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Energy balance in lactating undernourished Indian women

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An energy balance study was conducted in eight lactating poor-income Indian women from delivery to 6 months. Energy intake and expenditure were assessed for 7 days every month (30–37 days). Every month, basal metabolic rate (BMR) and milk ingested by infants was measured. An energy balance was computed. As a group these women were in energy balance, indicated by small body weight changes with respect to time. However, only two of these women were in a positive energy balance. Women with higher body weight lost more weight. Estimated mean energy intake was higher than energy expenditure. BMR showed a slight but not significant fall during the second month of lactation and was not different from the BMR seen in 13 non-pregnant, non-lactating women matched for body weight from the staff of the Institute. The energy cost of lactation was 2.3 MJ (549 kcal), a figure that justifies the Recommended Dietary Allowance for energy recommended by FAO/WHO/UNU (1985) and ICMR (1989).

Energy requirement during lactation is known to be increased due to breast-milk secretion. On the basis of the average amount of milk secreted daily and its energy content, an additional energy intake of 2.30 MJ/day (550 kcal/day) has been recommended for Indian lactating women of 50 kg body weight besides their normal energy intake to cover day to day work, which varies from 7.85 to 12.26 MJ/day (1875–2925 kcal) depending upon the level of occupational activity (ICMR Expert Group, 1989). However, results of diet surveys among lactating women of poor-income groups indicate that daily energy intake is much below the recommended levels, inadequate even to meet her requirement during the non-pregnant non-lactating periods (Prema, Madhavapeddi & Ramalakshmi, 1982; Shankar, 1962). This and similar observations from other parts of the world (Durnin, 1981; Prentice *et al.*, 1983), regarding the dichotomy between energy intake and energy output during lactation, has led to postulations on the possible operation of adaptive mechanisms during lactation for conservation of energy (Prema *et al.*, 1982; Prentice *et al.*, 1983). Both increased efficiency of energy utilization and energy conservation during normal activity of the lactating women has been suggested as a possible mechanism of adaptation. However lack of reliable data on long-term energy balance during lactation renders the suggested mechanism only speculative. Studies on lactating women of low-income groups have reported that they lose body weight during nursing, indicating a negative energy balance (Prema *et al.*, 1982; Shankar, 1962; Prentice *et al.*, 1983). The present study was undertaken with the view of obtaining long-term data on energy balance by measuring energy intake, energy expenditure during rest and activity and energy output through breast milk on lactating women belonging to the low-income group.

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Subjects and methods

Eight normal healthy lactating women belonging to the urban low socio-economic group were enrolled for the study with informed consent. They had all delivered normally and had had no complications during pregnancy or at delivery. These subjects were followed-up from delivery for the next six consecutive months each month (30–37 days). These women lived in single-room tenements in urban areas. After 3 months of lactation two of the women helped their husbands at home. One was a cobbler and the other a vegetable vendor. Their work, however, was mostly sitting. All infants were fed exclusively up to 4 months. Thereafter commercial baby foods were introduced by two mothers because they both felt that breast milk was inadequate for the baby. These women subsisted on cereal-based diets which was the main source of all nutrients. All of them were non-vegetarians but poverty was the major reason for meat and meat products being excluded from their diets. Information on the following parameters was collected to compute their daily energy intake and output each month (30–37 days).

Basal metabolic rate (BMR) was measured in the hospital. The subjects were admitted to the hospital 20–24 h before the BMR measurements. A mock trial was run on each subject to familiarize them with the entire procedure. The next morning 10–15 min after awakening measurements were started. The pulse rate was taken before and after measurement of BMR. Expired air was collected for 10 min according to the standard procedure using the Douglas bag. The oxygen concentration in the expired air in the bag was measured using the Servomax Oxygen analyser. The volume of gas in the bag was measured using a gas volume meter. Room temperature was also recorded and the oxygen uptake corrected for standard temperature and pressure. If duplicate values did not agree within ±5%, a third measurement was taken; otherwise, the measurement was repeated the next day. BMR was measured every month for 6 months. BMR was also measured in 13 non-pregnant, non-lactating controls matched for body weight from the laboratory staff.

