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MATERNAL AND FETAL RESPONSES IN CONSECUTIVE PREGNANCIES TO THE STRESS OF LACTATION CONCURRENT WITH PREGNANCY AND OF SHORT RECUPERATIVE INTERVALS

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Running Head: Lactation Concurrent with Pregnancy

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ABSTRACT

Frequent reproductive cycling often leads to the overlap of lactation with subsequent pregnancy and the shortening of potentially recuperative (non-pregnant/non-lactating) intervals within the reproductive cycle. This increased energetic stress may lead to maternal nutritional depletion among populations living in poverty.

Although differing responses to the above conditions of energetic stresses from frequent reproductive cycling have been demonstrated previously, it is important to control for inherent characteristics of the mothers. This is accomplished in this study by contrasting the responses to differing stresses of consecutive pregnancies within individual Guatemalan women. The results indicate that overlap is most stressful, short recuperative interval follows, and long recuperative interval is least energetically stressful on the mother. Maternal responses to the stresses are increased supplement intake and reduced fat stores but fetal growth in term gestations is not affected, as measured by birthweight. The results indicate that fetal growth is being protected at the "cost" of maternal nutritional status.

KEY WORDS: Maternal Depletion, Pregnancy, Lactation, Birth Spacing, Supplementation, Infant Feeding, Birthweight, Maternal Anthropometry, Maternal Nutrition

INTRODUCTION

Frequent reproductive cycling increases energetic stresses experienced by women (1). One dramatic illustration of the increased stress resulting from frequent reproductive cycling is the phenomena of lactation occurring concurrent with pregnancy. When births are closely spaced the prevalence of the overlap of lactation with pregnancy increases. Although evidence is accumulating that in many cultures women are often breastfeeding the previous child during some portion of their current pregnancy (1 - 4), study of the energetic stress of this situation on women has just begun.

In a sample of Guatemalan women, it was shown that lactation concurrent with pregnancy (overlap) resulted in increased supplement intake during the first trimester of pregnancy (1). Another result of frequent reproductive cycling is the shorter recovery time available to women between reproductive events such as pregnancy and lactation. The Guatemalan study also demonstrated that short recuperative periods (non-pregnant/non-lactating < 6 months prior to conception) resulted in increased supplement intake during the first and second trimesters of pregnancy and slightly reduced maternal fat stores relative to long recuperative periods (non-pregnant/non-lactating > 6 months prior to conception). The results also suggested that long recuperative periods (> 6 months) and the absence of overlap may favor fetal growth very slightly (1).

A potential bias within the design of the Guatemalan study is that women who are likely to have long recuperative intervals may be different from women who are likely to overlap lactation with pregnancy in certain unmeasured factors. These potential differences between women may affect the outcomes (maternal supplement intake, maternal fat, and fetal growth) independent of the postulated effects of presence or absence of overlap and

of length of recuperative intervals. Using a subsample of the same study population, the analysis reported here eliminates this potential confounding by using each mother as her own control in analysis of consecutive pregnancies. By taking advantage of the fact that women vary from pregnancy to pregnancy in terms of the nutritional stresses they confront, this approach allows for maternal and fetal responses to a particular stress, such as overlap of pregnancy and lactation, to be contrasted to that of another stress, for example short recuperative interval. The strength of this analysis is that it controls for all aspects associated with each woman that do not change appreciably from pregnancy to pregnancy (e.g. genetic predisposition, maternal height, socioeconomic status, etc.).

Hypotheses

Presence of overlap is expected to lead to greater energetic stress on pregnant women. Women who are lactating while pregnant must supply energy for milk production <u>and</u> fetal growth in addition to their own needs. A longer non-pregnant/non-lactating interval before conception would be expected to allow for nutritional recuperation of the mothers and lead to improved maternal status and fetal outcomes (5 - 7).

Based on these postulated energetic stresses and on previous research, the following relationships are hypothesized. These hypotheses are predicting the relative impact of three types of pregnancies (overlap, short recuperative interval, and long recuperative interval) on each outcome of interest.

1) Mothers consume more during a pregnancy with overlap than during a pregnancy preceded by a short recuperative interval; and even more relative to the amount consumed during a pregnancy preceded by a long recuperative interval.

2) Mothers have lower fat stores during a pregnancy with overlap than during a pregnancy preceded by a short recuperative interval; and even lower fat stores relative to those during a pregnancy preceded by a long recuperative interval.

3) Fetal growth during a pregnancy with overlap is poorer than during a pregnancy preceded by a short recuperative interval; and even poorer relative to fetal growth during a pregnancy preceded by a long recuperative interval.

