Maternal and fetal responses to the stresses of lactation concurrent with pregnancy and of short recuperative intervals[1-3]

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ABSTRACT In many regions of the world, women breast-feed one child while pregnant with the next. Among rural Guatemalan women participating in a nutrition-supplementation trial, lactation overlapped with pregnancy in 253 of 504 (50.2%) of the pregnancies. For cases where overlap occurred, 41.4% continued to breast-feed into the second trimester and 3.2%, in the third trimester. The maternal and fetal responses to the energetic stresses of overlap and of the duration of the recuperative (nonpregnant, nonlactating) interval were assessed. Overlap resulted in increased supplement intake. Short recuperative periods (< 6 mo) resulted in increased supplement intake and reduced maternal fat stores. The energetic stresses of overlap and short recuperative periods did not significantly affect fetal growth. The mother appears to buffer the energetic stress, protecting fetal growth. This research demonstrates that evidence of depletion of maternal nutrient stores caused by a demanding reproductive history is found when reproductive stress is characterized adequately. *Am J Clin Nutr* 1990;52:280–8.

KEY WORDS Maternal depletion, pregnancy, lactation, birth spacing, supplementation, infant feeding, birth weight, maternal anthropometry, maternal nutrition

Introduction

Lactation and pregnancy are generally studied as separate phenomena. To an extent these physiological states are incompatible because of antagonistic effects produced by their corresponding hormonal controls. For example, the steroids of pregnancy inhibit the onset of lactation (1); breast-feeding in turn delays cyclic ovarian activity through poorly understood hormonal mechanisms (2). However, pregnancy and lactation can and do overlap. Lactation is not prevented by pregnancy if it has been established before conception.

In traditional societies with long durations of lactation, conceptions will occur despite breast-feeding. This is not to negate the fact that breast-feeding generally prolongs the period of postpartum amenorrhea. Ovulation may be delayed for many months but eventually it will reappear in women who breast-feed, generally after the introduction of other foods to the infant's diet. Therefore, in societies where the use of artificial contraceptives is rare, many women will become pregnant while breast-feeding unless there are strong taboos against sexual intercourse during the period of lactation.

Behavioral studies in the Third World indicate that pregnancy is cited frequently as a reason for weaning (3). The belief is widespread that pregnancy and lactation are incompatible states. For example, breast milk sometimes is viewed as harmful to the fetus; conversely, pregnancy sometimes is thought to spoil or damage the milk. The fetus, the toddler, or even the mother may be viewed as being at risk if pregnancy and lactation overlap. However, overlap is probably common because many women may not realize they are pregnant for several months after conception. Also, not all women may choose to wean their children upon discovering they are pregnant.

Surprisingly, little is known about the frequency and extent to which pregnancy and lactation overlap. Where information is available, however, indications are that overlap is a common occurrence. A study of breast-feeding practices in central Java found that 40% of the mothers who weaned their children were known to be pregnant (4). In Senegal, 30% of the study sample who were breast-feeding became pregnant. A substantial proportion of these women continued to breast-feed a previous child: 62% were breast-feeding at 3 mo, 19% at 6 mo, and > 4% into the ninth month of pregnancy and beyond (5). It was estimated by use of cross-sectional data from Bangladesh that 12% of the women who were pregnant at the time of one survey were also breast-feeding a previous child. The cumulative probability of lactation during pregnancy was calculated by use of data from several successive surveys in the same study. These calculations indicate that among women who were pregnant and breast-feeding a previous child, 45% continued breast-feeding through the sixth month of pregnancy and nearly 20% were breast-feeding at the beginning of the ninth month (6).

Lactation and pregnancy are each very energetically de-

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manding processes. Therefore, when these two physiological states occur simultaneously, the risk of depletion of nutrient stores in the mother or growth retardation of the fetus might increase, particularly among women with limited access to food. There is also the possibility that the breast-fed child will be harmed if breast-feeding patterns are altered or if milk volume is reduced. No one to our knowledge has assessed the implications for nutrition of the overlap of pregnancy and lactation for the mother, the fetus, or the breast-feeding child.

A longer nonpregnant, nonlactating interval before conception could permit repletion of maternal nutrient stores and lead to improved maternal status and fetal outcomes (AR Pebley and J DaVanzo, unpublished observations, 1988) (7). The overlap of lactation with pregnancy is more likely to occur, and less recuperation is possible, when birth spacing is close. Therefore, it is important to isolate the effects of the higher energetic demands of overlap per se from those resulting from short recuperative intervals when identifying causes of depletion in maternal nutrient stores.

This investigation, by use of longitudinal data from a nutrition-supplementation trial conducted in four rural communities of Guatemala, examines the phenomena of lactation concurrent with pregnancy and of recuperative intervals, and assesses their implications for nutrition of mother and fetus. Specifically, the following questions are addressed: To what extent does lactation during pregnancy occur in rural Guatemala? Do mothers consume more supplement when overlap occurs? Are maternal fat stores affected by overlap? Is fetal growth reduced when overlap occurs? Finally, for those women who do not lactate while pregnant, does the recuperative interval (the nonpregnant, nonlactating interval) affect supplement intake, maternal fat stores, and/or fetal growth?

Methods

Data

This investigation uses data from a nutrition-supplementation trial conducted by the Instituto de Nutrición de Centroamérica y Panamá (INCAP) in four rural communities in the Guatemalan department of El Progreso between 1969 and 1977. Two communities each were assigned randomly to receive either a high-protein, high-energy supplement (11 g protein and 163 kcal per 180 mL) called atole or a low-energy, nonprotein supplement (59 kcal/180 mL) called fresco. The study was reviewed by a human subject's panel of INCAP and was conducted in accordance with National Institutes of Health guidelines.

