (23), who found no

TABLE 4
Results of multivariate-regression model for first trimester weight gain*

Variable	Coefficient	SEE	t
Intercept	5.32	2.14	2.49†
Gestational week‡	0.06	0.03	2.34§
Prepregnancy BMI‖	−0.21	0.03	−7.51§
Maternal age			
>35 y	0.66	0.41	−1.58
<18 y	0.10	0.32	0.33
Nonpregnant interval			
<6 mo	−0.57	0.21	−2.72§
6–12 mo	−0.14	0.15	−0.90
Parity	0.18	0.04	4.93§
Maternal height	−0.01	0.01	−0.85
Overlap of pregnancy and lactation	−0.01	0.01	−1.39
High energy intake	0.07	0.15	0.45

* R^2 = 0.1119, n = 712; F = 9.97, P = 0.0001.
† $P < 0.05$.
‡ Week of pregnancy when last weight measurement was taken.
§ $P < 0.01$.
‖In kg/m^2.

TABLE 5
Results of multivariate-regression model for total weight gain*

Variable	Coefficient	SEE	*t*
Intercept	−1.27	3.56	−0.35
Gestational week†	0.22	0.04	5.18‡
Prepregnancy BMI§	−0.33	0.04	−7.70‡
Maternal age			
>35 y	−1.91	0.62	−3.06‡
<18 y	0.57	0.48	1.18
Nonpregnant interval			
<6 mo	−1.27	0.33	−3.79‡
6–12 mo	−0.43	0.23	−1.85
Parity	−0.00	0.05	−0.00
Maternal height	0.05	0.02	2.50‡
Overlap of pregnancy and lactation			
0–12 wk	0.35	0.25	1.43
12–28 wk	−0.06	0.25	−0.25
>28 wk	−2.19	0.69	−3.17‡
High energy intake	0.50	0.23	2.18‖

* $R^2 = 0.15$, $n = 751$; $F = 12.09$, $P = 0.0001$.
† Week of pregnancy when last weight measurement was taken.
‡ $P < 0.01$.
§ In kg/m^2.
‖ $P < 0.05$.

effect of maternal age. However, Hediger et al (14) found that very young maternal age (< 14) significantly predicts weight gain after the first trimester. Our study could not duplicate this finding because the youngest woman in our sample was 15 y.

Our finding that underweight women gain weight at a higher rate than normal-weight women during the first trimester is the first evidence of such an effect among women in a LDC. This is particularly important because information on first trimester weight changes is determined from actual measurement rather than recall of prepregnancy weight. Studies from developed countries have been inconsistent in demonstrating an effect of prepregnancy body weight on the pattern of weight gain (24). Nonetheless, based on studies of pregnancy outcome, weight gain recommendations for underweight women are higher than those for normal-weight or overweight women.

The pattern of weight gain among women who lactate while pregnant is intriguing. No other studies have examined this effect. Merchant et al (15) found positive effects of overlapping pregnancy and lactation on maternal energy intake from food supplements during pregnancy but no effect on fetal outcomes. If there are competing energy needs for lactation and growth of maternal and fetal tissues, then one might predict a detrimental effect of lactation on maternal weight gain. In previous studies of Cebu women (25) we showed a negative effect of lactation on postpartum weight. Based on the multivariate model, this study shows that lactation into the third trimester also has a negative effect on pregnancy weight gain. In contrast, women with overlap only in the first trimester tend to gain slightly more weight than women with no overlap, though this observation was not statistically significant ($P = 0.15$). Our comparisons of mean weekly weight gains show that women with any overlap of pregnancy and lactation have higher third trimester weight gains compared with women with no overlap. These data appear to suggest a kind of rebound effect for women with short periods of overlap. Once the additional stress of lactation is eliminated, women are able to gain weight at a faster rate. This is a topic worthy of additional research.

The Cebu study shows a strong effect of the length of the nonpregnant interval on both first trimester and total weight gain. Our estimate of the effect of the nonpregnant interval is derived from a sample of women with a mean interval of 10.5 mo but includes women with intervals from 2 to 18 mo. Although we cannot extrapolate these results to women with longer birth intervals, this result is still very important because such a high percentage of births in LDCs occur after pregnancy intervals in the range covered by our analyses. In addition, short pregnancy intervals are well recognized as a risk factor for poor pregnancy outcomes.

The relationship among energy intake, maternal weight gain, and birth outcome is controversial (26–30). Our study does not examine birth outcomes but does show a positive effect on total weight gain of energy intake in the highest tertile [> 5950 kJ/d (1422 kcal/d)]. It does not show, as might be predicted, a negative effect of low energy intake on weight gain. It is possible that nutritional factors other than dietary energy play a more significant role in predicting poor maternal weight gain. Scholl et al (28) recently have shown that teenagers with inadequate weight gain tend to have a diet lower in iron. Additional studies are needed to examine the effect of various amounts of macro- and micronutrients in the maternal diet on pregnancy weight gain.

This study has important implications for women in LDCs. First, the results emphasize the importance of birth spacing and nutritional status before pregnancy on pregnancy weight gain. Public health programs should continue to encourage women to space their children to allow for adequate restoration of body energy and nutrient stores between pregnancies. Second, lactation into the third trimester of pregnancy should be recognized as a risk factor for poor pregnancy weight gain. Given the importance of breast-feeding for infant health, breast-feeding during pregnancy should not be discouraged but attention should be paid to meeting the additional energy and nutrient demands of this practice.

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