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Energy expenditures and food intakes of lactating women in Guatemala[1, 2]

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ABSTRACT Total energy expenditures and intakes were simultaneously assessed in 18 free-ranging lactating women (10 months postpartum) and compared to six similarly-sized, nonlactating, nonpregnant but multiparous women living in the same rural villages in the Guatemalan highlands. Energy intakes were estimated by the 24-hr recall method for each of 4 consecutive days. Energy expenditures were determined for 2 days by monitoring heart rate throughout the day and relating heart rate to oxygen consumption by individually-determined regression lines. The mean energy intake for the 4 consecutive days was estimated to be 1929 ± 360 kcal/day (39.2 kcal/kg per day) for the lactating group; and 1876 ± 404 kcal/day (38.3 kcal/kg per day) for the nonlactating group. The 2-day mean energy expenditures were estimated to be 2007 ± 292 kcal/day for the lactating women (41.8 kcal/kg per day) and 1966 ± 382 kcal/day for the nonlactating women (40.1 kcal/kg per day). The way of life of both groups was judged "moderately active" by 1973 FAO/WHO classifications. Most of the lactating women had been losing weight progressively during the past 6 months. Over the 10-week period prior to our measurements, the mean weight loss was more than 10 times greater in the lactating group (−369 g/month) ($P < 0.01$) than in the nonlactating group (−35 g/month) (ns). The high correlation ($r = 0.87$) between weight loss and the reduction in the sum of the three skinfolds suggested adipose tissue loss. There were no significant differences between the two groups in terms of daily energy intake, daily energy expenditure, the energy cost of specific activities, or the pattern of activities throughout the day. The slope of the heart rate/oxygen consumption regressions suggest adequate cardiorespiratory fitness. This study suggests that the energy cost of lactation was met to a greater extent by fat loss than by either increased energy intake, reduced energy expenditure, or both. *Am. J. Clin. Nutr.* 33: 892–902, 1980.

Previous dietary surveys in the same rural highland villages in Guatemala have repeatedly reported low energy intakes throughout pregnancy and lactation (1) when compared to the 1973 recommended dietary standards of FAO/WHO (2) as adapted for the Guatemalan population (3).

The purpose of this study was to estimate total energy intakes and expenditures, the energy cost of activities and the cardiorespiratory fitness of lactating women; and to compare this group with similarly sized, nonpregnant, nonlactating women living in the same villages.

Methods

Description of the population

This study took place in three Ladino[6] villages in the rural highlands of eastern Guatemala. These villages were participating in a longitudinal study of the effects of chronic malnutrition upon physical growth and mental development (4). The experimental design and data col-

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[6] Mestizos or Indians who have adopted Western customs and culture.

lection plan of the longitudinal study has been described recently (5). As a part of that study, all villagers may benefit from preventative and curative medical care offered gratuitously. In addition, one of two types of food supplements were made available gratuitously twice daily in the local health unit of each village. "Atole", a gruel prepared from milk and vegetable mixtures provided 6.0 g protein and 90 kcal/100 ml, "fresco" a sweetened, artificially flavored drink contained no protein and only a third of the caloric concentration of "atole" (33 kcal/100 ml). Both preparations contained similar concentrations of supplemental vitamins and minerals. Participation in the medical care and food supplementation programs was voluntary.

Before the longitudinal study began, about 15% of the newborn died within the 1st year of life. Chronic protein-calorie malnutrition and infectious diseases were endemic. Children were severely retarded in physical growth (9).

At the time these data were gathered, the median family income of the three villages was about $200 per year. The typical houses were built either of adobe or cane husks and palm leaves. The houses had neither sanitary facilities nor electricity. Drinking water was obtained from wells or rivers near the villages. The incidence of maternal illness during pregnancy (6), particularly the prevalence of intrauterine infection (7) was high in these populations compared with developed countries. Most of the mothers were illiterate. Their mean weight gain during gestation was about 7 kg. The median number of deliveries was four, ranging from 0 to 13 (8). The mean birthweight was 3.0 kg but a third of the children with a gestational age of 37 to 44 weeks weighed 2.5 kg or less. Infants were usually breast-fed and nursing may last 24 months. The mean length of lactation was 17 months (10). The diet staples are corn and black beans.

Our study was carried out in October and November 1975 in three highland villages of the same altitude (mean altitude = 1000 m). The mean daylight temperature was 22 C and mean barometric pressure was 686 mm Hg.

Subjects

The criteria for the selection of lactating women were: *1*) a current lactation of more than 6 months; *2*) an age range of 18 to 38 years; *3*) residence within less than 1 km of the field unit; and *4*) willingness to participate. The selection criteria resulted in a reduction of the potential sample of about half. Eighteen women were included in the lactating group. In addition, six nonpregnant, nonlactating, but multiparous women were selected as a control group. Medical examinations were then conducted to screen out those subjects whose health conditions might affect dietary intakes or energy expenditures. One subject was replaced on this basis. The public health nurse explained to each subject the objectives of the study and the various procedures to be involved. All of the subjects selected were willing to participate in the study as unpaid volunteers and gave their informed consent. All women who started the study completed it. All of the women were living at home, and not working outside of family endeavors.