The supplements were free and available twice daily to all inhabitants at centrally located feeding centers in each community. One hundred and eighty milliliters was offered initially; more was provided if requested. Leftovers were measured and actual amounts consumed were recorded for pregnant and lactating women as well as for children up to the age of 7 y. Twenty-four–hour dietary-recall surveys were used at 3-mo intervals to measure the home dietary intakes of the women.

A health center was set up in each village to provide free primary health care to all community members. Anthropometric examinations were scheduled at 3-mo intervals during pregnancy and during the first 24 mo of lactation from 1971 to 1977. All measures were made by the same individual. Birth

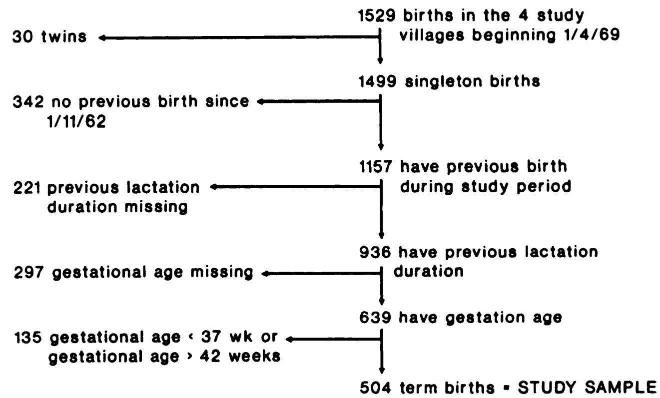

FIG 1. Sample-selection criteria.

weight was measured within 24 h after delivery. Duration of lactation was determined through maternal recall for all children aged ≤ 7 y at the beginning of the study period (January 1969) and prospectively during home visits occurring bimonthly for all those born within the study period. Pregnancies were identified as early as possible (also during home visits).

Gestational age was calculated as the difference between the date of birth and the date of onset of the last menstrual period. The date of conception was estimated by first subtracting 2 wk from the gestational age as calculated above, and then subtracting this value from the date of birth. Several surveys were conducted during the intervention period to assess the socioeconomic status of all households. A more detailed description of the specific data collected and methods used is given by Lechtig et al (8) and Delgado et al (9).

Sample selection

A total of 1529 births was recorded in the four study villages during the study period (1969–1977). Of these, 504 births were selected for study in this investigation (**Fig 1**). The study sample was selected for the following characteristics: term, singleton pregnancies of mothers with a previous child with a known birthdate and known lactation duration. Data for previous siblings were only available for children aged ≤ 7 y. Birth date and lactation duration for the previous child were required to establish unequivocally whether or not overlap in pregnancy and lactation had occurred. Pre- and postmature births were excluded on the grounds that these were either truly special subpopulations or cases with errors in the measurement of gestational age. Some women (48%) contributed data from more than one pregnancy to the study sample.

The selected study sample (n = 504) was similar to the total sample (n = 1529) in the following general characteristics: lactation duration of the previous child (C_{n-1}), birth interval, mother's height and head circumference, father's height and head circumference, distance from home to supplementation center, average energy intake from the home diet, proportion receiving each supplement type (fresco or atole), and proportion of male to female newborns. Of those examined, three characteristics differed between the selected study sample and the total sample. The mean maternal age, gestational age, and lactation duration of the current child (C_n) were higher in the selected subsample by 2 y, 0.5 wk, and 1 mo, respectively. All mothers of the selected study sample were multiparous; there-

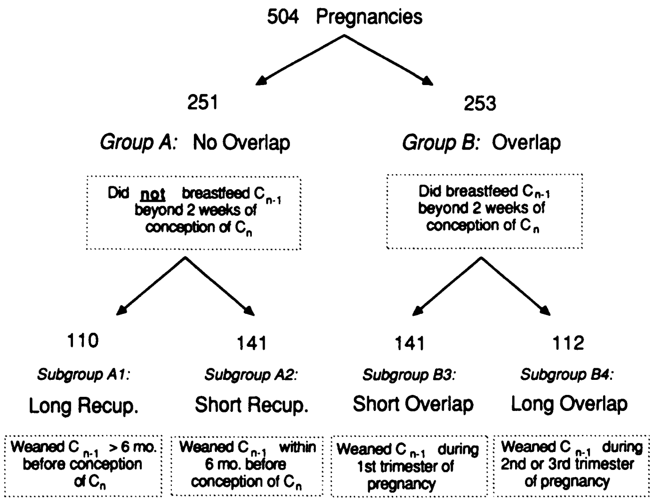

FIG 2. Classification strategy. C_{n-1}, previous child; C_n, index child.

fore, the age difference would be expected. The minimum maternal age for the total sample was 12.7 y and 16.1 y for the selected study sample. The restriction of the study sample to term births is the likely explanation for the slightly longer mean length of gestation; the minimum gestational age recorded for the total sample was 25 wk and, for the selected study sample, it was 37 wk.

Analytic approach

Classification. Pregnancies were divided into two groups based on time of weaning of the previous child (C_{n-1}) relative to the conception of the index child (C_n). Group A (no overlap) comprised cases in which C_{n-1} was weaned ≤ 2 wk after the date of conception of C_n and group B (overlap) comprised cases in which C_{n-1} was weaned > 2 wk after the date of conception of C_n. A conservative definition of overlap (> 2 wk) was used to minimize the possibility of misclassification of those who did not overlap in the overlap group.

Differences between group A and B in maternal and fetal outcomes (the central contrast in this study) cannot be attributed solely to the higher nutrient demands of concurrent lactation and pregnancy vs only pregnancy. The overlap group also has a shorter mean birth interval than does the no-overlap group (as would be expected). In an effort to separate the effects of overlap from short recuperative intervals, the main groups were subdivided (**Fig 2**). Group A was divided into subgroup A1 (cases where C_{n-1} was weaned > 6 mo before the conception of C_n) and subgroup A2 (cases where C_{n-1} was weaned within the 6 mo before the date of conception of C_n). Group B was divided into cases where C_{n-1} was weaned during the first trimester of pregnancy (subgroup B3) or during the second (104 instances) or third (8 instances) trimester (subgroup B4) of pregnancy.

