MATERNAL NUTRITIONAL STATUS AND MILK VOLUME. IS THERE A CAUSE-EFFECT RELATIONSHIP?[1]

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SUMMARY

Studies on human lactation were examined in order to gather some answers about questions concerning the effect of maternal food intake, size, fatness and economic status on milk production. Up to date, evidence in the literature is insufficient to permit definitive answers, but a general conclusion can be drawn: milk volume varies little among mothers with largely variable energy intakes, sizes and economic status. There is a great need for more controlled studies focusing on the relationship between maternal energy balance and milk output.

Although many studies have separately addressed the nutritional changes in mothers througout lactation (1-8) and milk consumption by infants (9-17), very few have correlated maternal nutritional conditions and the volume of milk consumed.

This report will consider investigations published from 1975 and on, combining data on maternal nutritional status and milk production in the same individual. The rationale is that around 1975 more accurate and standardized methodology began to be used in related studies. Milk output is estimated by the summatory of the differences of body weights of infants obtained before and after each milking episode during 24 hours. Before 1975 the balances used for such a purpose had very poor precision, and this interfered seriously on the inter and intra-personal variability of the measurements. Electronic scales made available after that year gave enough

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reliability to the procedure. This report is comprised of studies from birth to four months postpartum, when energy supplementation is less common, and quantitatively less important.

Nutritional status of the mothers will be analyzed on the basis of four categorizing variables: social and economic status, anthropometry, food intake and body composition.

I. BREAST MILK PRODUCTION IN A POPULATION WITH DIFFERING SOCIAL AND ECONOMIC STATUS

In very early studies, women from developed nations reportedly produced 800-2,400 grams of milk per day (18-20), while those living in developing countries seemed to produce between 360-820 g of milk per day (21-23). The highest milk outputs were obtained from professional wet nurses, and most of the studies were performed using very imprecise scales. More recently, better controlled studies have demonstrated that mothers from developing and developed countries have similar milk outputs (Table 1) (10-17). A note of caution is in order; supplementary energy intake of infants was not

TABLE 1

REPORTED AMOUNTS OF MILK CONSUMED (g) BY INFANTS OF DEVELOPED AND DEVELOPING COUNTRIES (1975-1988)

Author	Country	Age of infants, months 1	2	3	4
Developed					
(16) Hofvander[b]	Sweden	660	755	780	795
(31) Whitehead[b]	UK	740	785	784	717
(15) Chandra[a]	Canada			793	856
(44) Pao[b]	USA	569		523	
(17) Picciano[a]	USA	606	601	626	
Developing					
(34) Hennart	Zaire	517		605	
(14) Van Steenberg	Kenya	675			555
(35) Prentice[a]	Gambia	649	705	782	582
Gross	India	454	476	479	496
(27) Hanafy[c]	Egypt		879		882
(30) Brown[a,c]	Bangladesh	582	635	690	714
Villalpando[a,d]	Mexico				890

a Exclusively breast feeding.
b Supplemented.
c Admitted to a hospital.
d Stable isotopes.

controlled in several of these studies. However, when comparing data on exclusively breast-fed (15, 17) and supplemented infants (10, 16), no significant differences are noted. Although they were categorized as supplemented, quantitative data on the energy supplied are not available.

In a recent collaborative study supported by WHO (24), groups with contrasting social and economic status within the same country were compared (Table 2). There were no striking differences within or between countries. Two exceptions have to be pointed out: the upper class of Philippines and the lowest class of Zaire, both with the lowest milk outputs. Philippine mothers had no evidences of significant changes in nutritional status, while poor mothers of Zaire had the most compromised nutriture. In both groups a large proportion of infants (68-85%) were supplemented from the first month of life, but again, no quantitative information is available. This fact might be largely confounding because of its effects on prolactin secretion and in time on milk output. In the presence of such disparity in nutritional status a cause-effect relationship can not be clearly established. The studies in this section are inconclusive and suggest that at these planes of nutrition, changes in maternal economic status do not significantly affect milk production.