Energy intake

Energy intakes were assessed using the 24-hr diet recall method. Even though this is not generally considered a quantitative procedure, in this population the subjects were well acquainted with the method because 24-hr diet recalls had been carried out with them several times a year over the previous 7 years (1). We minimized interaction between the interviewer and subject by using the same dietetic personnel who usually carried out the surveys with these same women.

A dietary interviewer visited the mother in her home and asked her to report all the kinds of foods she had consumed during the previous day and to estimate the amounts of food she had ingested using local household measurements (cups, bowls, spoons of different sizes). The dietary interviews required about 10 to 15 min per subject and were repeated on 4 consecutive days by the same interviewer. Calculations of total energy intake were obtained from INCAP food composition tables (11). The particular dietary survey methodology has been described previously (12).

Energy expenditure

The technique we used to measure energy expenditure is based on monitoring heart rate continuously throughout the day. Then heart rate was related to oxygen consumption by means of individually-determined regression lines between heart-rate and oxygen consumption. The regression lines were prepared from six levels of activity that bracketed the expected range of heart rate for these individuals. Knowing the average heart rate over a period of time, the corresponding oxygen consumption was obtained directly from the regression line. Oxygen consumption was then transformed to energy expenditure by means of the Weir formula which sets the mean energy equivalent of oxygen at 4.92 kcal/liter oxygen consumed (13). Bradfield has described this technique in detail previously (14).

Daily heart rate monitoring

Two types of instruments were used to count heart beats daily. The digital Biocom EKG Totalizer (Model 6704; Model Digital Heartbeat Accumulator, BIOCOM, Inc. Transmed Scientific, San Luis Obispo, Calif.) and the SAMI (Socially Acceptable Monitoring Instrument; One-way SAMI, TEM Sales Ltd., Gatwick Road, Crawley, Sussex, England) (14). We read the instruments hourly so that we could obtain estimates of the energy cost of work patterns during the day.

Establishment of the individual relationship between heart rate and oxygen consumption

A regression line was established for each individual by taking simultaneous measurements of heart rate and oxygen consumption over six different levels of activity.

Changes in heart rate and oxygen consumption were achieved by having the subjects carry out activities that comprised a significant portion of their daily life. The activities measured included sitting down at rest, walking at a slow pace, grinding corn by hand in the same manner and rate as normally done for the preparation of tortillas, and patting out tortillas from corn flour by hand while standing. In addition, a higher activity point was achieved by a step-test using a 20-cm block of wood and a frequency of 28 to 30 steps per minute. Bradfield has recommended that standing-still and sitting-still values not be included in regressions due to the pooling of blood in the extremities which result in increased heart rates relative to oxygen consumption (14). However, in this study we included sitting values because we believed that the movements associated with nursing practices minimized blood pooling.

For each of these activities, heart rate was measured after a "steady state" had been maintained for 1½ to 2 min. Heart rate was measured using telemetry techniques (Biocom FM Transmitter; Model Digital Heartbeat Accumulator, BIOCOM, Inc. Transmed Scientific, San Luis Obispo, Calif.). The heartbeat signals were received on a transistor radio and recorded on a battery operated tape recorder. The heart rate was counted with a stop watch and then verified with the tape recording. Two- to 3-minute samples of expired air were collected in a Darex Meteorological Balloon after steady state of heart rate had been obtained (14). After mixing the contents of the bag, 300-ml samples were taken with a syringe and immediately analyzed for oxygen by means of a Teledyne Oxygen Analyzer (Model 320B, Teledyne Analytical Instruments, San Gabriel, Calif.). The Teledyne was calibrated against ventilated room air before each measurement and was stabilized for at least ½ hr. A Wright Anemometer (Physiological Model, British Oxygen Company, Ltd., Spencer House, St. James' Place, London, SW1, England) was used to measure gas volume. It was calibrated several times before the outset of the study using a 100 l Tissot at the air flow used (20 liter/min). There was a mean discrepancy of ± 0.5% between the 100-liter Tissot readings and the Wright readings at a constant flow of 0.5 l/sec. Correction factors were applied. Gas volumes were corrected to standard temperature and pressure (STPD). Calorie values were determined from oxygen consumption using the Weir formula (13). Ambient temperatures were similar on all test days.

Calculation of total daily energy expenditure

Energy expenditures for periods of time were obtained by using the mean hourly heart rate for the corresponding period and referring to the individual's regression line for the oxygen consumption corresponding to that heart rate (14). The total oxygen uptake during waking hours was obtained by summing the oxygen consumed during each 1-hr period. As suggested by Durnin and Passmore (15), the oxygen consumption during sleeping hours was assumed to be equal to that determined under standardized resting conditions. The resting metabolic rate was determined 12 hr after the last meal in a well-ventilated dark-room between 6:00 and 7:00 AM after the subjects had been resting in a supine position for about 20 min. Duplicate respiratory collections of 5 min each were made and the lowest value was used for the calculations. The subjects were already accustomed to the use of nose clamps and mouth pieces. Tests were not initiated until the resting heart rates had stabilized for more than five minutes. The resting metabolic rate was calculated from the oxygen uptake assuming an energy equivalent of 4.8 kcal/liter oxygen consumption as suggested by Durnin and Passmore (15).