Contrasts of interest. The contrast between subgroups A1 (no overlap, long recuperation) and A2 (no overlap, short recuperation) allows for an estimation of the unique effect of short recuperation intervals on maternal and fetal outcomes. On the other hand, the contrast between subgroup A2 and group B estimates the unique effect of overlap. Within group B the contrast between subgroups B3 (short overlap) and B4 (long overlap) is made to explore the implications of duration of overlap on maternal and fetal outcomes. The net effect of close birth spacing, whether because of recuperation or overlap, is estimated by contrasting the long recuperation (subgroup A1) with the other three subgroups (A2, B3, and B4).

Outcome variables. Although ideally maternal dietary intake should be based on home dietary intake plus supplement intake, supplement intake was chosen as the preferred maternal intake variable in this study. The precision and accuracy of these data are much higher and the completeness of these data is greater than those of the home dietary data, which were measured by 24-h recall. The original daily maternal-supplement-intake data were summarized by trimester of pregnancy and data are available only for average intake across each trimester in the INCAP data tapes. This poses some limitations (discussed later) for the analytic approach. Maternal fat stores were assessed by use of the thigh fatfold thickness (an average of the medial and the lateral thigh-fatfold-thickness measures). Of the seven fatfold sites—triceps, biceps, subscapular, suprailiac, knee, thigh, and calf—Taggart et al (10) demonstrated that the thigh-fatfold-thickness measure shows the largest absolute change across pregnancy. In addition, preliminary descriptive analyses of this Guatemalan study sample revealed that the thigh-fatfold-thickness measures showed the largest absolute change across pregnancy. For a thorough discussion of the measurement of maternal nutrition status as well as a description of previously observed values of various measures of maternal fat stores during pregnancy and lactation, *see* the review by Merchant and Martorell (7). Fetal growth was assessed by birth weight.

Statistical methods. Two-tailed Student's t tests with $p = 0.05$ were used to assess differences between group means for continuous descriptive characteristics. Chi-square analyses were used to assess differences in proportions between groups for categorical descriptive characteristics. Pearson's correlation coefficients were calculated to evaluate the relationship between home dietary intake and supplement intake. To address the research questions, first a prevalence of overlap was calculated, and second, two-tailed t tests ($p = 0.05$) were made to test the significance of the contrasts of interest between group or subgroup means (adjusted for potential confounders) for the following outcome variables: supplement intake at each trimester of pregnancy and at 3 mo postpartum, thigh fatfold thickness at each trimester of pregnancy and at 3 mo postpartum, and birth weight. Among the variables identified as potential confounders, only those related to the outcome variables with $p < 0.20$ (by use of an F test on the coefficients calculated by linear regression) were retained as covariates to calculate adjusted means. Assuming an ordinal scale with equal intervals, the p value of the regression coefficient for the subgroup rank (1 to 4) for birth weight was calculated by a one-tailed F test to test for a trend. The *Statistical Analysis System* (SAS Institute Inc, Cary, NC) was the computer software system used for data analyses. The adjusted means and the corresponding standard errors were calculated by SAS's *PROC GLM* with *LS-MEANS/STDERR.*

Results

Sample description

Descriptive statistics for selected variables for groups A and B are shown in **Table 1.** Anthropometric characteristics of

TABLE 1
Descriptive statistics, by group*

	Group A (no overlap)†	Group B (overlap)‡
C_{n-1} lactation duration (mo)	15.7 ± 6.5 [251]	17.7 ± 3.9§ [253]
Birth interval (mo)	35.0 ± 16.9 [251]	23.4 ± 4.3§ [253]
Mother's age at birth of C_n (y)	30.2 ± 6.8 [249]	28.7 ± 6.7‖ [252]
Parity (n)	5.8 ± 3.0 [247]	5.4 ± 2.8‖ [253]
C_n gestational age (wk)	39.7 ± 1.3 [251]	39.8 ± 1.4 [253]
C_n lactation duration (mo)	17.4 ± 7.3 [247]	17.0 ± 7.0 [252]
Mother's height (cm)	148.6 ± 4.9 [229]	149.4 ± 5.6 [248]
Mother's head circumference (cm)	51.2 ± 1.2 [229]	51.1 ± 1.4 [248]
Father's height (cm)	160.1 ± 5.6 [202]	160.9 ± 6.3 [185]
Father's head circumference (cm)	54.2 ± 1.5 [202]	54.3 ± 1.7 [185]
Walking distance to supplementation center (min)	2.5 ± 1.1 [236]	2.5 ± 1.1 [247]
Average maternal home diet (kcal/d)	1410 ± 432 [45]	1409 ± 418 [44]

* $\bar{x}$ ± SD. n in brackets. C_{n-1}, previous child; C_n, index child.
† Atole/fresco = 0.53/0.47; C_n male/C_n female = 0.55/0.45.
‡ Atole/fresco = 0.60/0.40; C_n male/C_n female = 0.52/0.48.
§‖ Significantly different from group A: §$p < 0.0001$, ‖$p < 0.05$.

mothers and fathers, walking distance from home to the supplementation centers, and gestational length of C_n pregnancies did not differ between groups. Maternal age and parity at the time of birth of C_n children, birth interval (equivalent to age of C_{n-1} at birth of C_n), and lactation duration for the C_{n-1} children differed between groups.