II. EVIDENCE BASED ON ANTHROPOMETRIC MEASURES

Anthropometric parameters have been used as indicators of nutritional status: actual height compared with expected height reflects the effect of chronic undernutrition, while weight for height and derived measures reflect the effects of acute malnutrition (25, 26). In adults, cutoff values may not be stable across the range of heights to which they are applied. In addition, there are no universally accepted reference population data. Therefore, correlations between milk production and any of these anthropometric parameters should be interpreted with caution. One study done in Egypt in 1972 (27), classified mothers as malnourished or as healthy on the basis of clinical inspection; mean body weight and arm circumference were significantly different. A second study done in Kenya (28), categorized mothers using 90% of the predicted w/h as a cutoff point. The resulting two groups were called w/h minus and w/h plus. In both studies a significant difference in milk yield was claimed. Nevertheless, inconsistency in the pattern and the small sample sizes, when statistical control of postpartum age was intended, made such conclusion unsustainable.

Very preliminary data of a study carried out by our group in collaboration with the Baylor College of Medicine measuring the milk output by isotopic dilution techniques, showed no significant correlation between height, weight, weight/height^2 or total body fat and milk output.

Butte studied 45 well-nourished mothers in Houston (29). No correlation was found between milk production and the anthropometric parameters. However, when milk production of mothers classified in the upper and lower deciles of body weight were compared, heavier mothers tended to produce more milk than leaner ones. The smallness of the sample size measured in each decile (N=4) gave limited strength to the conclusion.

Brown, in Bangladesh, studied 60 lactating mothers (30). The intra and

TABLE 2

AMOUNT OF MILK AND SOME CHARACTERISTICS OF MOTHERS AND INFANTS OF THE WHO COLLABORATIVE STUDY (24)

		Philippines			Guatemala			Zaire			Hungary	Sweden
		A	B	C	A	B	C	A	B	C		
Amount of milk	(g)	320-404	502-639	571-689	524-653	519-584	543-686		588-656	338-368	607-681	642-791
Height	(cm)	150-153	148-150	151-153	156-159	149-150	145-150		151-154	157-158	161-163	167-169
Weight	(kg)	51.3-46.9	46.0-47.3	49.2-47.9	58.1-56.5	49.0-50.7	47.9-50.4		54.9-56.4	51.5-50.7	61.7-61.7	63.6-59.8
Per cent of supplemented infants		75-85	26.34	27-44	59-75	34-48	11-15		11-37	46-70	1-53	4-14

Authors defined grossly three subsamples in accordance to their general economic status:

A Urban, good economic status and education, B Urban, poor economic sttus and education and

C Rural traditional, living on subsistence farming.

inter-individual variability of maternal nutritional status in relationship to milk output, was analyzed. No correlation was found between anthropometric variables and milk production with the exception of body weight. Mothers who gained 200 g or more during the first three months of lactation produced more milk (648 + 78 g) than those gaining less (546 + 81 g).

In summary, there is some convincing evidence about a relationship between maternal body weight and the amount of milk produced. It holds true for well-nourished as well as marginally-nourished mothers, but the physiological significance may differ in each case. It might be suggested in the case of well-nourished mothers, a partitioning of energy intake between the milk and the maternal compartment. In the case of marginally-nourished mothers, there seems to be a clear subsidizing of lactation, using for that purpose the maternal energy stores.

III. EFFECTS OF MATERNAL FOOD INTAKE VARIATIONS ON MILK OUTPUT

Some studies have shown noticeable variations on energy intake during the seasonal shortage of food in communities living on subsistence farming, especially affecting lactating mothers. Studies performed in Gambia (31, 32), Kenya (33), Zaire (34), and Bangladesh (30) have described such seasonal variations.

The most detailed study was reported by Prentice in Gambia (32, 32). Mothers' energy intake decreased from 1,773 kcal during the harvest season, to 1,215 kcal during the "hungry" months. Body weight varied from a gain of 450-700 g/month to a loss of 700-1,000 g/month, respectively. Associated with these changes, milk consumption by infants dropped from 653 g to 580 g. The most noticeable changes in milk output were observed in late stages of lactation, particularly from the seventh month and on. From zero to three months postpartum, changes were less pronounced (Table 3). Criticisms were raised, due to the fact that milk output data were derived from measurements taken in a 12-hour period. Although data were reanalized in 1986, the basic criticisms are still standing (35).