Anthropometry

Body weight was routinely measured to the nearest 10 g twice weekly at the health center using a clinical scale (Health-O-Meter, Continental Balance, Oakland, Calif.) checked regularly for accuracy with standard weights. Clothing was weighed separately and subtracted. Triceps, subscapular, and upper thigh skinfold thicknesses were measured using a Lange caliper.

Results

Characteristics of the sample population

The mean age, weight, height, percentage weight/height (16) skinfold thickness, hemoglobin, hematocrit, time postpartum, resting heart rate, resting respiratory volume (VE), and resting oxygen consumption (VO_2) for the two groups are shown in Table 1.

Longitudinal observations in these villages placed the median birth interval at 24 months, and the median duration of lactation at 17 months (10). This suggests that most young women who were not pregnant were likely to be lactating. Our sample of nonlactating women were on the average 26 months postpartum.

The mean duration of lactation in the lactating group was 10 months (median 9 months) with a range between 6 to 18 months. When compared to the median duration of lactation (17 months), the lactating group would be placed in the middle of the expected length of the lactation period. On the average the lactating women reported that they nursed their children six times daily with a range of two to 10 times.

Energy intakes

Individual dietary intake data are given in Table 2. The 4-day mean energy intakes were

TABLE 1.
Sample characteristics

Characteristics	Lactating (n = 18)	Nonlactating (n = 6)
Age (yr)	28 ± 5[a]	23 ± 3
Weight (kg)	49.2 ± 9	49.0 ± 6
Height (cm)	149 ± 6	152 ± 4
Surface area (m^2)	1.41 ± 0.13	1.43 ± 0.10
Wt/ht (%)	98	95
Triceps skinfold (mm)	9 ± 0.4	7 ± 0.7
Subscapular skinfold (mm)	13 ± 0.6	10 ± 0.2
Thigh skinfold (mm)	14 ± 0.4	12 ± 0.2
Hemoglobin (g/100 g)	13.3 ± 1	13.7 ± 1
Hematocrit (%)	39 ± 3	39 ± 3
Time postpartum (mo)	10 ± 3	26 ± 23
Number of living children	4 ± 2	3 ± 1
Resting heart-rate (beats/min)	69 ± 8	71 ± 10
VE (l (STPD)/min)	3.99 ± 0.72	3.72 ± 0.62
VO_2 (ml (STPD)/min)	158 ± 20	152 ± 26
Resting metabolic rate		
kcal/min)	0.76 ± 0.10	0.73 ± 0.13
(kcal/m^2·hr)	32.5 ± 2.6	30.7 ± 3.7

[a] Mean ± SD.

TABLE 2
Individual energy intakes, expenditures, and resting metabolic rates

Subject	Total energy intake				Intake		Resting metabolic rate	Total energy expenditure		Expenditure	Total energy expenditure
	1st Day	2nd Day	3rd Day	4th Day	4 Days	2 Days[a]		2nd Day	4th Day	2 Days	
	kcal/24 hr				*X̄ ± SD*			*kcal/24 hr*		*X̄ ± SD*	*kg body wt*
Lactating											
1		(3339)	2112	2050	2081 ± 44	2050	1116	2388	1786	2087 ± 426	48.6
3	1750	1441	1392	1574	1539 ± 160	1508 ± 94	(1477)[b]	(2422)[b]	(2645)[b]	(2533 ± 158)[b]	(45.7)[b]
4	1597	1737	2251	1985	1893 ± 288	1861 ± 175	1336	2082	2280	2181 ± 140	28.1
5		1316	1836	715	1289 ± 561	1016 ± 425	1027	2186	1511	1848 ± 477	43.4
6	1421	2473	2184	1757	1959 ± 464	2115 ± 506	999	1847	2088	1967 ± 170	42.9
8	1850	1950	3475	1958	2308 ± 779	1954 ± 6	998	1950	1698	1824 ± 178	37.8
9	2731	2138	2476	2184	2382 ± 277	2161 ± 33	1224	2196	2151	2174 ± 32	47.3
10	2056	2940	2632	2292	2480 ± 387	2616 ± 458	1130	1559	1800	1679 ± 170	36.3
11		1523	1653	1190	1455 ± 239	1357 ± 235	860	1434	1425	1429 ± 6	39.5
12	1534	1661	1732	1567	1624 ± 90	1614 ± 66	799	1522	1813	1667 ± 206	40.4
13	2826	1190	2680	3056	2438 ± 846	2123 ± 1319	1067	2100	2190	2148 ± 69	48.9
16		961	1691	2368	1673 ± 704	1665 ± 995	1165	2288	2704	2496 ± 294	49.7
18	2120	1968	2389	2421	2225 ± 218	2195 ± 320	1207	1674	1910	1792 ± 167	30.4
19	2038	2134	2132	1671	1994 ± 220	1903 ± 327	1246	2448	1953	2200 ± 350	43.8
20	1629	2635	2476	1689	2107 ± 522	2162 ± 669	1130	2560	2045	2303 ± 366	43.2
21	1780	1713	1509	1546	1637 ± 130	1630 ± 118	1024	1937	2249	2093 ± 221	46.4
22	2450	2406	1573	1656	2021 ± 471	2031 ± 530	1051	1937	1632	1784 ± 216	38.4
23	1130	1480	1363	2462	1609 ± 587	1971 ± 694	1218	2448	2450	2449 ± 1	44.8
X̄ ± SD	1922 ± 488	1945 ± 629	2086 ± 550	1897 ± 534	1929 ± 360	1885 ± 369	1094 ± 138	2033 ± 345	1981 ± 338	2007 ± 292	41.8 ± 6.2
Nonlactating											
2	1434	1300	2200	1686	1655 ± 397	1493 ± 273	897	1650	1467	1558 ± 129	32.4
7	1337	1516	1584	1567	1501 ± 113	1542 ± 36	863	1496	1725	1610 ± 162	34.8
14	1736	1913	1489	1771	1727 ± 176	1842 ± 100	1300	2699	2415	2557 ± 201	42.5
15	980	1912	1674	2154	1680 ± 506	2033 ± 171	1014	1697	1897	1797 ± 141	40.8
17	3198	2667	1788	2729	2596 ± 588	2698 ± 44	1004	1818	2405	2111 ± 415	48.4
24											
24	1780	2023	2305	2268	2094 ± 244	2145 ± 173	1261		2164	2164	41.9
X̄ ± SD	1744 ± 769	1888 ± 471	1840 ± 336	2029 ± 438	1876 ± 404	1959 ± 445	1057 ± 184	1872 ± 476	2012 ± 383	1966 ± 382	40.1 ± 5.8