As shown in Table 1, information on energy intakes from home diets for all three trimesters of pregnancy was available for 89 pregnancies. The mean intake of the home diet (averaged over pregnancy) for the overlap group was 1409 kcal/d per pregnancy and 1410 kcal/d per pregnancy for the no-overlap group. No relationships were demonstrated between home diet and supplement intake for any of the trimesters of pregnancy. The Pearson's correlation coefficient between home dietary intake and supplement intake was not statistically significant for any trimester of pregnancy or for the average values across pregnancy (first, $r = -0.032$, $p = 0.76$, $n = 97$; second, $r = 0.055$, $p = 0.43$, $n = 201$; third, $r = -0.037$, $p = 0.57$, $n = 234$; average, $r = 0.042$, $p = 0.70$, $n = 89$). Adjusting supplement intake for home diet with this limited sample did not alter the results reported in the supplement-intake section.

Lactation during pregnancy

Lactation overlapped with pregnancy in 253 of 504 (50.2%) of the pregnancies in this study sample. Where overlap occurred, 141 of the cases of 253 pregnant mothers (55.7%) breast-fed only during the first trimester of pregnancy, 104 of 253 (41.1%) continued to breast-feed into the second trimester, and 8 of 253 (3.2%) continued into the third trimester. A histogram of the duration of overlap of lactation with pregnancy (n = 253) is shown in **Figure 3.**

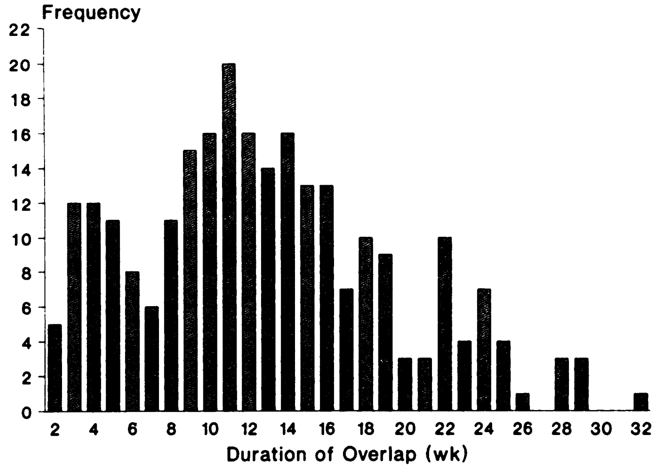

FIG 3. Frequency distribution for the duration of overlap of lactation with pregnancy within the overlap group (n = 253).

Maternal supplement intake

Main groups. The amount of supplement ingested during pregnancy was related to lactation (**Fig 4**). Group B had a significantly higher mean supplement intake for all three trimesters of pregnancy than did group A. Differences in supplement intake between groups were no longer present 3 mo after the birth of C_n. Multiple-regression analyses revealed that supplement intake was not associated with mother's height, mother's age, parity, or distance in minutes from the home to the supplementation center. The type of supplement (atole or fresco) and time since the beginning of the study (study month) were significant explanatory variables for supplement intake (ie, intake was greater in atole villages and increased through the years) and were retained in the model to calculate adjusted group means of supplement intake. Adjusted means for the main groups are plotted in Figure 4. The adjustment for these potential confounders did not alter the results.

Subgroups. The mean supplement intake of subgroup A1

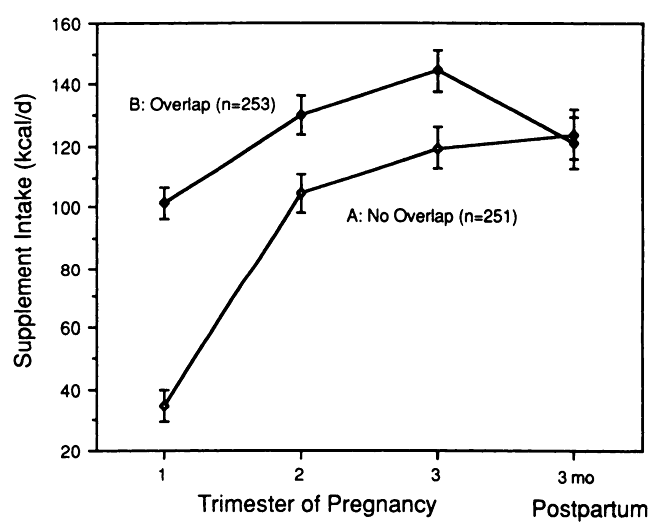

FIG 4. Maternal supplement intake across pregnancy and early postpartum for overlap and no-overlap groups ($\bar{x}$ ± SEM). Means are adjusted for supplement type and study month.

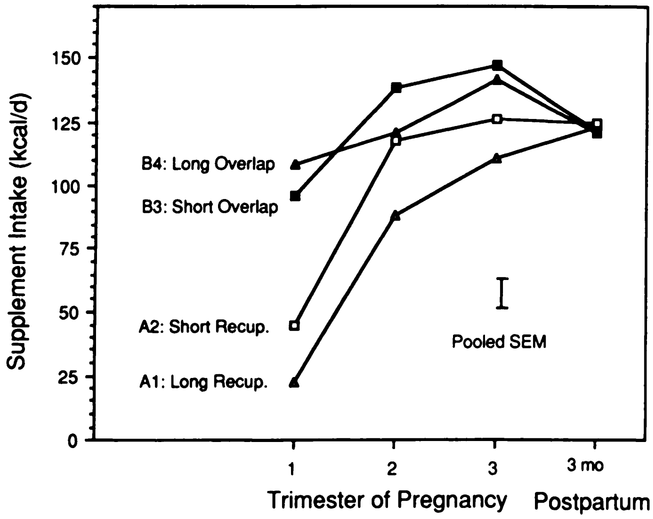

FIG 5. Mean maternal supplement intake across pregnancy and early postpartum for each subgroup. Means are adjusted for supplement type and study month.

