Postpartum Amenorrhea: How Is It Affected by Maternal Nutritional Status?

Abstract. *The average length of postpartum amenorrhea reported by breast-feeding women in rural Bangladesh in 1975 was 18 to 20 months. Its duration was found to be only slightly related to maternal nutritional status. There was no evidence of a threshold of weight for height necessary for the resumption of menses postpartum. Factors related to the duration of postpartum amenorrhea were maternal age, socioeconomic status, and supplemental feeding of the infant.*

Following a live birth, a woman generally experiences a 6-week period of amenorrhea related to the hormonal concomitants of pregnancy (*1*). This amenorrheic state may be extended by the practice of breast-feeding, the duration of the amenorrhea being strongly correlated with the duration of lactation. In developing countries where prolonged breast-feeding is practiced, postpartum amenorrhea has been observed to last 18 to 24 months on the average (*2*). Such extended intervals help to maintain fertility rates below those observed in areas of the developed world among women not practicing contraception (*3*). This natural fertility regulation has prompted searches for the factors contributing to prolonged maintenance of postpartum amenorrhea.

Maternal malnutrition has been postulated to be such a factor because extended postpartum amenorrhea has been observed among populations where nutritional status is poor (*4*). The major theory is based on research conducted by Frisch and McArthur (*5*). They found in a group of Western women who experienced secondary amenorrhea associated with anorexia nervosa that normal menstrual cycles did not resume until body weights increased by 10 to 15 percent. Frisch calculates that this weight gain represents the attainment of a body composition in which fat is at least 22 percent of body weight (*6*).

On the basis of these findings Frisch suggests that amenorrhea occurring among poorly nourished lactating women may be a direct effect of their having insufficient body fat (*7*): A certain percentage of body fat may be critical for the normal mechanism of ovulation. The added nutritional requirements of pregnancy and lactation may lead to a nutritional state reduced to less than that needed to maintain ovarian function. This condition could be especially prevalent among poor women who are unable to increase their energy intakes to meet the added requirements of pregnancy and lactation. With the frequency of breast-feeding decreasing as the infant becomes older and more able to consume other foods, the woman could gain the fat necessary to trigger the hormonal reflex system. The critical proportion of body fat determines the minimum weight for height necessary for resumption of menses. Frisch suggests that the threshold may be different for different racial and ethnic groups but argues that each population should exhibit the threshold pattern (*5*).

In this study we examine whether this hypothesis is supported by data collected in rural Bangladesh, where 2048 breast-feeding women 13 to 21 months postpartum were interviewed in 1975. Heights, weights, and arm circumferences of the women and their infants were measured. Information on menstrual status, socioeconomic status, supplementation of the infant diet, and maternal and infant morbidity was also collected.

We do not have weights at resumption of menses, but we can compare the weights of menstruating and amenorrheic women at each postpartum interval to determine whether the menstruating women are heavier (Table 1). There is generally a difference of only 1 to 3 percent between the mean weights of the menstruating and the amenorrheic women. The smallness of this difference and the fact that neither group appears to gain or lose weight as the time postpartum increases suggest that it is unlikely that the menstruating women gained 10 to 15 percent body weight before resumption of menses.

This type of comparison could, however, obscure a possible threshold of weight for height below which all women would be amenorrheic. To examine this issue, Fig. 1, A and B, provides plots of the weights and heights of individual breast-feeding women 17 to 18 months postpartum (the median postpartum interval of our sample).