METHODS

Data

This investigation uses data from a nutritional supplementation trial conducted by the Instituto de Nutrición de Centroamérica y Panamá (INCAP) in four rural communities in the Guatemalan department of El Progreso. The period of the health and nutrition intervention was 1969 through 1977. Two communities each were assigned randomly to receive either a high-protein (11 g/180 ml), high-energy (163 kcal/180 ml) supplement called "atole" or a low-energy (59 kcal/180 ml), no-protein supplement called "fresco".

The supplements were free and available twice-daily to all inhabitants at centrally-located feeding centers in each community. A cup (180 ml) 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 seven years. Twenty-four hour dietary recall surveys were used at 3-month 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 three-month intervals

during pregnancy and the first 24 months of lactation from 1971 to 1977. All measures were made by the same individual. Birthweight was measured within 24 hours after delivery. Duration of lactation was determined through maternal recall for all children 7 years or younger at the beginning of the study period (1/69) 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 two weeks 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 were recorded in the 4 study villages during the study period (1969-1977). From this total sample of births, the study sample was selected for the following characteristics: women with two consecutive, term, singleton pregnancies, each with a known birthdate and lactation duration for the previous child. In addition, it was required that all study women were lactating during at least one of the two consecutive pregnancies. Data for previous siblings were only available for children seven years or younger. 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

post-mature births were excluded on the grounds that these were either truly special subpopulations or cases with errors in the measurement of gestational age.

Study Sample - Of the 304 women who contributed at least one pregnancy to the study sample of the previous investigation (1), 102 women had at least two consecutive pregnancies, of which at least one was a pregnancy in which lactation occurred concurrently. These 102 paired pregnancies form the study sample for this investigation (204 of the 504 births of the sample selected for study previously (1)).

The selected study sample of births was comparable to the total sample of births for 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 and 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 years, 1/2 week and 1 month, respectively. All mothers of the selected study sample were multiparous (parity of at least 3), therefore the age difference would be expected. The minimum maternal age for the total sample was 12.7 years and the selected study sample 18.0 years. 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 weeks and for the selected study sample was 37 weeks. More thorough information regarding the descriptive characteristics of the total sample (n=1529) is reported elsewhere by Merchant (10).

Analytic Approach

Classification - Initially, both pregnancies of each mother were divided into three categories (overlap, short recuperative interval and long recuperative interval). These groups were defined by the time of weaning of the previous child (C_{n-1}) relative to the conception of the index child (C_n). The overlap category (O) was defined as pregnancies in which C_{n-1} was weaned after 2 weeks following the date of conception of C_n. The short recuperative interval category (SRI) was defined as pregnancies in which C_{n-1} was weaned within the time period of 6 months before the date of conception of C_n to 2 weeks following the date of conception of C_n. Therefore, the duration of the non-pregnant/non-lactating interval was less than six months. The long recuperative interval category (LRI) was defined as pregnancies in which C_{n-1} was weaned more than 6 months before the date of conception of C_n. Therefore, duration of the non-pregnant/non-lactating interval was more than six months. A conservative definition of overlap (lactation > 2 weeks past conception) was used to minimize the possibility of misclassification of those who did not overlap in the overlap group.

The pairs of consecutive pregnancies of each mother were then classified into five possible combinations of these categories: (1) first birth - O, second birth - LRI, (2) first birth - O, second birth - SRI, (3) first birth - O, second birth - O, (4) first birth - SRI, second birth - O, and (5) first birth - LRI, second birth - O (Figure 1). The five categories created by the various combinations of pairing were ordered from 1 to 5 by the postulated trend of difference in energetic stress between the two consecutive pregnancies, creating the "stress difference category". The predictions for differences between births (2nd birth minus 1st birth) of each outcome by the stress difference category are described in Figure 2. The

diagrammatic representation of the times of weaning in Figure 2 are drawn to fall precisely in the middle of the appropriate interval. This implies that the absolute value of the differences in the specified outcomes between successive pregnancies in categories 1 and 5 as well as categories 2 and 4 would be equivalent. In actuality, the time of weaning falls somewhere within the marked interval and the mean time of weaning may not be equivalent between categories 1 and 5 or categories 2 and 4, particularly because the sample sizes are small in several categories in this study. Therefore, no predictions regarding equal magnitude of the differences of outcomes between successive pregnancies for categories 1 and 5 as well as categories 2 and 4 are being made.