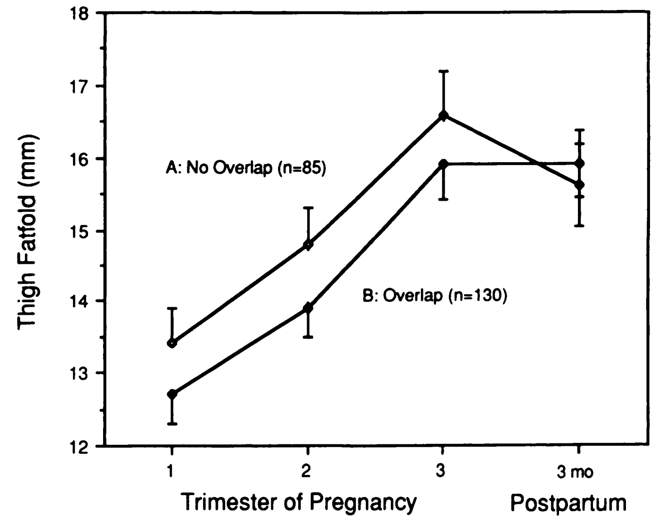

FIG 6. Maternal thigh-fatfold-thickness measurements across pregnancy and early postpartum for overlap and no-overlap groups ($\bar{x}$ ± SEM). Means are adjusted for maternal parity, age, relative measurement date, and study month.

was significantly lower than that for subgroup A2 during the first two trimesters of pregnancy but not during the third trimester of pregnancy or at 3 mo postpartum (**Fig 5**). However, the mean supplement intake for subgroup A1 was lower than that for subgroups B3 and B4 for all three trimesters of pregnancy and was significantly lower in subgroup A2 than in subgroups B3 and B4 only during the first trimester. Subgroups B3 and B4 never differed significantly from each other. None of the subgroups were significantly different from each other at the postpartum measure.

Maternal body stores

Rates of missing data were high for maternal anthropometry. In part this is because the collection of maternal anthropometric data was begun in early 1971, 2 y after the beginning of the study. Only a subsample of instances had data for all three trimesters and at 3 mo postpartum. Values can be reported in two formats: all available data at any of the four measurement periods (mixed longitudinal) and values for instances where there were data for each of the four measurement periods (longitudinal subsample) as reported in **Table 2.** The patterns described below and in the accompanying figures are for the longitudinal sample (for brevity) but they apply as well for the mixed longitudinal sample. Maternal height, gestational length, and supplement type were not associated with the thigh-thickness-fatfold measure at any trimester of pregnancy or at 3 mo postpartum. The reported means are adjusted for maternal age, parity, relative measurement date, and study month. The relative measurement date refers to the timing of the anthropometric exam relative to conception.

Main groups. The mean thigh-fatfold-thickness for group A was slightly but consistently greater than that for group B for all three trimesters of pregnancy. After birth, mean thigh fatfold thickness was similar in both groups (**Fig 6**).

Subgroups. When the main groups were divided into subgroups, a more complex pattern was revealed (**Fig 7**). Subgroup A1 had higher mean thigh-fatfold-thickness measures than did the other subgroups at all times. The other three subgroups were similar to each other throughout pregnancy (the largest difference between any two subgroups was only 1.5 mm). Although the three subgroups were not statistically different, they maintained a constant ordering (subgroup B4, highest; subgroup B3, lowest; and subgroup A2, falling between). Postpartum, subgroups A1 and B4 converged and subgroups A2 and B3 converged: the no-overlap subgroups (A1 and A2) lost fat and the overlap subgroups (B3 and B4) maintained fat.

TABLE 2
Thigh-fatfold-thickness values for the main groups and subgroups of the longitudinal subsample*

	Group A (no overlap) (*n* = 85)	Subgroup A1 (long recuperation) (*n* = 29)	Subgroup A2 (short recuperation) (*n* = 56)	Group B (overlap) (*n* = 130)	Subgroup B3 (short overlap) (*n* = 74)	Subgroup B4 (long overlap) (*n* = 53)
Trimester						
First	13.3 ± 4.4	15.5 ± 4.4	12.2 ± 4.2	12.6 ± 4.4	12.0 ± 4.1	13.3 ± 4.3
Second	14.7 ± 4.6	16.3 ± 4.6	13.9 ± 4.5	13.8 ± 4.7	13.2 ± 4.5	14.7 ± 4.6
Third	16.6 ± 5.4	18.1 ± 5.5	15.9 ± 5.4	16.0 ± 5.5	15.4 ± 5.4	16.8 ± 5.5
3 Mo postpartum	15.6 ± 5.0	17.1 ± 5.1	14.8 ± 4.9	15.8 ± 5.1	15.2 ± 5.0	16.6 ± 5.0

* $\bar{x}$ ± SD. Adjusted for maternal age, parity, relative measurement date, and study month.

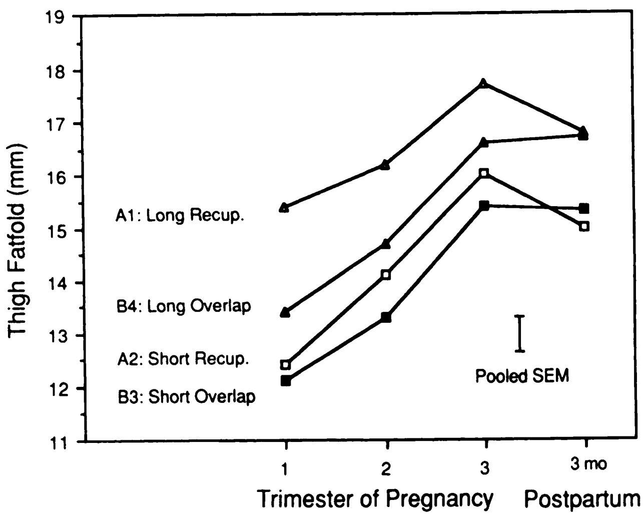

FIG 7. Mean maternal thigh-fatfold-thickness measurements across pregnancy and early postpartum for each subgroup. Means are adjusted for maternal age, parity, relative measurement date, and study month.