Breast-milk output in the subjects was measured by test-feeding technique where the milk volume output is equated to the milk ingested by the infant. A Sartorious electronic balance programmed for 100 serial readings and stabilized for the baby's movements was used for recording the infant's weight before and after every feeding. Plastic nappies were used during the feeds to prevent any losses through urine. Initially 24-h milk volume was obtained for 3 consecutive days; thereafter, depending on the patients' compliance, milk volume was obtained for 24 or 48 h. Milk volume was measured every month for 6 months. The energy lost through milk and the energy cost of milk production were calculated assuming 80% efficiency of conversion from dietary energy to milk energy.

The physical activity of the subjects was recorded every 15 min from 7.00 a.m. to 6.30 p.m. The time spent in different activities from 6.30 p.m. until the subjects went to bed was recorded next morning by the recall method. Physical activity was thus measured for 7 consecutive days each, every month for 6 months. The energy costs of different activities were calculated using the modified Bouchard tables (Sathyanarayana *et al.*, 1988; Bouchard *et al.*, 1983) after correcting for body weight.

Dietary intakes were measured at home by oral questionnaire method using volumetric cups. While intakes at breakfast, lunch and tea were recorded the same day, intake during dinner was recorded the next day by the recall method. Energy intakes were calculated from the raw amount equivalent, using the nutritive value of Indian foods (Gopalan *et al.*, 1989). Dietary intake was obtained for 7 consecutive days during each month for 6 months. Maternal body weights were recorded every month.

Results and discussion

The physical characteristics of the study population are given in Table 1. Only those women who consented to attend regularly for follow-up to 8 months were enrolled for the study.

Table 1. Physical characteristics

Group	*Height (cm)*	*Weight (kg)*	*BMI (kg/m²)*	*BMR (MJ(kcal))*	
				24 h	*kg body wt.*
Non-pregnant non-lactating (13)	157.5 ± 8.16	44.92 ± 6.72	18.1	3.90 (924)	0.086 (20.5)
Lactating (8)	153.4 ± 5.68	44.84 ± 7.22	19.0	3.72 (888)	0.083 (19.8)

Values are mean ± SD.

Mean values for energy input and output parameters are given in Table 2. Basal metabolic rate during 1–6 months of lactation first decreased and again increased, showing a U-shaped curve and ranged between 3.19 and 4.18 MJ/24 h (762 and 999 kcal/24 h). This observation is similar to that reported in Gambia (Prentice & Prentice, 1988). The mean BMR over the 6 months was 3.72 MJ/24 h (888 kcal/24 h), this being lower than the earlier reported values (Dakshayani & Ramana Murthy, 1964).

The milk volume ingested by the infants is given in Table 3. For the first 3 days the mean volume of milk ingested daily by the infants was only 241 ml. Thereafter it ranged between 623 ml and 776 ml. All the women put the baby to breast within 24 h after delivery. All the infants were exclusively breast-fed up to 4 months. Two infants received small but insignificant amounts of supplements after 4 months. The milk outputs recorded in the present study are higher than those earlier reported (Gopalan, 1958; Belavady, 1979) by 140–200 ml/day. The energy expended in milk ranged between 0.67 and 2.03 MJ/24 h (157 to 486 kcal/24 h). The energy loss through milk

Table 2. Energy balance over six months of lactation

Subject	*Energy intake*[a]	*Energy expenditure*[a]	*Body weight (kg)*	*Balance*
1.	9.44 (2255 ± 234.4)	10.69 (2555 ± 176.5)	−4.1	−
2.	8.56 (2046 ± 332.0)	10.78 (2577 ± 379.0)	−2.5	−
3.	9.70 (2330 ± 252.0)	9.12 (2179 ± 104.6)	+2.6	+
4.	9.67 (2313 ± 405.5)	9.02 (2156 ± 284.0)	+2.3	+
5.	11.2 (2680 ± 314.4)	9.26 (2213 ± 258.3)	−0.7	−
6.	5.52 (2037 ± 170.0)	9.16 (2189 ± 250.0)	−0.2	±
7.[b]	7.13 (1704 ± 58.2)	7.63 (1825 ± 122.3)	−3.9	−
8.	7.54 (1802 ± 704.9)	8.94 (2137 ± 377.7)	−2.5	−

[a] Units: MJ/24 h (kcal/24 h ± SD).
[b] Patient unwell at times.