Outcome Variables - Although ideally maternal dietary intake should be based on home dietary intake plus supplement intake, supplement intake has been 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 that of the home dietary data (which were measured by 24-hour recall). For a more thorough discussion of the implications and rationale for this decision, see the previous investigation (1). The original daily maternal supplement intake data have been summarized by trimester of pregnancy and data are available only for average intake across each trimester in the INCAP data tapes. Maternal supplement intake per day was averaged by trimester of pregnancy and during the 3 month postpartum period. The average supplement intake per day over pregnancy was calculated by averaging the three trimester values --(1st T intake + 2nd T intake + 3rd T intake)/3. Each of the five resulting supplement intake variables (1st, 2nd, 3rd trimesters, average over pregnancy, 3 mo. postpartum) for both births of each pair were then adjusted for the study month using linear regression to calculate the residual

values. This adjustment was made because it has been previously shown that mean maternal supplement intake increased over the 7-year study period (11). (It has been previously shown that supplement intake was not associated with mother's age (1), therefore adjustment for maternal age was not necessary.) The difference between paired supplement intake residual values were then calculated (2nd birth of pair minus 1st birth of pair). These five differences were used as the maternal supplement intake outcome variables.

Maternal fat stores were assessed using the thigh fatfold (an average of the medial thigh and the lateral thigh measures). Of the seven fatfold sites --triceps, biceps, subscapular, suprailiac, knee, thigh and calf-- Taggart et al. (12) demonstrated that the thigh fatfold measure shows the largest absolute change across pregnancy. The thigh fatfold measures were taken during each trimester of pregnancy and at 3 months postpartum. The average thigh fatfold measure over pregnancy was calculated by averaging the three trimester values --(1st T fatfold + 2nd T fatfold + 3rd T fatfold)/3. Each of the five resulting thigh fatfold measures (1st, 2nd, 3rd trimesters, average over pregnancy, 3 mo. postpartum) for both births of each pair were then adjusted for the study month and the stage of pregnancy at exam time using linear regression to calculate the residual values. (It has been previously shown that thigh fatfold was not associated with gestational length over the range of values observed in this sample of term births (1).) The difference between paired fatfold residual values were then calculated (2nd birth of pair minus 1st birth of pair). These five differences were used as the maternal fat outcome variables.

Fetal growth was assessed using birthweight. Birthweight was adjusted for the newborn's sex and gestational age and for the age of the mother at the time of birth using

linear regression to calculate the residual values. (It has been previously shown that birthweight was not associated with study month, supplement intake or type of supplement in this sample (1).) The difference between paired birthweight residual values were then calculated (2nd birth of pair minus 1st birth of pair) and used as the fetal growth outcome variables.

Statistical Methods - A test for trend (α = .05) was made on each of the eleven outcome variables, using linear regression and calculating the p-value of the regression coefficient of the expected trend variable. The expected trend variable was assigned by assuming an ordinal scale of equal intervals for the postulated trend of difference in energetic stress across paired categories from 1 to 5 (Figure 2). The Statistical Analysis System (SAS Institute, Inc., Cary, NC) was the computer software system used for data analyses.

RESULTS

Sample Description

Descriptive statistics for general characteristics of the study sample are given in Table 1. Descriptive statistics for general characteristics for the study sample by stress difference category are given in Table 2. The paired mean differences between consecutive births for general characteristics are given in Table 3. The general characteristics do not differ in substantial or unexpected directions between the stress categories of the study sample or the consecutive birth pairs of the subsample.

Maternal Supplement Intake

A trend for differences in maternal supplement intake between consecutive births (2nd birth - 1st birth) across stress difference categories is highly significant for all three trimesters of pregnancy and the average over pregnancy, but not for the first three-month postpartum period (Table 4). The type of supplement did not modify these relationships.

Maternal Fat

A trend for differences in maternal thigh fatfold between consecutive births (2nd birth - 1st birth) across stress categories is highly significant for the first two trimesters of pregnancy, but not for the third trimester of pregnancy or for the first three-month postpartum period (Table 5).

Fetal Growth

A trend for differences in birthweight between consecutive births (2nd birth minus 1st birth) across stress categories is not significant (Table 5).

DISCUSSION

When examining the descriptive characteristics for the study sample by stress category (Table 2), it can be seen that certain patterns hold for all the pregnancies in which overlap occurred. (Overlap occurred during the pregnancies for the 1st birth of the pair in stress categories 1, 2 and 3, and for the 2nd birth of the pair, stress categories 3, 4 and 5. Non-overlap pregnancies occurred for the 2nd birth of stress categories 1 and 2 and the 1st birth for stress categories 4 and 5. Refer to Figure 1.) The mean of the lactation

duration for the previous child was higher in overlap pregnancies than for the non-overlap pregnancies. The mean birth interval was lower in overlap pregnancies than non-overlap pregnancies. Although the differences in both of these cases are generally small, they are consistent and would be expected. A longer duration of lactation for the previous child and a shorter birth interval increase the likelihood that overlap between lactation and the subsequent pregnancy will occur. Differences across stress categories for the other characteristics are variable and generally of small magnitude, particularly relative to the variation and the small sample sizes within some categories. The paired mean differences between consecutive births are minimal with the exception of maternal age, which necessarily must be higher for the second birth of the pair.