Fetal growth

Main groups. Although not statistically significant, a difference of 30 g in mean birth weight between groups was observed [no overlap 3143 ± 455 g ($\bar{x}$ ± SD), n = 211; overlap 3113 ± 488 g, n = 243]. Study month, supplement intake, and type of supplement were not associated with birth weight. Maternal height, age, and parity and sex and gestational age of the newborn were significant predictors of birth weight. When the sample size was restricted to cases with complete information on maternal height, age, and parity, the difference between unadjusted means increased to 52 g (no overlap 3156 ± 458, n = 197; overlap 3104 ± 468, n = 234). The difference is 57 g and is still not statistically significant (p = 0.19) after adjusting for gestational age, sex, and maternal height, age, and parity (no overlap 3159 ± 449; overlap 3102 ± 459).

Subgroups. The mean birth weights for subgroups A1 through B4 adjusted for maternal height, age, and parity, as well as for sex and gestational age of the newborn, are shown in **Table 3.** The mean birth weight decreases across subgroups (A1 to B4) as the postulated energetic stress increases across subgroups (A1 to B4). This trend across the four subgroups is nearly statistically significant (p = 0.10).

Discussion

A potential source of bias was identified when pregnancies classified by presence or absence of overlap were compared for a range of general characteristics. The presence of overlap was associated with a shorter birth interval than was the absence of overlap (mean difference of ~1 y). Although this was expected because close birth spacing increases the opportunity for overlap to occur, it is of particular concern because close birth spacing also results in a short interval of time for the mother to recuperate from the previous pregnancy and lactation cycle. The potential confounding of two consequences of close birth spacing (overlap and short recuperative intervals) was of enough concern to warrant an additional set of analyses to assess the impact of the recuperative interval on the three outcomes of interest: maternal supplement intake, maternal fat stores, and fetal growth.

The potential confounding of the effect of recuperative interval with overlap was minimized by eliminating data from subjects who had a long recuperative interval (subgroup A1) from the contrast to assess the effect of overlap. This reduced the mean difference between the no-overlap (subgroup A2) and overlap (subgroups B3 and B4) groups from 1 y to 3 mo. This strategy eliminated the other potential sources of bias, maternal age and parity. The means for maternal age and parity were not significantly different among these three subgroups (A2, B3, and B4), indicating that this strategy was effective.

Maternal supplement intake

Supplement intake was higher among those of the overlap group than among those of the no-overlap group during the first trimester of pregnancy. This relationship persisted after controlling for potential confounding with birth interval. It would be expected that the effect of overlap would be most clearly demonstrated in the first trimester because this is when the maximum proportion of the overlap group was actually breast-feeding. By the second trimester 55.7% had weaned; 96.8% had weaned by the third trimester. As mentioned previously, available supplement-intake data were summarized by average intake over the trimester of pregnancy; therefore, it was not possible to assess the intake of those who are actually lactating while pregnant at any given time in the stage of pregnancy. The result of categorizing pregnancies by absence or presence of any overlap is to reduce the precision with which the potential overlap effect is estimated, particularly during the later trimesters.

To evaluate the potential strength of the duration of overlap (dose response) on the outcomes, subgroups B3 and B4 were contrasted. However, no dose response of supplemental intake was detected (the means did not differ). There are several possible explanations for this. It may be that the duration of overlap does not accurately represent the energetic stress of lactation during pregnancy. Data on milk production by the mother or milk intake by the infant would represent this stress more precisely. Unfortunately, there are no data from this study or in the literature on patterns of breast-feeding behavior of mothers who are pregnant. It may be that the second-trimester feedings were progressively less frequent, with the goal of weaning foremost in the mother's mind. It also may be that milk production was reduced (through the interaction with pregnancy or through decreased feeding frequency), resulting in subgroup B3 resembling subgroup B4 in energetic stress more than originally anticipated.

TABLE 3
Birth weight for subgroups adjusted for sex and gestational age of newborn and for maternal height, age, and parity*

Subgroup	Birth weight
	g
A1 (long recuperation)	3204 ± 470 [85]
A2 (short recuperation)	3120 ± 466 [112]
B3 (short overlap)	3105 ± 458 [131]
B4 (long overlap)	3089 ± 457 [103]

* $\bar{x}$ ± SD. n in brackets.

Had the effect of the recuperative interval not been taken into account (eg, had only the group A vs group B contrasts been made), the effect of overlap on supplement intake would have been overestimated because the intake for those of the overlap group was higher than for those of the no-overlap group during all three trimesters of pregnancy. When the effects were separated, supplement intake was higher for the first two trimesters among those with a short recuperative interval (subgroup A2) than among those with a long recuperative interval (subgroup A1).

Conversely, if the effect of overlap was not separated from the effect of a long recuperative interval (and therefore long birth intervals), one might contrast subgroup A1 with subgroups A2, B3, and B4 and overestimate the effect of a long recuperative interval on the maternal supplement intake during pregnancy.

Although there is limited information regarding home dietary intakes, given the data available there is no evidence to suggest that marked replacement of the home diet by the supplement occurred. The fact that the supplements were liquids and that they were made available only between regular meal times probably minimized effects on home food consumption. Also, there is no reason to believe that replacement rates varied by study subgroup.

There are two additional considerations for the interpretation of the supplement-intake results. Intake may not represent appetite. Women who were pregnant and lactating may have chosen to consume more supplement based on the belief that it was particularly important for them. Another behavior that may influence the results (particularly the first trimester supplement intake) is that women who were lactating right up to the time of conception and women who had been lactating recently (subgroups A2, B3, and B4) may have been in the habit of consuming supplement more frequently. The supplement was always available to all members of the communities but participation (particularly early in pregnancy) could have been influenced by length of time since weaning. It may be that neither of these factors is exerting much of an influence though, because all pregnant and/or lactating women were encouraged to participate. And even the women who were neither pregnant nor lactating just before conception had young children (all women of this study had children aged < 7 y who were a major target of the supplementation program) and so their participation was also encouraged.