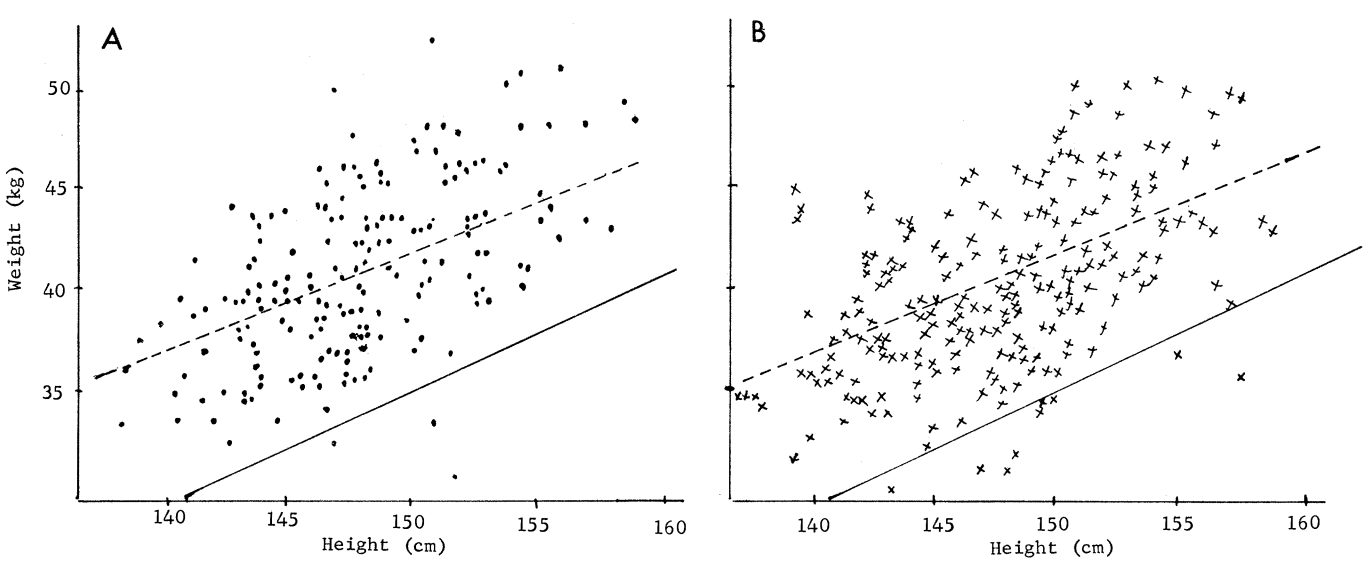

Fig. 1. Scattergram of weights and heights of (A) menstruating women 17 to 18 months postpartum (N = 175) and (B) amenorrheic women 17 to 18 months postpartum (N = 265) in Bangladesh. Dashed line corresponds to a minimum level of weight for height suggested by Frisch to be necessary for menses to resume among Western women (*4*). Solid line, empirically derived, indicates weights for heights below which few of the Bangladeshi women were menstruating.

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Table 1. Mean weights of breast-feeding women in rural Bangladesh, by menstrual status and postpartum interval, 1975.

Months post-partum	Amenorrheic			Menstruating			Difference in mean weights (%)
	N	Mean weight (kg)	Standard deviation	N	Mean weight (kg)	Standard deviation	
13	66	40.27	4.47	19	43.22	3.52	6.8
14	172	40.90	4.55	66	41.43	4.80	1.2
15	190	41.06	4.19	79	41.92	4.59	2.1
16	163	40.11	4.26	82	42.73	3.78	6.1
17	130	40.17	4.44	82	40.90	4.71	1.8
18	135	40.06	4.40	93	40.51	4.03	1.1
19	138	40.20	4.47	108	41.15	5.15	2.3
20	138	40.66	4.66	88	41.81	4.36	2.8
21	111	40.65	4.37	122	41.61	4.46	2.3
Total	1243			739			

Table 2. Proportion amenorrheic by percentile of weight for height and percentile of proportion body weight composed of water.

Weight for height			Proportion body weight composed of water*			
Centile	N†	Proportion amenorrheic	Centile	N†	Proportion amenorrheic	Mean proportion water
≤ 10	200	.76	91+	196	.77	.61
11-20	198	.63	81-90	191	.61	.59
21-30	201	.62	71-80	198	.64	.58
31-40	203	.67	61-70	193	.68	.57
41-50	195	.65	51-60	193	.62	.56
51-60	197	.62	41-50	216	.62	.55
61-70	196	.62	31-40	195	.62	.55
71-80	202	.62	21-30	196	.62	.54
81-90	200	.52	11-20	197	.55	.53
91+	190	.56	≤ 10	207	.55	.51

*Calculated by the method employed by Frisch (*4*). Since the applicability of the equations used is in question (*11*), these figures are intended only for comparison with Frisch's data. †The numbers are not equal in all centiles because of duplications in the frequencies at some centiles.