The highly significant trend ($p < .0001$) of differences in supplement intake between consecutive births across pregnancy was in the expected direction. This supports the findings of the previous study (1). In addition, the trend of supplement differences between consecutive births in the postpartum (first 3 month period) period was not significant. This confirms the expectation that the increased intake is a response to the stress of overlap rather than a lasting change in the eating patterns of the mothers. It is particularly interesting that a strong trend was seen in spite of the small sample sizes in some categories.

Clearly significant trends were seen across stress difference categories for the differences in thigh fatfolds between consecutive pregnancies during the first and second trimesters ($p < .01$). The trend was in the expected direction again, with the overlap pregnancies showing lower thigh fatfold measures. During the third trimester of pregnancy this trend difference disappears. Possibly the increased intake of the earlier trimesters

helped close the gap in terms of an energy deficit by the third trimester. In addition, fatfold measures taken close to the time before birth may not accurately reflect the fat layer. Some dramatic and unexplained changes in fatfold measures have been observed between late pregnancy and early postpartum (12) that may be physiological changes of maternal tissue interfering with measurement. The sample sizes are noticeably smaller when thigh fatfold is the outcome. Rates of missing data were high for maternal anthropometry. In part this is due to the fact that collection of maternal anthropometric data was begun in early 1971, 2 years after the beginning of the study. In addition, in this analysis paired measures from corresponding measurement periods were required for each pregnancy of the pair in order to calculate the differences, creating a further limitation. A stress-related trend for change in thigh fatfolds was not present at 3 months postpartum. It would be expected that such a trend would not be present at this point in time, particularly since it was not present in the third trimester of pregnancy.

Note that maternal age is always higher for the second pregnancy of the pair. And yet, regardless of birth order, the differences in maternal outcomes --supplement intake and thigh fatfold-- between consecutive pregnancies occur in the expected directions --based on the ordering of what is postulated to be the more stressful pregnancy.

The postulated trend in birthweight was not demonstrated, although given the relatively large variation seen with birthweight, the sample size may have been a limitation. Additional support for the postulated stress of presence of overlap and a short recuperation on birthweight has not been provided by these results. However, this is consistent with the suggestion of the previous work (1) that fetal growth is being protected at the "cost" of maternal nutritional status.

CONCLUSIONS

Further examination of the maternal and fetal responses to the stress of lactation concurrent with pregnancy and of short recuperative intervals has provided additional support for the hypothesis that these are stressful conditions for the mother --increasing supplement intake and reducing fat stores. The stress of these conditions on fetal growth was not demonstrated in these analyses, although there was a suggestion of it in previous analyses (1). It is important to control for inherent characteristics of the mothers that could confound the relationships of interest (among maternal and fetal responses to the presence of overlap, and the duration of recuperative intervals). This was accomplished in these analyses by pairing consecutive pregnancies within women. The results indicate that overlap is most stressful, short recuperative interval follows, and long recuperative interval is least energetically stressful on the mother. Data on three consecutive pregnancies for each woman (the two pregnancies of the consecutive births, in addition to the pregnancy prior to the first pregnancy of the pair) were required to address the questions of this study and the Guatemalan data set provided a rare opportunity to do this. In future research, a larger sample size would be desirable to examine more thoroughly the birthweight differences between consecutive pregnancies. More research is needed to address the consequences of frequent reproductive cycling, particularly the overlap of lactation with pregnancy and the length of recuperative intervals on mothers and their children.

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Table 1: Descriptive Statistics for Study Sample

	Paired Births - n	1st Mean (SD)	2nd Mean (SD)
C_{n-1} Lactation Duration (mo)	102	16.9 (4.9)	17.8 (4.8)
Birth Interval (mo)	102	26.9 (9.0)	25.6 (8.0)
Mother's Age (y) at Birth of C_n	102	28.3 (6.3)	30.4 (6.5)
Parity	100	5.0 (2.5)	6.0 (2.5)
C_n Gestational Age (wk)	102	39.8 (1.3)	39.6 (1.3)
C_n Lactation Duration (mo)	102	17.8 (4.8)	17.1 (7.6)
Mother's Height (cm)	101	149.8 (5.4)	
Mother's Head Circumference (cm)	101	51.2 (1.3)	
Father's Height (cm)	82	160.6 (6.1)	
Father's Head Circumference (cm)	82	54.3 (1.6)	
Distance to Supplement (min)	102	2.4 (1.0)	
<u>Proportions</u>			
Atole / Fresco		.63 / .37	
C_n Male / C_n Female		.51 /.49	.53 /.47