TABLE 3

MILK OUTPUT IN GAMBIA
g/24 hr

	Months postpartum			
	0 - 3	3 - 6	6 - 9	9 - 12
Dry season*	653	614	574	583
Wet season*	640	580	611	574
Cambridge*	741-785	588-783	328-493	

Source * Prentice, A.M. *et al. Am. J. Clin. Nutr.*, *34:* 2790-99, 1981 (32).
* Prentice, *Human Lactation II.* 1986, p. 18 (35).

Although initially, the authors suggested a cause-effect relationship between the nutritional limitation and the decreased milk output, other factors were considered in the 1986 reappraisal. For instance, changes in feeding habits and a higher rate of infant morbidity were observed. In Gambia older infants are left at home while their mothers work in the fields during day-light hours. Consequently, the number of feedings in 24 hours and the amount per feeding were both decreased. A similar trend was observed in Kenya. Such behavioral changes may explain why milk intake in children six months and olders is more affected than in younger infants. The latter are carried by the mother out to the fields, and presumably suckled there.

Prevalence of infectious diseases, especially diarrhea, are at its highest during the rainy season. The anorexic effects of these illnesses and the consequent decrease in growth velocity may seriosly interfere with the infants' demand for milk. When authors analyzed individual cases, the fall-off in milk consumption was associated with clustering of illnesses, and in one case such fall-off in milk consumption was observed during the dry season.

Preliminary data of the study carried out by our group in a farming village of Mexico, have shown a similar decrease in energy intake and in body fat, during the lean season. No changes in milk output, however, have been noticed so far.

Effect of Dietary Supplementation on Milk Production

Probably the most direct way to test the hypothesis postulating a direct relationship between food restriction and milk production, are studies in which deliberate intervention increasing the limited energy intake takes place. Several such attempts have been made since 1925 with varying and inconclusive results. More recently, Edozien (36) admitted a group of undernourished lactating women of Nigeria to a hospital ward and increased their protein intake from 25 to 100 g/day. This was followed by an impressive increase of around 240 g of milk per day above the previous milk consumption rate. Weight in infants increased 22 g/d. Strong criticism may be made about how hospitalization affects energy, expenditure, the number of feedings and maternal and infant stress as compared to the free living state. It is clear that apart from energy expenditure, the remaining variables affect milk production, so actual figures may be underestimated. If switching from a high energy expending activity, as farming, to a relatively sedentary activity in a hospital ward, can spare enough energy to increase milk output; then, it can be deduced that at this plane of nutrition fluctuation in the balance of energy expenditure would affect milk production. Unfortunately, the energy expenditure was not controlled and its effects can not be separated from those of the dietary intervention itself.

In 1975, Chávez published his observations on a group of inadequately nourished Mexican women (37); he supplemented their diet with 300 kcal per day from late pregnancy until weaning. A slight increment in milk volume was observed, but in terms of energy it was offset by a 15-20% dilution of milk. Despite the fact that the energy content of milk apparently did not change, a measurable impact on infant's growth was detected. Sensitivity of their test weighting procedure was probably insufficient to detect small differences.

The main problem in these studies has been the lack of consistency in the amount of energy provided as a supplement. The difference in energy intake between lactating mothers of industrialized and developing countries is about 700-1,000 kcal. But in none of the studies so far discussed, was the energy supplement that large. In addition, no control of the substitution effect of supplementary energy on the costumary home diet was mentioned.

The Dunn Nutrition Unit team was able to supplement Gambian mothers with 830 kcal (38, 39), displacing only 100 kcal of the home diet; total intake amounted to 2,291 kcal. No effect on milk production was observed, and total energy content of the milk remained unchanged. Furthermore, in mothers with a previous history of low outputs or low energy intake, supplementation did not increase their milk production (35).

The authors pointed out that milk production previous to the dietary intervention was quite adequate, even under harsh nutritional conditions, and was comparable to the output of affluent mothers. A second possibility was a reduction in metabolic efficiency. A relevant point to analyze is what happens to the extra energy eaten (730 net kcal), since the amount of energy in the milk was the same as in the preintervention period and the maternal weight gain was so little (1.8 kg). Rasmussen pointed out that instruments were insensitive for assessing small differences in the 12-hr determinations of milk yield and probably there was an increased energy expenditure of the mothers or changes in the breast-feeding patterns (40).

It is not surprising that no change in breast milk volume occurred, if we consider these results in the context of a total energy balance. In high-yield animals such as dairy cows, goats or rodents, the energy demand for milk synthesis is two-fold the energy needed for the maintenance of the maternal compartment.

