Food Supplementation during Pregnancy, Maternal Anthropometry and Birth Weight in a Guatemalan Rural Population*

by AARON LECHTIG, REYNALDO MARTORELL, HERNAN DELGADO, CHARLES YARBROUGH *and* ROBERT E. KLEIN

Division of Human Development, Institute of Nutrition of Central America and Panama (INCAP), Calzada Roosevelt, Zone 11, Guatemala City, Guatemala, C.A.

Introduction

The high proportion of babies with low birth weight (LBW ≤ 2.5 kg) prevailing in the low socio-economic strata of many countries constitutes a major public health problem,[1-6] and there is evidence that improved maternal nutrient intake decreases the incidence of these LBW babies,[7-9]. However, concern has arisen as to the possibility that increased nutrient intake of the mother may increase fetal growth without improving maternal nutritional status, or worse still, at the cost of a nutritional deterioration of the mother. This question is explored in the present paper by examining the relationship between food supplementation during pregnancy, maternal nutrition—as estimated by anthropometrical measurements—and birth weight, in a chronically malnourished population.

Methods

The data presented herein were drawn from a long-term prospective study dealing with the effects of chronic malnutrition on physical growth and mental development[10] carried out in four Guatemalan rural villages. The experimental design and the principal examinations made during pregnancy and at birth have been described elsewhere.[7] Two types of food supplements were provided: two villages received *atole* (protein–caloric) and the other two received *fresco* (caloric). The latter provided only one-third of the calories contained in an equal volume of *atole*, and both preparations had a similar concentration of the vitamins and minerals in which the diets of the populations studied are possibly limiting.[7,8] Attendance to the supplementation centers was voluntary, and individual intake of supplement was measured daily. In addition, all villagers benefited from free preventive and curative medical care. At the time the study began, severe malnutrition and preventable infectious diseases were endemic in the four villages.[7,8,11,12]

The main variables analyzed in the present article are shown in Table I. The data collection and their main characteristics have been described in previous papers.[7,8,11,12] Maternal anthropometrical measurements were taken by a single carefully trained observed, following standard techniques[13] and a strict quality control system.[14]

Both initial values as well as changes of maternal anthropometric measurements (MAM) during pregnancy were analyzed. Mothers were measured at least twice during pregnancy, usually some time during the second trimester and at the end of the

Table I
Main Variables used in the Present Analysis

I. *Maternal ingestion of food during pregnancy*
- —Experimental treatment: food supplementation (calories)
- —Daily home diet at the end of the second and third trimester

II. *Maternal anthropometry during pregnancy*
- —Mass and length: weight, height, sitting height, and total arm length
- —Perimeters: head, chest, mid-arm, thigh, and calf
- —Osseous diameters: biestyloid, and bicondylar
- —Skinfolds: biceps, tricipital, subscapular, mid-axillary, anterior and lateral thigh and medial calf

III. *Birth weight*

IV. *Potentially confounding variables*
- —Parity, gestational age, birth interval, age of the mother, lactation during present pregnancy, diastolic blood pressure and presence of lower limbs edema
- —Composite indicator of maternal morbidity based on duration of diarrhoea, anorexia, and remaining in bed due to illness
- —Cord blood IgM levels
- —Composite indicator of maternal socioeconomic status based on house, clothing and teaching

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Table II
Mean and Standard Deviations of Maternal Anthropometric Measurements during the Last Trimester of Pregnancy (four villages)