C_{n-1} = Previous Child, C_n = Index Child

Table 2: Descriptive Statistics for Subsample by Stress Category

	Stress Category 1			Stress Category 2			Stress Category 3			Stress Category 4			Stress Category 5		
		Paired Births 1st	Paired Births 2nd		Paired Births 1st	Paired Births 2nd		Paired Births 1st	Paired Births 2nd		Paired Births 1st	Paired Births 2nd		Paired Births 1st	Paired Births 2nd
	n	Mean (SD)	Mean (SD)	n	Mean (SD)	Mean (SD)	n	Mean (SD)	Mean (SD)	n	Mean (SD)	Mean (SD)	n	Mean (SD)	Mean (SD)
C_{n-1} Lactation Duration (mo)	7	16.3 (5.4)	13.8 (9.5)	14	17.8 (3.3)	16.0 (6.0)	40	17.2 (3.2)	17.8 (4.1)	21	15.6 (6.8)	20.0 (3.7)	20	17.1 (6.1)	18.6 (2.4)
Birth Interval (mo)	7	21.4 (6.4)	40.6 (21.7)	14	24.2 (3.8)	26.9 (6.9)	40	22.8 (3.2)	23.3 (4.1)	21	26.0 (6.5)	25.4 (4.5)	20	39.9 (10.3)	24.3 (3.0)
Mother's Age (y) at Birth of C_n	7	29.7 (8.2)	33.1 (9.3)	14	28.1 (7.0)	30.4 (7.1)	40	26.3 (6.0)	28.3 (6.1)	20	29.8 (6.0)	31.9 (6.2)	20	30.2 (5.4)	32.2 (5.5)
C_n Gestational Age (wk)	7	40.1 (1.9)	38.8 (0.4)	14	40.1 (1.5)	39.8 (0.7)	40	40.0 (1.2)	39.3 (1.3)	21	39.1 (0.8)	39.3 (1.4)	20	40.0 (1.4)	40.7 (1.0)
C_n Lactation Duration (mo)	7	13.8 (9.5)	12.0 (8.2)	14	16.0 (6.0)	17.7 (5.9)	40	17.8 (4.1)	16.2 (7.8)	21	19.6 (3.7)	17.8 (7.2)	20	18.6 (2.4)	19.3 (8.1)
Mother's Height (cm)	7	149.5 (4.2)		14	150.9 (5.4)		40	149.7 (5.4)		21	148.8 (6.1)		20	150.6 (5.6)	
Mother's Head Circumference (cm)	7	51.8 (1.3)		14	51.2 (1.4)		40	51.0 (1.5)		21	51.4 (1.1)		20	51.2 (1.2)	
Father's Height (cm)	5	160.5 (3.6)		12	160.6 (3.8)		31	161.1 (7.1)		19	160.6 (7.0)		15	159.7 (5.2)	
Father's Head Circumference (cm)	5	53.8 (2.0)		12	53.3 (0.6)		31	54.4 (1.4)		19	54.6 (2.0)		15	54.6 (1.4)	
Distance to Supplement (min)	7	2.6 (1.3)		14	2.2 (0.9)		40	2.3 (1.0)		21	2.2 (0.9)		20	2.6 (1.0)	
Proportions															
Atole / Fresco		.43 /.57			.50 /.50			.70 /.30			.52 /.48			.75 / .25	
		Paired Births 1st	Paired Births 2nd		Paired Births 1st	Paired Births 2nd		Paired Births 1st	Paired Births 2nd		Paired Births 1st	Paired Births 2nd		Paired Births 1st	Paired Births 2nd
C_n Male / C_n Female		.43 /.57	.29 /.71		.43 /.57	.43 /.57		.52 /.48	.58 /.42		.62 /.38	.62 /.38		.45 /.55	.50 /.50

C_{n-1} = Previous Child, C_n = Index Child

Table 3: Mean Differences Between

Consecutive Births (2nd Birth of Pair minus 1st Birth of Pair)

for General Characteristics

	n	Mean	SD
C_{n-1} Lactation Duration (mo)	134	-0.88	6.87
Birth Interval (mo)	134	-0.83	12.20
Mother's Age (y) at Birth of C_n	133	2.29	0.77
C_n Gestational Age (wk)	134	-0.17	1.72
C_n Lactation Duration (mo)	134	-0.49	8.18

Table 4: Tests for Trend Categories in Differences Between Consecutive Births (2nd Birth of Pair minus 1st Birth of Pair) for Supplement Intake