[a] Mean of the same 2 days energy expenditure was measured (2nd and 4th). [b] Data not included in mean due to hyperventilation during resting metabolic rate measurement.

1929 ± 360 and 1876 ± 404 kcal/day for the lactating and nonlactating groups, respectively. There were no significant differences between the 4- and 2-day means of energy intake for either group. The mean total protein intake was 47.6 g/day for the lactating group and 40.2 g/day for the nonlactating group, representing 10 and 9%, respectively, of the calories derived from protein. The mean supplement intake for the 4 days was 280 ± 190 kcal/day for the lactating group and 256 ± 185 kcal/day for the nonlactating group. There was no significant relationship between the total home diet intake and supplement consumed ($r = 0.01$ NS), nor was there a significant relationship between supplement intake and weight change ($r = 0.22$ NS), or between total energy intake and weight change ($r = 0.32$ NS).

Energy expenditure

The mean 24-hr resting metabolic rate was 1094 ± 138 kcal in the lactating group and 1057 ± 184 kcal in the nonlactating group (Table 2). The mean CV of duplicate samples was 4.1% (range <1 to 12%) for lactating and 3.7% (range <1 to 8%) for the nonlactating groups. The mean total energy expenditure for the 2-day period was estimated to be 2007 ± 292 and 1966 ± 383 kcal/day respectively, for the lactating and nonlactating groups. Expressed in relation to body weight, the mean total energy expenditure was 41.8 ± 6.2 kcal/kg per day for the lactating group and 40.1 ± 5.8 kcal/kg per day for the nonlactating group. When the total energy expenditure was expressed in multiples of resting metabolic rates (METs), the values were 1.84 ± 0.15 METs (range 1.40 to 2.14) and 1.8 ± 0.19 METs (range 1.72 to 2.10) for the lactating and nonlactating groups, respectively.

There were no significant differences in energy expenditure between the lactating and nonlactating groups expressed either in absolute terms, or when normalized for body weight or resting metabolic rate (METs). Neither were there significant correlations between energy intake and energy expenditure for the 2 days ($r = 0.25$ NS), nor between mother's age and total daily energy expenditure for either group.

We made a qualitative assessment of types of activities for 48 subject-days on the basis of hourly interviews during the day. The principal activities were sitting (nursing, talking to friends) and walking about the village (with and without the child), walking to the village grocery store, gathering fire wood and water. In the home, food preparation occupied considerable time with activities such as grinding corn by hand on a stone slab. The subjects also spent time in activities such as washing clothes in the central fountain or in the river, cleaning the house, looking after children, and various miscellaneous household duties.

Table 3 lists the energy cost and heart rate of different typical activities. No significant differences were found between the two groups for any of the specific activities listed in Table 3. The differences were even less when the results were normalized for body weight or resting oxygen consumption rate (METs).