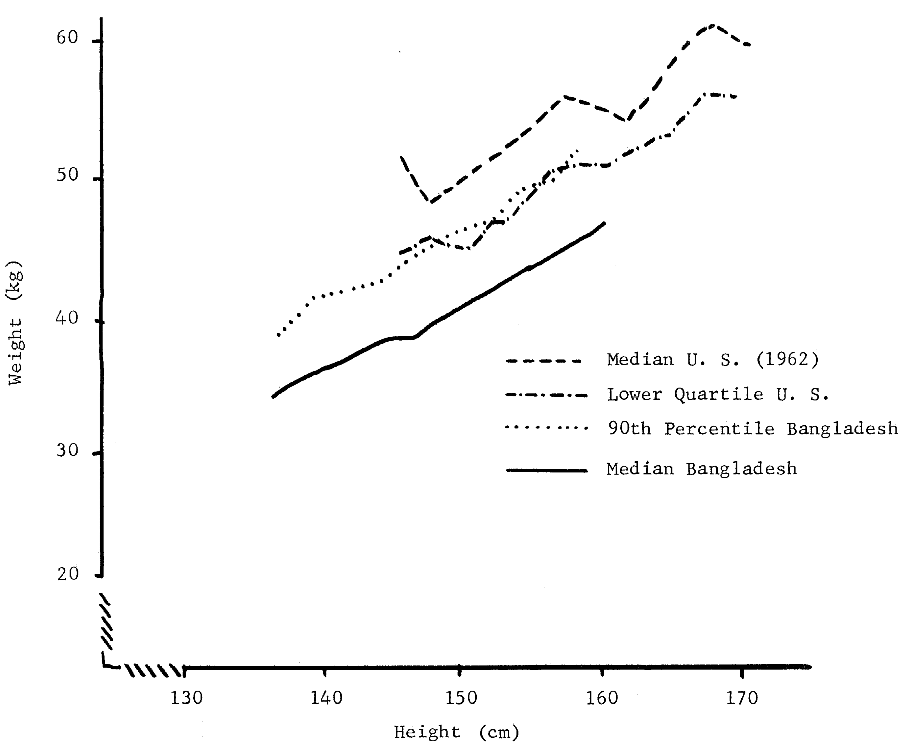

Fig. 2. Comparison of weights for heights of U.S. and Bangladeshi women.

Frisch derives the percentage of body weight that is fat from a formula for calculating from height and weight data the percentage that is water (*5*). Frisch's line representing the weight for height at which body fat is supposedly about 22 percent (total water 56.1 percent) is drawn on the scattergrams. As Fig. 1A illustrates, for this population that line does not indicate a threshold between menstruation and amenorrhea; at least half the menstruating women have weight-for-height values below that line. If the threshold values vary among populations, we should be able to derive such a line empirically for this population. In Fig. 1A we have drawn a line below which few of the menstruating women (1 percent) are represented. This line and Frisch's line are added to the scatterplots of points for amenorrheic women in Fig. 1B. There are a few more amenorrheic women (less than 4 percent) below the derived line. This is not surprising, since it probably represents extreme states of malnutrition. Basically, however, there is virtually a complete overlap of the weights for heights of menstruating and amenorrheic women. This is the pattern also for women 13 to 16 and 19 to 21 months postpartum. If maternal nutritional status were a determinant of prolonged lactational amenorrhea, one would expect that the women who were still amenorrheic so long after childbirth would have had a substantially different weight-for-height distribution from that of the menstruating women.

One criticism of this study might be that we were dealing only with severely malnourished women. It may be seen, however, that at least 10 percent of the Bangladeshi women (Fig. 2) fell within the weight-for-height range of normal American women (*8*), and 56 percent of that group were amenorrheic, compared with 60 percent of all the Bangladeshi women in the study (Table 2). Table 2 also shows that the variations in proportion amenorrheic in groups differing in percentage of body weight calculated to be water are not extreme. These figures are given only to permit comparisons with Frisch's data; we have reservations concerning the calculations of body water (or fat) from height and weight data. Both Tables 1 and 2 show effects in the direction postulated by Frisch, but the differences are small except at the extremes. This again indicates that such extended lactational amenorrhea can hardly be said to result primarily from malnutrition.