Table 3. Milk intakes in infants (g/24 h)

Subject	*Initial*	*Months of lactation*					
		1	*2*	*3*	*4*	*5*	*6*
1.	315	771	655	574	531	480	468
2.	123	679	1052	892	686	1035	825
3.	–	622	735	557	466	665	589
4.	74	577	654	724	760	786	707
5.	635	789	891	–	867	812	943
6.	191	–	610	695	695	607	518
7.	218	–	433	297	503	–	–
8.	132	563	594	–	–	–	–
Mean ± SD	241 ± 190.7	667 ± 96.7	703 ± 191.4	623 ± 200.4	644 ± 148.3	731 ± 192.3	675 ± 184.5

Table 4. Energy expenditure in lactating women[a]

Parameter	*Initial*	*Duration of lactation (months)*						
		1	*2*	*3*	*4*	*5*	*6*	*Mean*
BMR	3.89 (929 ± 218.6)	4.01 (959 ± 129.1)	3.2 (762 ± 190.99)	3.47 (830 ± 83.0)	3.43 (820 ± 129.7)	4.2 (999 ± 231.8)	3.8 (917 ± 85.4)	3.7 (888) –
Energy spent in physical activity + rest	6.6 (1590 ± 235.6)	7.2 (1717 ± 235.6)	7.6 (1829 ± 264.6)	7.4 (1776 ± 201.0)	7.5 (1790 ± 201.5)	7.9 (1896 ± 215.2)	7.8 (1876 ± 227.4)	7.4 (1775) –
Energy drawn[b] for production of milk	0.82 (195 ± 154.5)	2.3 (559 ± 74.6)	2.3 (568 ± 158.1)	2.1 (501 ± 161.1)	2.1 (518 ± 112.4)	2.5 (593 ± 181.8)	2.3 (552 ± 137.1)	2.3 (549 –
Total energy expenditure	7.5 (1785)	9.5 (2276)	10.0 (2397)	9.5 (2277)	9.6 (2308)	10.4 (2489)	10.2 (2428)	9.5 (2277)

[a] Units: MJ/24 h (kcal/24 h ± SD).
[b] Energy lost in milk + 80% efficiency of conversion from dietary energy to milk energy.

(at 0.27 MJ/100 ml or 65 kcal/100 ml) and the energy cost of conversion of dietary energy to milk energy (assuming 80% efficiency) ranged between 0.82 and 2.48 MJ (195 and 593 kcal) during the 6 months of lactation. The energy intakes in lactating women ranged between 8.87 and 11.99 MJ/24 h (2121 and 2865 kcal) except during the fifth month.

Energy expenditure in daily activities ranged between 6.65 MJ/24 h (1590 kcal) in the initial month to 7.93 MJ/24 h (1896 kcal) during the fifth month of lactation (Table 4). The % time distribution for different categories of activity (Table 5) shows that in the initial month 52.2% of the time was spent on activity 1, i.e. sleeping, resting in bed, lying still but awake etc. By the sixth month this was reduced to 39% of the time. These women did not spend any time on high-energy-cost activity. In the initial month of lactation 88.7% of the time was spent on low-energy-cost activities. By the sixth month 79.5% of time was spent on such activities. With increased duration of lactation there was a gradual shift from category 1, i.e. sleeping/lying still but awake, to category 2. Activities grouped in category 3 pertaining to personal up-keep and household chores remained unchanged from the initial to the sixth month. Thus the subjects spent 80% of their daily time in activities involving low energy expenditure. The daily energy expenditure in terms of BMR units ranged from 1.9 to 2.25, corresponding to moderate activity.