Stress Difference Category	1		2		3		4		5			
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	ß p-value	Model R^2
Trimesters												
1st	7	-122 (105)	14	-46 (83)	40	-27 (77)	21	83 (128)	20	76 (125)	.0001	.25
2nd	7	- 43 (130)	14	-15 (108)	40	-22 (99)	21	49 (120)	20	58 (95)	.002	.09
3rd	7	9 (139)	14	-59 (14)	40	-39 (97)	21	36 (89)	20	70 (102)	.0005	.11
All	7	- 52 (116)	14	-40 (85)	40	-30 (70)	21	56 (89)	20	68 (86)	.0001	.21
Postpartum	5	- 44 (127)	14	9 (53)	38	-10 (95)	20	4 (123)	18	-32 (114)	.69	.002

Table 5: Tests for Trend Categories in Differences
Between Consecutive Births (2nd Birth of Pair minus 1st Birth of Pair) for
Thigh Fatfold and Birthweight

Stress Category	1		2		3		4		5			
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	ß p-value	Model R^2
Thigh Fatfold												
Trimesters												
1st	2	7.9 (9.3)	5	0.3 (2.2)	21	-1.0 (2.3)	6	-0.3 (2.8)	2	-3.7 (2.4)	.005	.19
2nd	2	4.2 (5.9)	8	1.4 (1.5)	23	-1.1 (2.8)	8	-1.6 (3.7)	5	-1.9 (3.7)	.007	.15
3rd	2	-1.3 (0.6)	8	-0.1 (4.2)	23	-1.6 (2.5)	7	0.7 (3.8)	6	-1.4 (3.6)	.98	0
All	1	-0.4 (NA)	4	-0.2 (3.0)	16	-1.1 (1.9)	6	-0.9 (2.1)	2	-4.4 (2.5)	.15	.08
Postpartum	2	4.4 (4.9)	11	0.7 (3.5)	30	-1.0 (2.1)	8	2.0 (2.1)	7	-2.0 (5.0)	.12	.04
Birthweight												
	6	32 (506)	13	36 (440)	36	-34 (469)	16	114 (410)	15	-110 (456)	.63	.003