When we plotted energy expenditures against time we found that the peak energy

TABLE 3
Energy cost and heart rate of different activities

Activities	Lactating		Nonlactating	
	Heart rate	Energy cost	Heart rate	Energy cost
	beats/min	*kcal/min*	*beats/min*	*kcal/min*
Nonstandardized				
1. Sitting (at rest)	82 ± 8	1.04 ± 0.14	85 ± 9	1.02 ± 0.24
2. Walking (usual pace)	87 ± 10	1.70 ± 0.30	89 ± 11	1.64 ± 0.32
3. Patting out tortillas (standing up)	92 ± 9	1.59 ± 0.24	96 ± 11	1.56 ± 0.25
4. Grinding corn by hand on stone slab (standing up)	99 ± 10	2.29 ± 0.35	102 ± 9	2.37 ± 0.43
Standardized				
1. Step test[a]	98 ± 9	2.57 ± 0.40	101 ± 12	2.54 ± 0.38

[a] Height of bench = 20 cm; frequency = 28 to 30/min.

expenditure was at midday. The trends of the two groups were similar throughout the day, varying between 2 and 3 METs (Fig. 1).

Heart rate versus oxygen consumption relationships

The regression lines for each individual, calculated both by oxygen consumption/minute and oxygen consumption/kilogram body weight/minute are shown in Table 4. There were no significant differences in either slope or intercept of the regression lines between the two groups. Results have been calculated for the "typical individual" of the group (mean slope, mean intercept). For the lactating group, the typical individual equation predicting oxygen consumption from heart rate was $\dot{V}O_2$ (ml/min) = −692 + 11.80 × (heart rate) whereas in the nonlactating group it was $\dot{V}O_2$ (ml/min) = −811 + 12.44 × (heart rate). The mean coefficient of variation of the regression line was 18% for the lactating group and 20% in the nonlactating women. If the typical individual of the group was assessed based on the median (instead of the mean) the equations relating heart rate to oxygen consumption were found to be almost identical: $\dot{V}O_2$ = −645 + 11.60 × (heart rate) for the lactating group and $\dot{V}O_2$ = −686 + 11.64 × (heart rate) for the non-lactating group.

For the typical *individual* the close association between heart rate and $\dot{V}O_2$ may be seen by the high correlation coefficient found (mean individual $r = 0.91$ ($P < 0.01$) in the lactating group and mean $r = 0.90$ ($P < 0.01$) in the nonlactating group (with a range of 0.80 to 0.98 and 0.86 to 0.99, respectively).

Because there were no significant differences between the group regression lines, we combined the data from the two groups and carried out a multiple regression analysis. We found that for this sample (n = 24) there was a *group* correlation of $r = 0.71$ between heart rate and oxygen consumption. When additional descriptive variables of the samples were introduced stepwise to normalize the population, the group correlation coefficient increased to 0.75. The only significant descriptive variable was weight.

Weight and skinfold thickness changes

We plotted the individual weight changes over the 28 weeks prior to the study, and then calculated 3 to 4 point regression lines of weight-on-time. The average weight gain or loss for each individual was computed from the slope. To determine whether the weight change was primarily due to body fat change, and not to changes in water balance, we also computed the change in the sum of the three skinfold thicknesses over the same period. We found a significant correlation between the two variables (r - 0.870; $P < 0.01$).