	Final*			Monthly change†		
Measurement	Mean	SD	No.	Mean	SD	No.
A. *Mass and length*						
Height (cm)	148.9	5.3	572	N.A.	N.A.	N.A.
Sitting height (cm)	79.5	3.1	192	N.A.	N.A.	N.A.
Total arm length (cm)	66.2	3.0	193	N.A.	N.A.	N.A.
Weight (kg)	53.9	6.6	192	1.17	0.56	137
B. *Circumferences (cm)*						
Head	52.8	26.0	193	N.A.	N.A.	N.A.
Chest	79.1	4.6	193	1.10	0.54	136
Arm	22.7	1.9	193	0.05	0.45	137
Calf	31.5	2.3	192	0.13	0.21	137
Thigh	44.4	3.4	192	0.50	1.23	137
C. *Diameters (cm)*						
Biestyloid	4.6	2.9	193	0.01	0.04	137
Bicondylar	8.3	7.1	192	0.05	0.82	136
D. *Skinfolds (mm)*						
Bicipital	47.80	18.04	193	0.05	0.24	137
Tricipital	104.37	29.69	193	-0.07	0.46	136
Subscapular	11.7	3.2	193	0.13	0.41	137
Mid-axillar	83.55	29:01	193	0.10	0.41	137
Calf	91.91	31.93	192	0.18	0.33	137
Lateral thigh	155.55	58.50	191	0.39	0.81	135
Anterior thigh	154.46	55.93	191	0.46	0.70	136

* At the end of the third trimester of pregnancy.
† Change per month of pregnancy (see methods in test).
N.A. = Not applicable.

third gestational trimester. Thus, the time interval between examinations fluctuated between 2 and 6 months. To correct for variability in time interval, changes during pregnancy were expressed as rates per month. No relationship between monthly changes and time interval between measurements was found, suggesting therefore that anthropometric changes during the last six months of pregnancy are linear and that no bias was introduced by the above procedure.

Results and Discussion

Relationship between Food Supplementation during Pregnancy and Maternal Anthropometry

Sample sizes, means, and standard deviations for maternal anthropometric variables, both for attained values (i.e. end of the third trimester of pregnancy) and for monthly changes, are presented in Table II. These values, particularly those for weight, height, and head and arm circumference, are below those usually reported for well-nourished populations from developed countries.[15,16] For example, mean maternal height of the study sample was about 16.7 cm below that of adult women from Denver,[15] a difference most of which had already become evident in similar comparisons of the same two populations at seven years of age.[17,18] The mean monthly weight gain during pregnancy was 1.2 kg/month (Table II), that is, approximately half the monthly weight gain observed in well-nourished women from Aberdeen.[16] The relationship between caloric supplementation during pregnancy and maternal anthropometry is shown in Table III for the total study population: *fresco* and *atole* villages combined. Correlations for 16 out of the 18 possible attained anthropometric variables were negative, indicating that bigger and more robust women tend to ingest fewer calories from the supplements. However, these correlations are quite small, being significant only for the medial calf circumference ($r = -0.18$; $P < 0.01$). In contrast, most of the correlations between supplemented calories and monthly changes were positive (Table III), even though again, quite small and insignificant. Interestingly enough, correlation between supplemented calories and monthly weight gain

Table III
Correlations between Supplemented Calories during Pregnancy and Maternal Anthropometrical Measurements in Four Rural Villages of Guatemala

Anthropometrical measurement	Final‡ (No. = 191)‖	Monthly changes§ (No. = 135)
A. *Mass and length*		
Total arm length	0.01	N.A.
Sitting height	0.02	N.A.
Weight	−0.04	0.12
Height	0.01 (No. = 572)	N.A.
Weight/height ratio	−0.04	N.A.
B. *Circumferences*		
Head	−0.03 (No. = 363)	N.A.
Chest	−0.05	0.13
Arm	−0.03	0.15
Calf	−0.01	0.16
Thigh	−0.05	−0.04
Mean changes in circumferences	N.A.	0.15
C. *Diameters*		
Biestyloid	−0.02	0.06
Bicondylar	−0.11	0.13
D. *Skinfolds*		
Bicipital	−0.11	0.07
Tricipital	−0.09	0.04
Subscapular	−0.01	0.08
Mid-axillar	−0.04	0.10
Medial calf	−0.18†	−0.02
Lateral thigh	−0.07	0.00
Superior thigh	−0.08	0.00
Mean skinfold changes	N.A.	0.06

* $P<0.05$.
† $P<0.01$.
‡ At the end of the third trimester of pregnancy.
§ During last two trimesters of pregnancy.
‖ When No. is different, it is presented in parenthesis.
N.A. = Not applicable.

became 0.213 (slope value: 294 g weight gain during pregnancy per 10^4 supplemented calories; No. = 137: $P< -0.05$) after statistically controlling for maternal home diet, height, head circumference, gestational age, parity, morbidity, socio-economic status, birth interval, and type of supplement (*atole* or *fresco*).