Maternal fat stores

If the contrast between the no-overlap (group A) and overlap (group B) groups is made without regard to potential confounding caused by recuperative intervals, the results suggest that those with no overlap had slightly more fat than did those with overlap; but when the groups were subdivided (controlling the effect of the recuperative interval), a different picture emerged. If the subgroups were the same at baseline (prepregnancy), it would be expected that those under the greatest energetic stress would mobilize more fat if the dietary intake was not increased proportionately and/or if the physical work was not decreased proportionately. The ordering of increasing energetic stress postulated for the subgroups is from the lowest, subgroup A1, to subgroup A2, to subgroup B3, to the highest, subgroup B4. A corresponding inverse relationship between postulated stress and fat accumulation by subgroup was not observed.

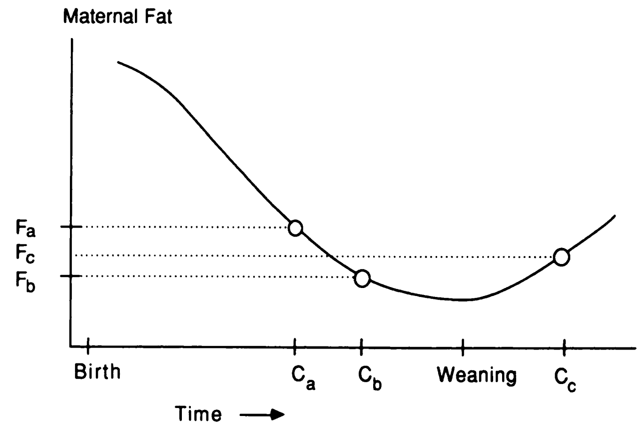

FIG 8. Theoretical maternal fat changes through a reproductive cycle. F, fat stores, C, date of conception; a, b, and c refer to three hypothetical women [adapted from Merchant and Martorell (7)].

A possible explanation for the ordering observed is that the subgroups may not have been the same at baseline. Women appeared to be tracking from a baseline position of thigh fat that actually differed between subgroups. There is no crossover between subgroups during the three trimesters of pregnancy and the postpartum measures at 3 mo for the four subgroups do not converge. In the original study, women were not measured anthropometrically if they were neither pregnant nor lactating; therefore, direct measures of baseline status are not available. The baseline measure is particularly crucial because fat is a cumulative measure.

If it is accepted that the women are following different tracks, what might explain their relative positions? Maternal nutrition status during the reproductive years is dynamic. This is theoretically depicted in **Figure 8,** which shows three hypothetical women who are all following the same course of fat change beginning at the birth of their babies. It was assumed that a decrease in fat occurred from birth to the time of weaning. The nadir of fat change is drawn to coincide with the time of weaning. (This exact correspondence is not necessary to the point being made although it is seen within this Guatemalan data set.) The different relative fat measures at the time of the subsequent conception for each woman (a, b, and c) are marked on the *y* axis. What varies between the women is the length of the interpregnancy interval (time between pregnancies). Note that for this example, both woman a and woman b conceive before weaning. The nadir of change has occurred for woman c and she is on a course towards repletion but has not yet reached the status of woman a.

Note that the same relative ranking that would be postulated was seen in the data for maternal stores of this study: interpret woman a as subgroup B4, woman b as subgroup B3, and woman c as subgroup A2. This is supported by the fact that, on average, subgroup B4 conceived the earliest after the previous birth (12.9 mo), subgroup B3 conceived next (15.7 mo), and subgroup A2 conceived the latest (17.3 mo). Although the relative rankings of the subgroups were maintained during pregnancy, they were not statistically significant for the longitudinal subsample. This may be a limitation of small sample size. When data from the larger mixed longitudinal sample were used, the relative rankings were statistically significant.

As expected, the women with long periods of recuperation (subgroup A1) had significantly higher fat stores than did women with short periods of recuperation (subgroup A2). Although the difference between groups was relatively small (~2 mm), the absolute measures of Guatemalan women in this sample are low relative to the average measures seen in a sample of healthy British women, where the means ranged from 34.8 ± 10.7 mm at 10 wk to 40.1 ± 10.2 mm at 38 wk of gestation (10). Because the Guatemalan study population is already at a marginal nutrition status, small differences may be of greater practical importance.

In addition to being in the expected direction, the magnitude of the difference between subgroups A1 and A2 was larger than that between subgroups B3 and B4, suggesting that the effect of recuperation is more critical than is the overlap effect on attained maternal fat stores.

It is crucial to remember that subgroups B3 and B4 consumed more supplement, quite possibly offsetting the potential risk of mobilization of maternal fat stores caused by the higher energetic demand of lactation with pregnancy. It is not known what would have happened had a convenient, freely available energy supplement not been available.

Fat stores have been observed to increase with maternal age in several populations (11), a potential concern because the mean maternal age was significantly higher in subgroup A1. And yet, the effect of recuperation on maternal fat stores does not appear to be due to confounding with maternal age or parity because the effect is seen regardless of statistical adjustment for these factors.

Finally, a comment regarding the method of assessing maternal body fat is in order. Maternal fat stores were assessed by use of the thigh-fatfold-thickness measure. This single measurement site may not accurately represent the relative amount of fat storage of a mother. However, during pregnancy the thigh fatfold shows the greatest absolute change compared with other sites. No attempt was made to estimate total fat stores of the mother. There are no pregnancy-specific prediction equations available for such a calculation.

Fetal growth

As in the case with supplement intake and maternal fat stores, it was postulated that presence of overlap represents a greater energetic stress and that fetal growth may be reduced under these circumstances. The main contrast between the overlap and no-overlap groups would have required an 85-g difference between means for a statistically significant effect (one-tailed, $p = 0.05$) to be detected with this sample size, but only 30- to 50-g differences were seen depending on the sample used. The difference, although not statistically significant, was in the expected direction.