It is *covered mainly by related increments in* energy intake (Table 4). Even though metabolic adaptation gears adipose tissue and muscle towards a negative balance, its contribuiton to the energy demands of the mammary gland are negligible (41, 42); under those circumstances any dietary limitation will have an immediate impact, in a negative fashion, on the milk yield.

TABLE 4

INTERSPECIES VARIATIONS ON THE COSTS OF MILK SYNTHESIS

	Percent dietary increment needed to cover milk costs	Fate of energy intake	
		Milk costs %	Maternal compartment %
Rat	300	66.7	33.3
Cow	250	60.0	40.0
Human	25	25.0[a]	75.0
		45.0[b]	55.0

a Considering a daily intake of 2,400 kcal.
b Considering a daily intake of 1,300 kcal.
Prentice, A.M. and R.G. Whitehead. *Symp. Zool. Soc. London,* 1987 (42).

In humans, the amount of energy needed for milk production is roughly 25% of the intake in well-fed mothers and as high as 45% in mothers from poor communities during "hungry" seasons. The large fat deposits laid down during pregnancy, make up for inadequate energy intake during lactation.

IV. STUDIES ON BODY COMPOSITION

Recently, Sadurskis in a study on well-nourished lactating women (43) demonstrated that almost 3.5 kg of fat-free body weight and 167 nmol of total body K, representing a 7% of the body muscle mass, are lost during the first two months postpartum. This represents a spare in energy of 110 kcal on the daily resting metabolic rate. This not widely known adaptation is perplexing, since diet or body fat could easily provide enough energy to cover the mammary gland demands. Fat started to be utilized from two months postpartum and on. At six months the average loss was 1.7 kg. On these premises, it can be speculated that in women belonging to poor communities and suffering chronic malnutrition the metabolically active, lean body mass might be smaller than in affluent women. Such adaptation may explain their ability to survive, in a life style characterized by intense physical activity and limited energy intake. Under the nutritional conditions described in most of the studies herein discussed, maternal energy stores have efficiently subsidized lactation. How severe dietary restriction has to be before body stores fail to the energy gap is not known. Such experimental conditions would be hard to set up in humans.

In summary, available evidence on the effects of maternal nutritional status on milk production, is contradictory and inconclusive. A satisfactory answer has yet to be found. It would have to be made in terms of total energy balance.

When studying the relationship between maternal nutrition and milk production, the following factors should be strictly controlled: infant's age, size, rate of growth, mortality rate and complementary feeding; mothers' age, parity and previous nutritional status; the parameters to be measured must include resting metabolic rate, changes in lean body mass and total fat, energy expenditure, energy content of milk, and dietary intake.

RESUMEN

ESTADO NUTRICIONAL MATERNO Y VOLUMEN DE LECHE. ¿EXISTE UNA RELACION DE CAUSA-EFECTO?

Se revisaron los estudios disponibles sobre la lactancia humana para obtener algunas respuestas acerca de los efectos del consumo materno de alimentos, el tamaño corporal, la adiposidad, y el estado socioeconómico sobre la producción de leche. Las evidencias publicadas hasta la fecha, son insuficientes para permitir respuestas definitivas, pero se puede sacar una conclusión general: el volumen de leche varía poco entre madres con consumos energéticos, tamaños corporales, y situaciones económicas, con un amplio margen de variación. Existe gran necesidad de estudios más controlados que

enfoquen la relación entre el balance materno de energía y la producción de leche.