These last results indicate that the relationship between caloric supplementation and weight gain was similar in the villages receiving *atole* (protein–caloric supplement) and in those receiving *fresco* (caloric supplement). In other words, the presence or absence of protein in the supplement did not appear to alter the above-mentioned relationship. Similar findings have been reported in the same population for the relationship between caloric supplementation and birth weight,[7] placental weight and chemical composition,[19] and early post-natal growth.[20,21]

Table IV
Correlations between monthly anthropometric Changes during Pregnancy and Weight Gain per Month (No. = 135)

Anthropometric change per month of pregnancy	*r*
A. *Circumferences*	
Chest	0.48†
Arm	0.18†
Calf	0.44†
Thigh	0.07
Mean changes in circumferences	0.59†
B. *Diameters*	
Biestyloid	0.02
Bicondylar	0.27†
C. *Skinfolds*	
Bicipital	0.36†
Tricipital	0.34†
Subscapular	0.37†
Mid-axillar	0.39†
Calf	0.42†
Lateral thigh	0.37†
Upper thigh	0.46†
Mean skinfold changes	0.51†

* $P<0.05$.
† $P<0.01$.

Moreover, as Figure 1 clearly shows, findings reveal that the greater the amount of food supplement consumed, the lesser the proportion of mothers with low weight gain during pregnancy (LWG: <0.5 kg per month) which was about seven times higher in the low-supplemented group, in contrast to the high-supplemented group. The upper limit used to define low weight gain (less than 0.5 kg/month during the last two trimesters of pregnancy) is equivalent to a total weight gain of about 3.0 kg. The risk of mothers with this weight gain of being delivered of LBW babies is about three times greater than in those who gain 12 kg during pregnancy (computed from 6).

Correlations between monthly weight gain and other anthropometric changes during pregnancy are shown in Table IV, where one can observe the strong relationship between weight gain and changes in almost all circumferences, diameters and skinfolds measured. Results indicate, therefore, that weight gain reflects generalized changes in almost all body dimensions.

Changes in anthropometrical measurements should reflect changes in body composition. However, estimates available in the literature,[22,23] consider changes in both lean body mass and fat as functions of changes in weight alone. Thus, even though pregnancy may be changing relative body composition, as the high correlations of weight change to skinfold change suggest (Table IV), the authors were not in a position to estimate these modifications in body composition.