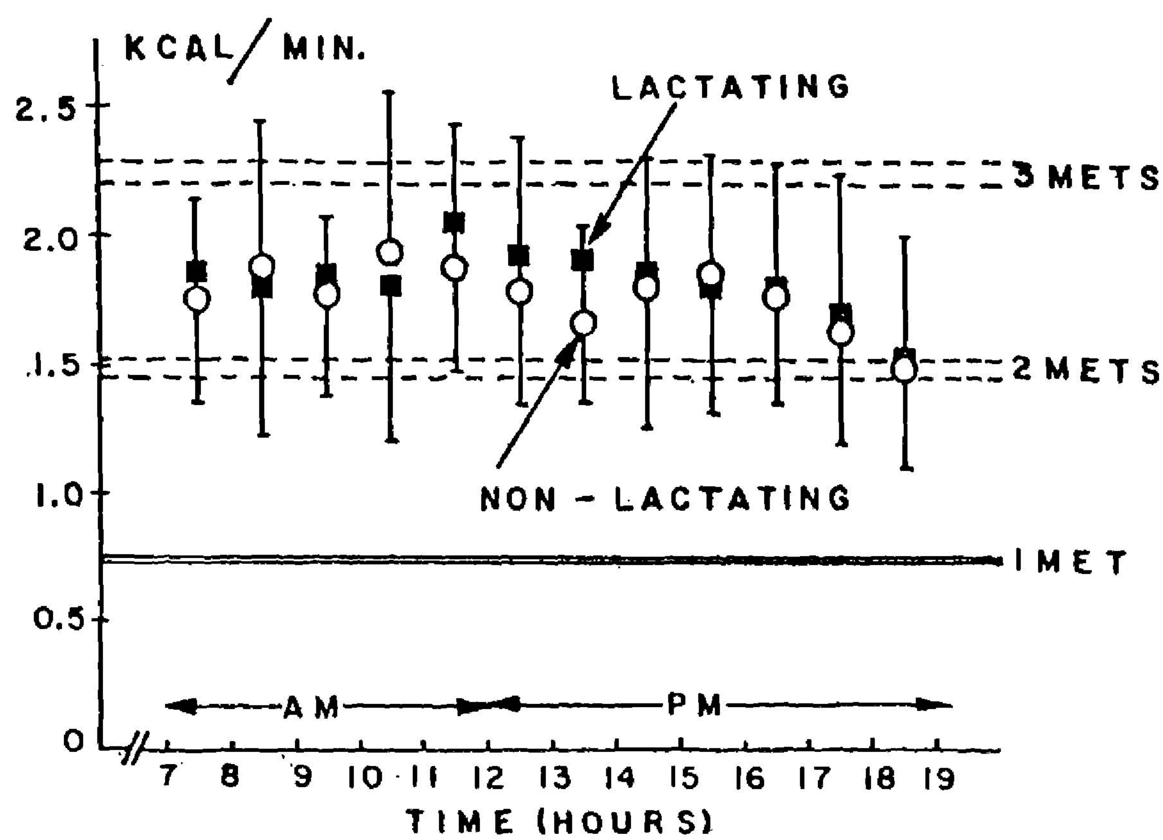

FIG. 1. Comparative trends in energy expenditure during the day.

TABLE 4
Linear regression characteristics

Subject	Age	Height	Weight	Weight change	Σ skinfold	Hb	Ht	Time post-partum	$\dot{V}O_2$ (ml STPD/min) vs HR[a]					$\dot{V}O_2$ (ml STPD/min/kg) vs HR[a]				
									Slope	Intercept	*r*	Syx	CV	Slope	Intercept	*r*	Syx	CV
	yr	*cm*	*kg*	*kg/wk*	*mm*	*g/100 ml*	*%*	*mo*					*%*					*%*
Lactating																		
1	27	154.5	42.9	−0.147	25.1	11.4	35	9	9.27	−482	0.939	51	16	0.216	−11.23	0.939	1.19	16
3	23	155.0	55.4	−0.257	32.2	15.3	44	13	18.83	−1267	0.970	48	11	0.340	−22.86	0.970	0.87	11
4	30	146.6	77.5	−0.043	80.4	13.9	42	7	12.66	−586	0.929	76	17	0.163	−7.57	0.929	0.98	17
5	34	145.7	42.6	−0.231	30.0	12.7	37	8	12.54	−760	0.959	49	15	0.294	−17.80	0.959	1.15	15
6	38	145.9	45.8	−0.033	42.4	12.1	36	13	12.29	−762	0.811	75	27	0.269	−16.65	0.811	1.64	27
8	29	152.7	48.2	−0.038	32.2	12.0	35	13	10.64	−656	0.881	76	24	0.221	−13.61	0.881	1.58	24
9	23	149.3	46.0	−0.125	28.8	14.6	43	11	9.66	−484	0.856	80	22	0.210	−10.54	0.856	1.74	22
10	20	147.4	46.2	−0.029	38.7	14.7	41	10	8.36	−604	0.797	87	27	0.181	−13.08	0.797	1.88	27
11	24	136.4	36.2	−0.240	24.5	12.3	35	18	5.93	−229	0.900	50	18	0.164	−6.33	0.900	1.38	18
12	22	144.5	41.3	+0.046	25.7	15.0	42	8	15.42	−1054	0.953	40	14	0.374	−25.53	0.953	0.97	14
13	22	141.6	43.9	−0.011	25.3	14.6	43	9	12.73	−634	0.962	42	13	0.290	−14.45	0.962	0.96	13
16	29	155.5	50.2	−0.054	23.0	11.8	38	15	15.34	−996	0.867	76	23	0.305	−19.82	0.867	1.51	23
18	31	160.1	59.0	+0.150	45.0	14.5	44	10	11.41	−737	0.940	65	17	0.194	−12.51	0.940	1.10	17
19	34	152.5	50.2	−0.314	32.2	13.6	40	8	11.66	−595	0.939	58	15	0.232	−11.85	0.939	1.15	15
20	29	154.0	53.3	+0.027	46.5	13.4	41	9	9.98	−560	0.925	63	17	0.187	−10.57	0.925	1.18	17
21	35	141.6	45.1	+0.025	45.4	13.2	38	8	12.78	−723	0.981	29	9	0.283	−16.03	0.981	0.64	9
22	25	147.0	46.4	−0.062	34.3	11.4	35	6	11.26	−759	0.964	43	13	0.243	−16.34	0.964	0.93	13
23	28	152.7	54.7	−0.215	40.9	13.6	40	8	11.55	−569	0.837	83	24	0.211	−10.40	0.837	1.52	24
$\bar{X}$ ± SD	28	149.0	49.2	−0.086	36	13.3	39	10	11.80	−692	±.912	61	18	0.243	−14.28	0.912	1.24	18
	±5	±6	±9		±13	±1	±3	±3	±2.88	±235	0.06	±17		±0.06	±5.0	±0.06	±0.3	
Nonlactating																		
2	25	150.0	48.1	−0.331	32.9	14.3	41	7	7.15	−390	0.883	80	26	0.149	−8.12	0.883	1.66	26
7	24	148.5	46.2	−0.012	27.5	13.0	39	21	7.89	−357	0.857	70	25	0.171	−7.73	0.857	1.52	25
14	25	158.2	60.1	+0.188	28.9	13.0	37	15	22.95	−1722	0.993	24	6	0.390	−29.43	0.993	0.40	6
15	18	153.1	44.0	+0.070	21.6	13.3	38	16	11.97	−699	0.886	65	21	0.272	−15.23	0.886	1.48	21
18	23	148.5	43.6	+0.040	29.1	12.8	36	25	11.30	−672	0.943	51	17	0.259	−15.43	0.943	1.17	17
24	21	153.7	51.7	[b]	33.8	15.5	45	72	13.36	−1024	0.855	92	24	0.259	−19.81	0.855	1.78	24
$\bar{X}$ ± SD	23	152.0	49.0	−0.009	29	13.6	39	26	12.44	−811	0.904	64	20	0.250	−15.96	0.904	1.33	20
	±3	±4	±6		±4	±1	±3	±23	±5.68	±508	±0.05	±24		±0.09	±8.1	±0.05	±0.5	