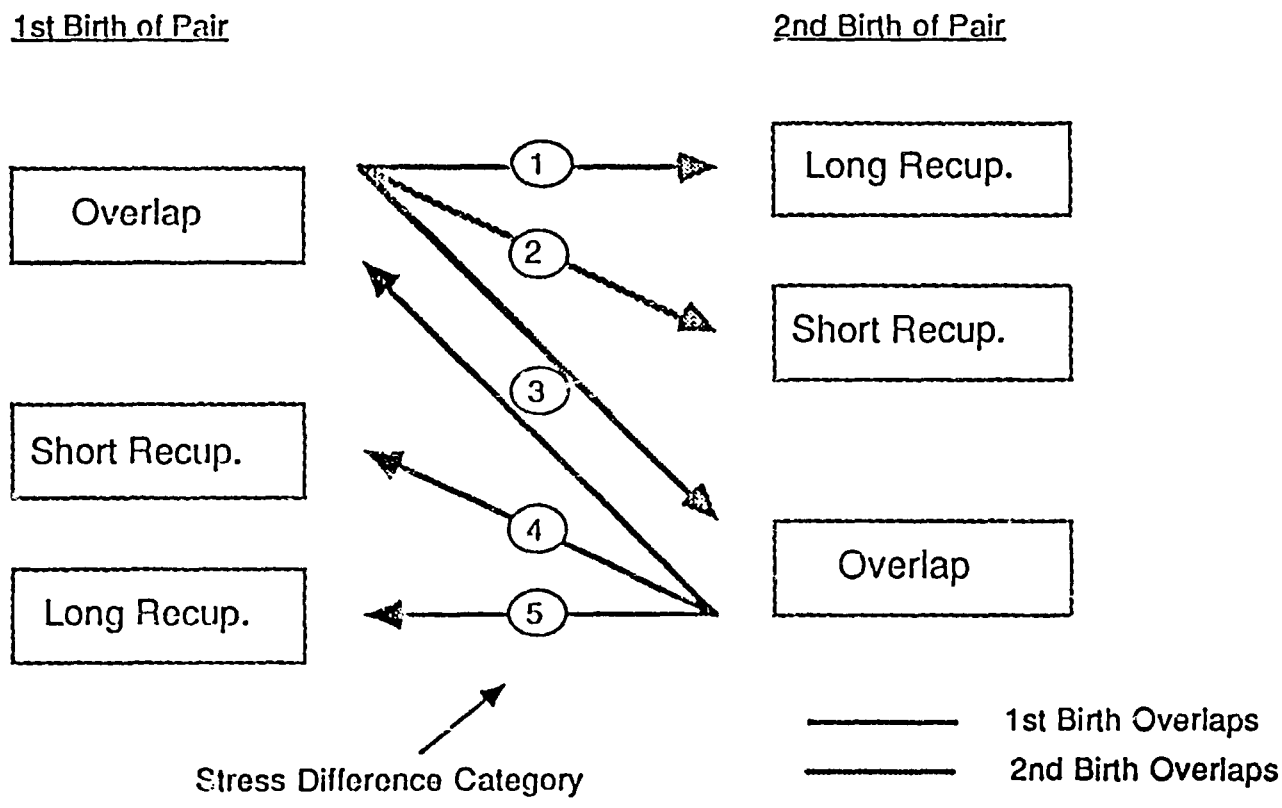
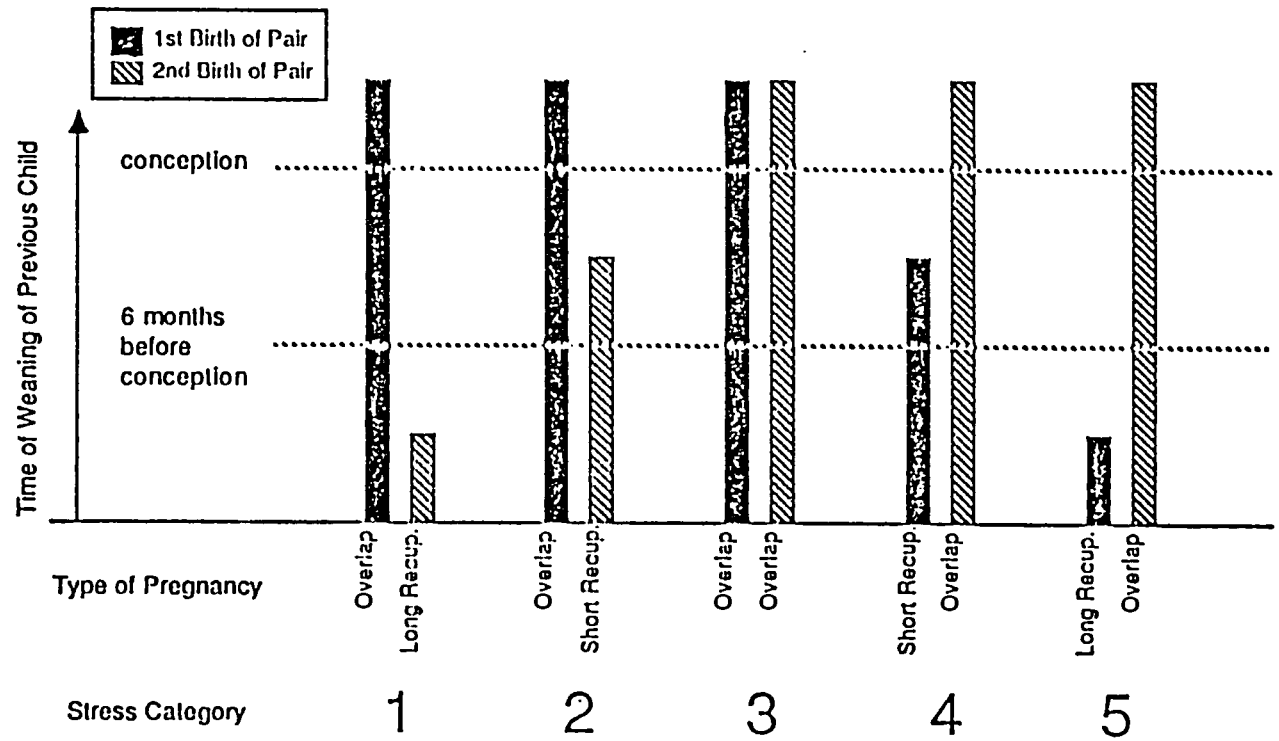


Figure 1: Classification into Stress Difference Categories



Predictions for Differences between Births (2nd Birth - 1st Birth) by Stress Difference Category :

Supplement Intake	−	−	No Change or +	+	+
Thigh Fatfold / Birthweight	+	+	No Change or −	−	−

Figure 2: Postulated energetic stress difference based on time of weaning of previous child for paired consecutive births

APPENDIX B

DISSERTATION

Merchant K. Maternal Nutritional Depletion: Consequences of the Energetic Stress of Frequent Reproductive Cycling on Mother and Fetus. Doctoral Dissertation. Ithaca, NY: Cornell University, Division of Nutritional Sciences. 1989.