BIBLIOGRAPHY

1. Geissler, C., D.H. Calloway & S. Margen. Lactation and pregnancy in Iran. II. Diet and nutritional status. **Am. J. Clin. Nutr., 31**: 341-354, 1978.
2. Butte, N.F., D.H. Calloway & J.L. Van Duzen. Nutritional assessment of pregnant and lactating Navajo women. **Am. J. Clin. Nutr., 34**: 2,216-2,228, 1981.
3. Dhaliwal, Y.F., V. Sagar & S.K. Bhatia. Food consumption pattern and nutritional status of lactating mothers in Hissar, India. **Philip. J. Nutr., 36**: 49-54, 1983.
4. Adair, L.S., E. Pollett & W.H. Mueller. Maternal anthropometric changes during pregnancy and lactation in a rural Taiwanese population. **Hum. Biol., 55**: 771-787, 1983.
5. Adair, L.S., E. Pollett & W.H. Mueller. The Bacon study: Effect of nutritional supplementation on maternal weight and skinfold thickness during pregnancy and lactation. **Brit. J. Nutr., 51**: 357-369, 1984.
6. Delgado, H.L., V. Valverde & E. Hurtado. Lactation in rural Guatemala: Nutritional effects on the mother and the infant. **Food Nutrition Bull., 7**: 15-25, 1985.
7. Arteaga, A., S. Díaz, M. Villalón, M. Valenzuela & A.M. Cubillas. Cambios en el estado nutricional de la nodriza durante la lactancia exclusiva. **Arch. Latinoamer. Nutr., 31**: 766-781, 1987.
8. *Reynolds*, R.D., P.B. *Moser*, S. *Acharya*, W. McConnell, M.B. Andon & P. Howard. Nutritional and medical status of lactating women and their infants in the Kathmandu Valley of Nepal. **Am. J. Clin. Nutr., 47**: 722-728, 1988.
9. Jelliffe, D.B. & E.F.P. Jelliffe. The volume and composition of human milk in poorly nourished communities. **Am. J. Clin. Nutr., 31**: 492-515, 1978.
10. Lonnerdal, B., E. Forsum & L. Hambreus. A longitudinal study on the protein, nitrogen and lactose contents of human milk from Swedish well-nourished mothers. **Am. J. Clin. Nutr., 29**: 1,127-1,133, 1976.
11. Butte, N.F., C. Garza, E. O'Brian Smith & B.L. Nichols. Human milk intake and growth in exclusively breast-fed infants. **J. Pediatr., 104**: 187-195, 1984.
12. Dewey, K.G., D.A. Finley & B. Lonnerdal. Breast milk volume and composition during late lactation. **J. Pediatr. Gastroenterol. Nutr., 3**: 713-716, 1984.
13. Prentice, A.M., W.A. Coward, H.L. Davoes, P.R. Murgatroyd, G.R. Goldberg, A.E. Black, M. Sawyer, J. Ashford & R.G. Withehead. Unexpectedly low levels of energy expenditure in healthy women. **Lancet, i**: 1,419-1,422, 1985.
14. Van Steenberg, W.M., J.A. Kusin & M. Van Rens. Lactation performance of Akamba mothers, Kenya. Breast feeding behaviour, breast: milk yield and composition. **J. Trop. Pediat., 27**: 155-161, 1981.
15. Chandra, R.K. Breast-feeding, growth and morbidity. **Nutr. Revs., 1**: 25-31, 1981.
16. Hofvander, Y., U. Hagman, C. Hillervik & S. Sjolim. The amount of milk consumed by 1-3 months old breast or bottle-fed infants. **Acta Pediatr. Scand., 71**: 953-958, 1982.
17. Picciano, M.F., E.J. Calkins, J.R. Garnick & R.N. Deering. Milk and mineral intake of breast-fed babies. **Acta Pediatr. Scand., 70**: 889-941, 1981.
18. Macy, I.G., H.A. Hunscher, E. Donelson & B. Nims. Human milk flow. **Am. J. Dis. Child, 39**: 1,186-1,204, 1930.
19. Deem, H.E. Observations on the milk of New Zealand women. **Arch. Dis. Child, 6**: 53-70, 1931.