This study did not directly measure breast-feeding practices, but other factors which could be considered indices of breast-feeding patterns were incorporated into the analysis. A multiple linear regression with menstrual status as a binary dependent variable was performed using an unweighted least squares analysis. The assumption of constant variance required by this technique was approximately satisfied, the proportion of amenorrheic women at each postpartum interval being generally within the limits of .30 to .70. Since we were not interested in predicting the probability of being amenorrheic but rather in estimating the relation of the independent and dependent variables, the unweighted least squares technique was considered appropriate. This analysis illustrated that when postpartum interval was controlled, maternal age, socioeconomic status (defined by wealth), and supplementary feeding of the infant were correlated with the probability of being amenorrheic; the correlations were statistically significant but the total amount of variance explained was not large (R^2 = .115): As has been found in other studies (*9*), older women were more likely to be amenorrheic than young women; richer women and those feeding their infants the better supplements were more likely to have resumed menstruation than the others in the same postpartum interval. With all variables present, maternal nutritional status explained less than 1 percent of the total variance. Current maternal and infant morbidity and infant anthropometric status were not associated with the probability of amenorrhea.

Socioeconomic status (wealth) was found to be unrelated to maternal nutritional status. This surprising finding may be explained by the generally poor sanitary and environmental conditions prevalent throughout villages in Bangladesh and by the low status of women in all socioeconomic ranks. We suspect that the independent effect of socioeconomic status on lactational amenorrhea reflects variations in breast-feeding practices. There is some evidence that as the frequency, intensity, and duration of suckling increases, postpartum amenorrhea is prolonged (*10*). Cultural factors differing between socioeconomic classes may result in variations in breast-feeding patterns.

The association between supplementary feeding and postpartum amenorrhea also supports the hypothesis that breast-feeding patterns affect lactational amenorrhea. Women who supplement their infants' diet with nutritious foods probably breast-feed less often than mothers who do not or who do so less. The decreased frequency of suckling would increase the probability of resuming menstruation. In short, breast-feeding patterns rather than maternal nutritional status may prove to be the determining factor in the prolongation of postpartum amenorrhea. Further research is needed to substantiate this theory.

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Absence of Microorganisms in Crustacean Digestive Tracts

Abstract. *Two marine and one terrestrial wood-boring isopod species and one wood-inhabiting amphipod species maintain a digestive tract free of microorganisms. Digestive tracts examined in toto with the scanning electron microscope were devoid of microorganisms. In contrast, the outer exoskeleton surfaces of these crustaceans support a dense bacterial flora. Observations of the hindgut of termites revealed a diverse gut microflora as expected.*

Gastrointestinal microorganisms have been found in a broad range of metazoans (*1*). These observations have led to the assumption that all animal digestive tracts possess an indigenous microflora (*2*). We report a clear exception to this premise. Selected genera of marine and terrestrial wood-boring isopods and a marine wood-inhabiting amphipod, members of the Crustacea, maintain a gut completely free of microorganisms.

Boring isopods cause extensive damage each year to wood structures in marine coastal zones. Species in the genus *Limnoria* have a cosmopolitan marine distribution bounded only by the approximate geographic constraints of 60° north and south latitude (*3*).

Ray and Julian (*4*), using a light microscope, failed to produce evidence of a microflora in the gut of *Limnoria tripunctata* (*5*). They concluded that these wood-borers produce their own cellulolytic enzymes (*6*). A study of *L. tripunctata* in our laboratory, using the scanning electron microscope, confirmed this observation (*7*).

The analysis reported here involved two marine wood-boring isopods, *L. tripunctata* and *Limnoria lignorum*; a marine wood-inhabiting amphipod, *Chelura terebrans*, which lives within the burrows of *Limnoria* species and feeds on limnorid fecal material; and a terrestrial isopod, *Oniscus asellus*.

Digestive tracts (*8*) were removed whole and intact by dissection in buffered glutaraldehyde under a binocular microscope. The tracts were fixed, dehydrated, dried at the critical point, and coated with gold-palladium for scanning electron microscopy by techniques described elsewhere (*7, 9*). The digestive tracts ranged from 1.5 to 2.0 mm in length.

No microorganisms were found in the entire digestive system of *L. tripunctata*, *L. lignorum*, and *C. terebrans* during repeated observations with the scanning electron microscope (Fig. 1, A to C). Wood particles taken from the digestive tracts shown in Fig. 1 were examined separately under the scanning electron microscope. The gut contents were devoid of microorganisms. These results led us to conduct a similar study on a phylogenetically close relative of *Limnoria* spp. which lives in an entirely different habitat. The wood-inhabiting isopod *O. asellus* is found in rotting logs (*8*). The entire digestive tract of this isopod was found to be devoid of microor-

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