PRESENTATIONS AND ABSTRACTS

1. "The Effect of Lactation Concurrent with Pregnancy on Fetal Growth, Maternal Nutritional Status and Dietary Intake in Supplemented Guatemalan Women." (Presented by Kathleen Merchant at the *Maternal Nutrition and Health Care Program; Technical Advisory Group Meeting*, January 24, 1989, Washington, D.C.)

2. "Lactation and Its Effect on Maternal Nutritional Status." (Presented by Tere Gonzalez-Cossio at the Maternal Nutrition and Health Care Program; Technical Advisory Group Meeting, January 24, 1989, Washington, D.C.)

3. Merchant, K and R. Martorell. The Effect of Lactation Concurrent with Pregnancy on Fetal Growth, Maternal Nutritional Status, and Dietary Intake in Supplemented Guatemalan Women. In: *Abstracts of the Federation of American Societies for Experimental Biology*, 3(3):A768. The 73rd Annual FASEB Meeting, New Orleans, Louisiana, March 21, 1989.

5. "Frequent Reproductive Cycling: Does It Lead to Nutritional Depletion of Guatemalan Mothers." (Presented by Kathleen Merchant at the *Field Seminar, Division of Nutritional Sciences*, Cornell University, Ithaca, New York, April 24, 1989.)

6. Merchant, K, Martorell, R and JD Haas. Effects of Overlap of Lactation with Pregnancy, Recuperative Intervals on Mother and Fetus. *The 14th International Congress of Nutrition*, Seoul, Korea, August 1989.

WORK IN PROGRESS

1. "The Effect of Parity on the Body Mass and Composition of Women during Lactation"

2. "Maternal Anthropometry to Predict Lactation Duration"

APPENDIX C

DESCRIPTION OF THE RESEARCH TEAM

Person	Present Employment and Address	Area of Specification	Role in Project
R. Martorell	Professor of Nutrition Food Research Institute Stanford University Stanford, CA 94305	Maternal and Child Health; Nutrition and Birth Weight	Principal Investigator
K. Merchant	Research Associate Food Research Institute Stanford University Stanford, CA 94305 (until December 31, 1989)	Reproductive Stress and Maternal and Fetal Responses	Major analytic and writing responsibilities
M. John	Associate Professor Office of Population Research 21 Prospect Road Princeton University Princeton, NJ 08544	Demography and Reproduction	Advisor on analytical methods
J. Rivera	Crecimiento y Desarrollo Division de Nutrición y Salud INCAP Carretera Roosevelt Zona 11 - Ap. Postal 1188 Guatemala City, Guatemala CENTRAL AMERICA	Maternal Nutrition and Birth Weight	Co-investigator; carried out research at INCAP
T. Gonzalez	Crecimiento y Desarrollo Division de Nutrición y Salud INCAP Carretera Roosevelt Zona 11 - Ap. Postal 1188 Guatemala City, Guatemala CENTRAL AMERICA	Maternal Nutrition and Birth Weight	Co-investigator; carried out research at INCAP

APPENDIX D

EVALUATION OF PARTICIPATION IN THE MATERNAL AND HEALTH CARE PROGRAM

Participation in a structured and coordinated multi-institutional research effort differs from the usual "take-your-money-and-go" administrative arrangement whereby each grantee works in isolation. Participation in ICRW's Maternal and Health Care Program gives one high expectations that the findings of the various investigators, by being integrated into a cohesive framework, will have a greater policy impact than ordinarily expected. We sincerely hope that this will be the case.

On a personal level, ICRW personnel, first Dr. Joanne Leslie and then Dr. Judith Timyan as Project Director and Ms. Laurie Parker as Administrative Assistant, made our job easier. They were always available and provided advise on administrative matters as required on a timely basis. Especially appreciated is the flexibility they have shown in meeting our research needs and in making accommodations to compensate for unforseen circumstances.

The positive aspects far outweigh the negatives. Of the latter, an important one is a sense of frustration at having stopped prematurely, at a point when we had uncovered major issues of importance. We realize that given the nature of the research "beast", analyses can seem to go on forever. However, the time frame of the project was too short; in our case by the time the data files were up and running, there was time to tackle some but not all of the major issues. It would have been a desirable feature of the time to have additional funding available to those research teams deserving assistance.

A second complaint had to do with the meeting held in January of 1989. The aims of this meeting were misunderstood by us, possibly because of poor communication. We thought the conference was to review preliminary research results in order to provide timely suggestions on design, analyses, and interpretation. Our presenters, K. Merchant and T. Gonzalez, felt that

members of ICRW's Advisory Committee expected finished products and that this may have explained the hostile reception to their presentation. Still, there were useful suggestions made in spite of some unpleasantness in the exchange of views. A recommendation for future meetings is to make them as inviting of free exchange as possible within a collegial environment.

The above complaint is minor and our feelings towards the project are very positive.