[a] $\dot{V}O_2$ as y, HR as x. [b] Previous weight not available.

Because some of the nonlactating group had been lactating 6 months previously, we also calculated the weight changes over the previous 10 weeks and used this figure in the calculations of energy "balance". Assuming that the trend in weight loss was linear, the lactating women were losing on the average of 86 g/week (369 g/month) ($P < 0.01$), whereas the nonlactating women were losing 10 times less weight on the average, 8 g/week (35 g/month NS) (see Table 4).

Wilmore and Behnke (17) have proposed an equation to estimate body fat from skinfold thicknesses of the tricep, subscapular area, and upper thigh. Although this formula was derived from a sample of young students of higher stature, and may have limited application to our sample of shorter women of different ethnic background, the calculation is nevertheless of interest. We found the predicted mean body fat estimate was 22% in the lactating group and 20% in the nonlactating group. The differences were not significant.

Discussion

Energy intakes

The energy intakes found in this study were similar to those reported in the same population several years previously (1), and are believed to be representative of the population. It should be stressed that the data reported here represent total energy intake (both the home diet and the supplement intake) in contrast to some previous studies that reported either home diet alone (6) or the supplement alone (5).

The total energy intake of the nonlactating group was judged nearly adequate (1959 kcal/day) when compared to INCAP recommended allowances (2050 kcal/day) (3). This is consistent with the recent stable weight history of these individuals, taken as a group. But when the substantial additional energy demand for normal lactation (2) is considered, the total energy intake of the lactating women (1885 kcal/day) was very low, 67% of the recommended 2600 kcal/day. This is consistent with the weight loss trend over the previous 10 weeks, taken as a group. The lack of a significant difference between energy intakes of lactating and nonlactating, nonpregnant women has been previously reported by Norgan et al. (18) in two New Guinea populations. We confirmed these findings in a different culture of similarly-sized individuals.

Energy expenditure

The resting metabolic rate was lower than the normal values established by Durnin and Passmore (15), being respectively 92% of the standards for the lactating and 84% for the nonlactating women. The difference between the groups was not significant. Nor did we find significant differences in the mean total energy expenditure between the lactating (2007 kcal/day) and nonlactating (1966 kcal/day) women. In this population, reduced voluntary activity had been postulated to explain low dietary intakes (1) but we did not find this to be the case. We did not find that the way of life of the lactating group was consistently and significantly altered because of their physiological state. Apparently the lactating women had to keep up their daily activities despite the fact that they were also carrying about and nursing a child. In fact, both the lactating and nonlactating groups should be classified as "moderately active" by the 1973 FAO/WHO standards (2). When we expressed energy costs of nonstandardized specific activities either in MET or on a body weight basis, the difference between the lactating and nonlactating groups were less than 5%.

The type of activities noted during the course of the day were similar to those described in a sociocultural study 3 years previously in the same villages by Pivaral (19). He described the daily routine of the villages as follows: After getting up (at about 5:30 AM) the woman gets dressed and starts preparing breakfast for the other members of the family. This includes getting the fire wood ready, making coffee, and cooking black beans. After the breakfast is completed (about 7:00 AM) the woman cleans the house. Because the black beans for lunch need to be cooked for several hours, she cleans and places them on the fire at midmorning. In addition, each day she must dehull the corn and grind it by hand on a stone slab in order to prepare tortillas. She also spends a considerable amount of time bringing water from the river (which may be as far as 1 km from the home). The water is carried in a jug on the woman's head. Once a week (or nearly every day if the woman has small children) she washes clothes in the river or (in one village) in a public fountain. This is also an important social occasion for the women. Lunch is eaten between 11:00 and 12:00 and dinner is served between 5:00 and 6:00 PM. When the husband lives at home, the woman takes lunch to him in the fields. Leisure activities include taking care of children, sewing, and talking to friends while going to the grocery store. After dinner the woman washes the dishes and then goes to bed at 7:00 to 8: 00 PM.