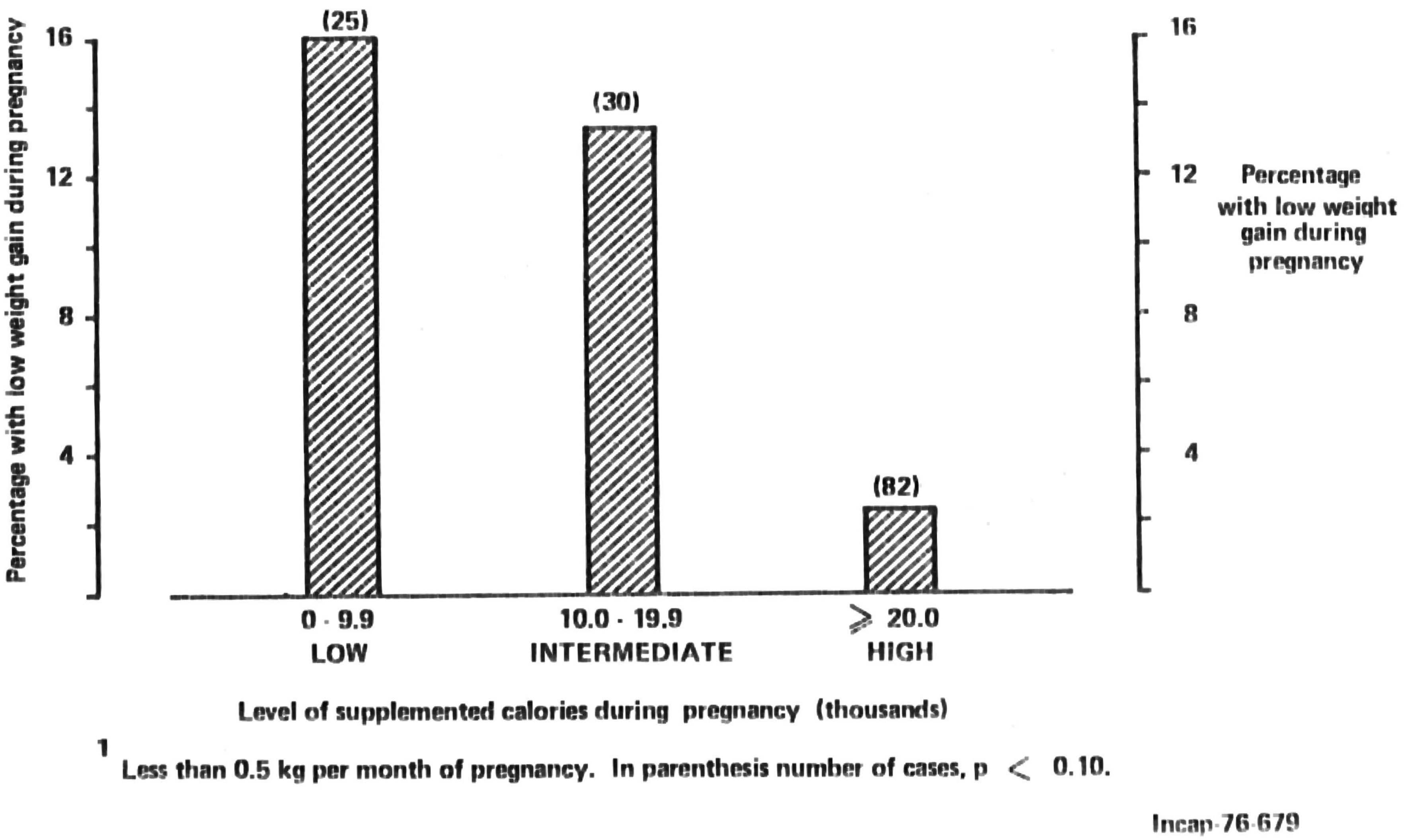

Fig. 1. Effect of supplemented calories on the proportion of mothers with low weight gain during pregnancy (less than 0.5 kg per month of pregnancy). (No. of cases in parenthesis, $P<0.10$.)

Relationship between Maternal Anthropometrical Measurements and Birth Weight

Correlations between maternal anthropometric variables (MAN) and birth weight are shown in Table V. Mass and length, circumferences, bone diameters and subscapular skinfold of the mother at the end of pregnancy were associated ($P<0.05$) with birth weight. Multiple regression analyses indicated that the maternal factors identified in Table I cannot explain the observed associations with birth weight. The extent to which correlations presented in Table V were due to covariation among the various anthropometric variables was also explored. It was found that maternal weight at the end of the third trimester was the most powerful predictor of birth weight. Once this variable entered into the regression equation, association between other maternal anthropometric variables and birth weight was almost totally erased. On the other hand, after controlling for height, head and arm circumference, most of the initial association between maternal weight and birth weight was also erased. These results suggest, therefore, that height, head and arm circumference are as good indicators as weight at the end of pregnancy for predicting birth weight.

Given the fact that the predictive value of these three variables is almost unaffected by gestational age[21] they may be used as indicators to select target populations for health and nutritional interventions. Their use would notably increase the efficiency, coverage and effectiveness of programs aimed to reduce the incidence of LBW babies.[14]

Regarding the incremental variables, a positive trend was observed between most of them and birth weight (Table IV), the association being statistically significant only for weight gain during pregnancy (<0.05).