When subgroups were analyzed, a similar situation resulted. Again, although none of the differences were significant, they were in the expected directions. Longer recuperation for the mother was expected to result in better fetal growth, and absence of overlap and a shorter duration of overlap were expected to result in better fetal growth. The trend of postulated stress across subgroups, increasing from A1, to A2, to B3, and then to B4, was not significant ($p < 0.10$). The practical significance of the birth-weight differences among subgroups is minimal given the small magnitude of the differences as well as the moderately satisfactory birth-weight means for each subgroup. In addition, the prevalence of low birth weight (< 2500 g) did not differ significantly between subgroups. Although insignificant, the observed trend in birth weight should not be dismissed entirely. Given the limited sample size, the results are suggestive that recuperative interval and presence of overlap both could have slightly influenced fetal growth, as indicated by birth weight in term gestations, particularly if the supplement had not been available.

The lack of a relationship between supplement intake and birth weight may surprise some readers familiar with a previous publication by Lechtig et al (8), which reported a relationship between these variables. Two important characteristics differ between the current study sample and the sample used in Lechtig's article. Lechtig's sample was made up of the births occurring during the first half of the study (January 1969 to February 1973). Although an important relationship between maternal supplement intake and birth weight was seen in this half of the study births from the second half of the study (March 1973 to December 1977) did not show such a relationship (G Marks, unpublished observations, 1985). The sample of the present study includes births from both halves of the study in approximately equal proportions. In addition, the current study sample is restricted to term births whereas Lechtig's sample was not. This may be an important distinction if supplementation effects differ by length of gestation. When these characteristics are taken into account, the relationships between birth weight and supplement intake are consistent between all three studies and therefore the selected sample of this study is not anomalous.

Conclusions

The phenomenon of overlap of lactation with pregnancy should no longer be overlooked. This study has provided evidence of a high prevalence (50.2%) of overlap in four rural Guatemalan communities during the 1970s. The duration of overlap of lactation with pregnancy extended beyond the first trimester (the period during which a woman may not recognize her pregnancy) for 44.3% of the cases of overlap. This indicates that many women made the decision to breast-feed during at least some portion of their subsequent pregnancy. Given the higher energetic demands of this situation, which appears to occur frequently in populations with close birth spacing and relatively low socioeconomic status (4–6), the risks of depleting maternal nutrient stores and poor child growth and development may be increased.

The data indicate that the presence of overlap resulted in increased supplement intake during the first trimester of pregnancy. A shorter recuperative period appears to have resulted in increased supplement intake during the first and second trimesters of pregnancy and in lower maternal body stores. Although differences in birth weight between groups or among subgroups were not large or statistically significant, the data suggest that both the absence of overlap and the longer recuperative period might favor fetal growth somewhat. It appears that the responses of the mother (to increase intake and mobilize stores) to the energetic stresses of the overlap of lactation with pregnancy and short recuperative intervals protects fetal growth.

These relationships were demonstrated in a population for which a nutrition supplement was available freely and conveniently between meals each day of the 8-y study period. In addition, primary health care was free and available. Depending on when in the study period their pregnancy occurred, supplementation and health care could have been available for up to 7 y. The presence of this nutrition supplement would be expected to reduce the impact of energetic stresses caused by short recuperative intervals and by the overlap of lactation with pregnancy. This is suggested also by the evidence of increased supplement intake under both of these circumstances. Without a freely available energy supplement, it would be expected that the negative effects on maternal stores and fetal growth would be greater than those found here. On the other hand, it is difficult to predict the extent to which overlap and short recuperative periods would be detrimental to women in more advantaged circumstances.

Although research in these areas is just beginning, the results suggest two practical recommendations: *1*) women living in circumstances of high energetic stress should space their births so that subsequent conceptions occur > 6 mo after complete weaning of the previous child and *2*) if pregnancy occurs sooner than this, an effort should be made to consume additional food that is calorically dense.

In addition to the formal research questions, three other points were demonstrated in this study. *1*) Maternal nutrition status is very dynamic during the reproductive years. The fluctuations are wide, are to be expected, and can influence interpretations of the data dramatically. *2*) It is crucial to consider the presence of overlap, particularly when assessing the effects of birth spacing (otherwise there may be an overestimation of the effect of birth spacing attributed to recuperation). *3*) Parity alone is a poor way to characterize reproductive history. When the reproductive cycle is examined closely and characterized adequately, evidence of depletion of maternal nutrient stores is seen.

For further study of lactation concurrent with pregnancy, specific and general research needs can be identified. The questions of practical importance are who (mother, fetus, or breast-feeding child) is most negatively affected by energetic stress and who (mother, fetus, or breast-feeding child) benefits from nutrition intervention. Building on this initial investigation, the issues of nutrient partitioning between mother and fetus can be explored further. The interrelationships among maternal supplement intake, fat stores, and fetal growth within the subgroups should be examined. And yet, more complete information on all components of energy balance is necessary to fully explore the complexities of nutrient partitioning during reproduction. Data on total dietary intake, milk production, and energy expenditure of the mother would be particularly useful.

In general, all studies of lactation or pregnancy should incorporate the fact that these conditions can and do occur together. Efforts should be made to estimate the prevalence and duration of overlap of lactation with pregnancy; attitudes, beliefs and behaviors regarding the practice of breast-feeding during pregnancy should be elucidated; measures of milk production by the mother, milk composition, and milk intake by the breast-feeding child during various stages of overlap are needed; the consequences in various ecological settings to mother, fetus, and breast-feeding child of weaning vs continuing to breast-feed a child after a woman discovers she is pregnant must be examined; and finally, recommendations should be developed and disseminated based on the research findings.

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