Greenfield and Clark (20) reported that physical activity was reduced during lactation in a New Guinea population—particularly during the first 6 months of lactation and particularly primipera. The authors suggest a cultural and behavioral adaptation to a new experience rather than physiological adaptation; which would be independent of birth order and would continue throughout the lactation period. We cannot compare our data directly because our subjects were multipara (mean = 4) and all were more than 6 months postpartum. Our data are similar to those reported by Norgan et al. (18) in a study carried out in New Guinea in two different areas. The women were of similar size but were of a different cultural background. Using a different technique for measuring energy expenditure (respirometer-diary), they found energy expenditures of 2173 kcal/day in 14 lactating Highlands women and 1841 kcal/day in 12 lactating Coastal women in the same age group—18 to 29 years (N. G. Norgan, personal communication). If the data for the present study and the New Guinea study were calculated on the basis of kilocalories per kilogram our values of 40.1 kcal/kg for the nonlactating group and 41.8 kcal/kg for the lactating group were intermediate to their values of 38.8 kcal/kg for the Coastal villages and 44.4 kcal/kg for the Highland villages in a population of lactating and nonlactating women (18).

Weight changes and milk production

We found that the most striking differences between the lactating and nonlactating groups were the considerable weight loss observed in the former over the previous 10-week period. There was no significant relationship between the weight loss and the time postpartum (r = 0.18 NS). The lactating women were still losing weight even when measured a year or more postpartum. This corroborates previous findings in the same population (10). The weight loss discovered in the majority of the lactating women suggests that, taken as a group, the lactating women were in negative energy balance and this was confirmed when energy intake was found to be lower than energy expenditures. In this population the cost of milk production is being partly met by weight loss, particularly by mobilization of adipose tissue, as indicated by the high correlation between weight loss and diminished skinfold thickness over the previous 7 months. In our study, total milk production was not measured. Ferro-Luzzi et al. (29) report that in New Guinea a mean milk output of 270 ml in one area and 320 ml in the other for women of the same size and similar energy intakes and expenditures. Martinez and Chavez (30) reported that between 9 to 13 months of lactation 440 to 460 ml milk was produced by Mexican women of similar nutritional and socioeconomic status and it is well known that milk volumes are reduced in women of low socioeconomic status (31).

Because the nonlactating women did not lose a significant amount of weight, even though they were of similar size and carried out the same activities, we assume that the weight loss in the lactating women was a result of the energy cost of milk production. On this basis we can calculate the fat loss provided about 80 kcal/day, assuming an energy cost of weight loss of 6.5 kcal/g which would be the equivalent of 130 ml of milk produced.

We have calculated that if a difference in energy intake of 200 kcal existed between the two groups, 55 women would be required in each group to demonstrate statistical significance. Thirty-six women would be required to show the same significant difference in energy expenditure so that our sample size was too small to show such small differences even if they existed.

Comparison of results with standards

Data of energy expenditure are essential to the nutritionist in order to make recommendations on energy intake based on life-style. INCAP has developed its own dietary standards, applicable to Central America and Panama, which are based on the FAO/WHO recommendations with adjustments for body size (3). INCAP recommended dietary allowances suggest intake values of 2050 kcal/24 hr for nonlactating women of the same size as our group. We found mean values of intake within 100 kcal of these recommendations for the nonlactating group and the subjects maintained body weight. In the lactating group, the additional recommendations for milk production results in an increase of 550 kcal/24 hr in the recommendations. For women who have had a deficient food intake throughout pregnancy, and for those who have lactated longer than 6 months, 750 kcal additional energy is suggested (2–3). Because here the lactating women were losing weight, our intake data are of less value and we, therefore, used the expenditure data. In the values suggested by FAO/WHO, the net cost of lactation due to milk synthesis inefficiency is included in the total additional requirement (+20%). For our calculations, this cost of milk synthesis should not be included because it should be accounted for in the measurement of oxygen consumption. Therefore, for energy recommendations based on FAO/WHO allowances for normal milk production, a value of +600 cal (750 kcal less 20%) should be added to the mean energy expenditure found (2007 kcal/day). When this is done, the total recommendation amounts to 2607 kcal, a figure identical to the INCAP energy recommendations for lactating women of adequate nutritional status during pregnancy.

However, it is well known that lactating women living on marginal food intakes are not able to produce as much milk as the "reference" women of the FAO/WHO standard (850 ml of milk per day) (30, 31). Assuming that the women at 10 months postpartum produced as an average 450 ml of milk (30) containing 270 kcal, a crude estimate of the total energy "requirement" at the time of the study would be 2007 kcal/day plus 270 kcal/day = 2277 kcal/day. This represents 81 or 88% of the total energy allowances based on the FAO/WHO estimate. However, this estimate should be interpreted with caution because "actual" does not necessarily correspond to their "ideal" energy requirements. Everything else kept constant, a higher energy intake than 2300 kcal would probably lead to a higher milk production, which in this population would be of greater benefit to the child.

Conclusions

This preliminary study showed that these lactating Guatemalan women at 10 months postpartum were moderately active rather than sedentary, using the FAO/WHO classification. They responded to the additional energy stress of lactation primarily by reducing their body fat stores rather than by either significantly increasing their energy intake (even when food supplement was available at no cost) or decreasing their energy level of expenditure, or both.

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