The total energy expenditure in lactating women, i.e. energy cost of physical activity and energy cost of milk production, ranged between 7.47 and 10.41 MJ/24 h (1785 and

Table 5. Time and % time spent in different activities during 24 h by lactating women

Category	*Typical activity*	*Energy cost (kcal/kg/h)*	*Initial month (min)*	*% Time*	*3rd month (min)*	*% Time*	*6th month (min)*	*% Time*
1.	Sleeping, resting in bed	(0.94)	751	52.2	647	44.9	566	39.3
2.	Sitting/eating etc.	(1.52)	240	16.6	254	17.6	293	20.3
3.	Walking, dressing etc.	(2.28)	285	19.8	318	22.1	283	19.7
4.	Light activity	(2.76)	23	1.6	43	3.0	66	4.6
5.	Light manual work	(3.36)	38	2.6	92	6.3	117	8.1
6.	Moderate activity, household work, etc.	(4.80)	–	–	16	1.1	22	1.5
BF.	Breast-feeding	(2.28)	103	7.1	70	4.9	93	6.3

2489 kcal) (Table 4). The mean energy expenditure over 6 months was 9.53 MJ/24 h (2280 kcal) and the mean energy intake over 6 months was 9.53 MJ/24 h (2280 kcal). Over 6 months the mean energy deficit was 0.46 MJ/month (111 kcal/month), a figure well within the errors of estimation of either intake or expenditure. Since energy balance occurs over a period of time and should be reflected in gross terms on body weights of the mothers, we looked at the body weights of the mothers. Mean body weights of the mother at the end of 6 months are similar to those observed in the initial month of lactation. However, individuals who were heavier lost weight and those who had lower body weights either maintained or lost ±1–2 kg body weight.

The results of the present study and an earlier study (Prema *et al.*, 1982) suggest that lactating women do household work, look after their children and apparently only lose 1–2 kg body weight during a period of up to 18 months of lactation. It would be tempting and too simplistic to hypothesize that adaptive mechanisms are in use. But, when viewed in conjunction with energy expenditure, it would appear quite the contrary. These women live in single-room tenements, the up-keep of which does not take much more than 15–20 min/day. Cooking is done once a day with a cereal dish and another side-dish, either a curry or lentil soup. It is therefore not surprising that household work and other light work put together accounts for no more than 139 min. These women thus spent 80% of their time engaged in activities involving low energy expenditures. The daily energy expenditure in terms of BMR units ranged from 1.7 to 2.25 (average 2.12), which corresponds to moderate activity groups.

Energy intakes of these women appear to be similar to those of the non-pregnant, non-lactating women (Rao, Sastry & Rao, 1987). However, we do not have data on the same women during their non-pregnant, non-lactating state, making it difficult to conclude whether or not there has been an increase in intakes during lactation *per se*.

These women appear to have achieved energy balance by (a) a modest but non-significant loss in body weight and (b) indulging in low-energy-cost activities. It is interesting to note that when energy spent in physical activity and milk volume peaks, BMR shows a fall. It is worthwhile to study in depth whether this has a cause and effect relationship, especially in the light of the fact that even cross-sectional studies suggest this (Dakshayani & Ramana Murthy, 1964).

Conclusions

The energy intakes of these lactating women are similar to the energy intakes observed in non-pregnant, non-lactating women (Rao *et al.*, 1987). The energy intakes and expenditure are in balance for this group of women. This is reflected by a meagre loss in body weight at the end of 6 months. The energy cost of lactation is 2.3 MJ/day (549 kcal), a figure close to the RDA recommended by ICMR (1989) and FAO/WHO/UNU (1985). This study emphasizes the need to compute both energy intake and energy expenditure over a long period in different environmental situations and known occupational groups to obtain reliable data on energy balance.

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