20. Walgren, A. Breast milk consumption of healthy full-term infants. **Acta Pediatr. Scand., 32:** 778-790, 1944.
21. Rajalakshmi, R. Reproductive performance of poor Indian women on a low plane of nutrition. **Trop. Geog. Med., 23:** 117-125, 1971.
22. Blankhort, D.M. Measured food intakes of young Indonesian children. **J. Trop. Pediatr., 8:** 18-21, 1962.
23. Martínez, C. & A. Chávez. Nutrition and development of infants in poor rural areas. I. Consumption of mothers milk by infants. **Nutr. Reps. Internat., 4:** 139-149, 1971.
24. **Quantity and Quality of Human Milk.** Geneva, World Health Organization, 1985.
25. Waterlow, J.C. Classification and definition of protein-caloric malnutrition. **Brit. Med. J., 3:** 566-569, 1972.
26. Baeragi, R. A comparison of five anthropometric indices for identifying factors of malnutrition. **Am. J. Epidemiol., 126:** 258-267, 1987.
27. Hanafy, M.M., M.R.A. Morsey, Y. Seddick, Y.A. Habib & M. Lozy el. Maternal nutrition and lactation performance. **J. Trop. Pediatr., 18:** 187-191, 1972.
28. Van Steenbergen, W.M., J.A. Kusin, C. De With, E. Lacko & A.A.J. Jansen. Lactation performance of mothers with contrasting nutritional status in rural Kenya. **Acta Pediatr. Scand., 72:** 805-810, 1983.
29. Butte, N.A. & C. Garza. Anthropometry in the appraisal of lactation performance among well-nourished mothers. In: **Human Lactation. II. Maternal and Environmental Factors.** M. Hamosh and A.S. Goldman (Eds.) New York, N.Y., Plenum Press, 1986, p. 61-67.
30. Brown, K.H., N.A. Akhtor, A.D. Robertson & M.G. Ahmed. Lactational capacity of marginally nourished mothers: Relationships between maternal nutritional status and quantity and proximate composition of milk. **Pediatrics,** 78: 909-919, 1986.
31. Whitehead, R.G., M.G.M. Rowland, M. Hutton, A.M. Prentice, E. Muller & A. Paul. Factors influencing lactation performance in rural Gambian mothers. **Lancet, ii:** 178-184, 1978.
32. Prentice, A.M., R.G. Whitehead, S.B. Roberts & A.A. Paul. Long-term energy balance in child-bearing Gambian women. **Am. J. Clin. Nutr., 34:** 2,790-2,799, 1981.
33. Van Steenbergen, W.M., J.A. Kusin, M. Van Rens, K. De With & A.A.J. Jansen. Lactation performance. In: **Maternal and Child Health in Rural Kenya.** J.K. Van Ginneken and A.S. Muller (Eds.) London, Coom Helm, 1984, p. 153-165.
34. Hennart, P.H. & H.L. Vis. Breast feeding and postpartum amenorrhea in Central Africa. I. Milk production in rural areas. **J. Trop. Pediatr., 26:** 177-183, 1980.
35. Prentice, A.M., A.A. Paul, A. Prentice, A. Black, T. Cole & R.G. Whitehead. Cross cultural differences in lactational performance. In: **Human Lactation. II. Maternal and Environmental Factors.** M. Hamosh and A.S. Goldman (Eds.) New York, N.Y., Plenum Press. 1986, p. 13-44.
36. Edozien, J.C., M.A. Rahim Khan & C.I. Woslien. Human protein deficiency: Results of a Nigerian village study. **J. Nutr., 106:** 312-328, 1976.
37. Chávez, A., C. Martínez & H. Bourges. Role of lactation in the nutrition of low socio-economic groups. **Ecol. Food. Nutr., 4:** 159-169, 1975.
38. Prentice, A.M., R.G. Whitehead, S.B. Roberts, A.A. Paul, M. Watkinson, A. Prentice & A.A. Watkinson. Dietary supplementation of Gambian nursing mothers and lactation performance. **Lancet, ii:** 886-888, 1980.
39. Prentice, A.M., P.G. Lunn, M. Watkinson & R.G. Whitehead. Dietary supplementation of lactating Gambian women. II. Effect on maternal health, nutritional status and biochemistry. **Hum. Nutr. Clin. Nutr., 37C:** 65-74, 1983.
40. Rasmussen, K.M. Maternal nutritional status and lactation performance. **Clin. Nutr.,**

7: 147-155, 1988.

41. Oftedal, O.T. Milk composition, milk yield and energy output at peak lactation: A comparative review. **Symp. Zool. Soc.,** London, **51:** 33-85, 1984.
42. Prentice, A.M. & R.G. Whitehead. The energetics of human reproduction. **Symp. Zool. Soc.,** London, 275-304, 1987.
43. Sadurskis A., N. Kabir, J. Wager & E. Forsum. Energy metabolism, body composition and milk production in healthy Swedish women during lactation. **Am. J. Clin. Nutr., 48:** 44-49, 1988.
44. Pao, E.M., J.M. Himes & A.F. Roche. Milk intakes and feeding patterns in breast-fed infants. **J. Amer. Diet. Ass., 77:** 540-545, 1980.