Final Comments

The study reported herein has shown that higher levels of caloric supplementation during pregnancy were associated with greater weight gain during pregnancy and, hence, with a decrease in the proportion of women with low weight gain and with a trend to positive changes in circumferences, diameters and skinfolds. In view of the fact previously demonstrated that in the same population groups, caloric supplementation produced an increment of the total caloric intake during pregnancy and of the weight of the child at birth,[7] it is reasonable to infer that this effect on birth weight was accompanied by an improvement of the nutritional status of the mother.

The public health implications of the observed associations are obvious. Mothers with low weight gains are more frequently delivered of LBW babies who, in turn, suffer high rates of morbidity and mortality. Moreover, in populations where breast-feeding is a common pattern, improved maternal

Table V
Correlations between Maternal Anthropometrical Measurements and Birth Weight

Anthropometrical measurement	Attained‡ (No. = 186)§	Monthly changes (No. = 135)
A. *Mass and length*		
Height	0.14† (No. = 399)	N.A.
Sitting height	0.22†	N.A.
Total arm length	0.08	N.A.
Weight	0.35†	0.21*
Weight/height ratio	0.34†	N.A.
B. *Circumferences*		
Head	0.28† (No. = 363)	N.A.
Chest	0.28†	0.11
Arm	0.27†	0.02
Calf	0.33†	0.08
Thigh	0.26†	0.06
Mean changes in circumferences	N.A.	0.15
C. *Diameters*		
Biestyloid	0.25†	−0.03
Bicondylar	0.14	0.06
D. *Skinfolds*		
Bicipital	0.10	0.05
Tricipital	0.12	0.01
Subscapular	0.14	0.04
Mid-axillar	0.08	0.03
Calf	0.04	−0.05
Lateral thigh	0.11	0.08
Upper thigh	0.10	0.01
Mean skinfold changes	N.A.	0.05

* $P<0.05$.
† $P<0.01$.
‡ At the end of the third trimester of pregnancy.
§ When No. is different, it is presented in parenthesis.
N.A. = Not applicable.

nutrition means a greater breast milk nutrient output to the baby,[25] accompanied by improved post-natal growth and fastest recovery from the increased demands of pregnancy and lactation.

Furthermore, the observed associations between maternal anthropometric measurements and birth weight may provide a basis to build indicators predictive of the risk of mothers being delivered of LBW babies. These high-risk indicators are crucial to improve the efficiency of programs aimed at decreasing infant mortality.[4]

Summary

Concern has arisen as to the possibility that the reported effects of food supplementation during pregnancy on birth weight, may be produced without a related improvement of maternal nutrition. A study on the relationship between food supplementation and maternal nutrition, as assessed through anthropometrical measurements, was carried out in four rural villages of Guatemala; the relationship of these measurements to birth weight was also explored. Findings revealed that caloric supplementation was positively associated with maternal monthly weight gain during pregnancy after controlling for maternal home diet, height, head circumference, gestational age, parity, birth interval, morbidity, socioeconomic status, and type of supplement (protein–calorie and calorie) ($r=0.213$; $b=294$ g of weight gain during pregnancy per 10^4 supplemented calories; No. = 135; $P<0.05$). The proportion of mothers with a monthly weight gain equal to or less than 0.5 kg was 15% in the low-supplemented group ($\leq 10{,}000$ Cal/pregnancy) and 2.4% in the high-supplemented group ($\geq 20{,}000$ Cal/pregnancy) (t test: $P<0.10$). Direct associations between birth weight and all maternal measurements of mass and length (weight at first, second and third trimester, weight gain during pregnancy, height, and sitting height); with all the perimeters (head, arm, leg, thigh, and chest), and the two osseous diameters measured (biestyloid and bicondylar) were also observed. Associations between birth weight and skinfolds (subscapular, bicipital, tricipital, midaxilar, lateral and anterior thigh, and leg) were less consistent. These results support the hypothesis that food supplementation improves not only birth weight but maternal nutritional status as well. Furthermore, the associations found between birth weight and parameters of maternal size allow the building of simple risk indicators of low birth weight babies (≤ 2.5 kg), useful to select population groups requiring prioritary attention in public health programs.

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