

Energy cost of various physical activities in healthy children

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Abstract

Twenty-eight studies that measured the energy costs of several common activities of children were found through an extensive literature search and personal communications. The characteristics of the children, the method used to measure energy expenditure and the energy costs of the activities from each study are presented in summary tables. The children's basal metabolic rate (BMR) and the energy cost of activities per kg or as multiples of BMR ($X \text{ BMR}$) were calculated to present the data uniformly. The activities were classified in ten categories. In most age groups there is no information about the energy cost of household work, agricultural chores, other common tasks, and many sports or games, especially for girls. Although the methodology varied between studies and the activities were not standardized, the data suggest that when energy costs are expressed as $X \text{ BMR}$: (a) they are similar for boys and girls, (b) there are no age-related differences in sedentary activities, (c) the cost of walking and moving around increases from preschool years to mid-adolescence, and (d) energy costs from 15 years onwards are similar to those of adults. The use of energy costs of adults per kg of body weight to calculate energy costs of children leads to errors which increase with decreasing age. Suggestions are made to estimate the energy costs of children based on their known or calculated BMR and from similar activities of adults expressed as fractional multiples of BMR. Additional investigations are necessary to confirm whether there are differences related to racial, geographic and socioeconomic conditions.

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1. Introduction

The latest Consultation of international experts, convened to assess energy and protein requirements, agreed that the energy intake from food must allow a level of physical activity consistent with long-term good health, adequate growth in children, and the performance of economically necessary and socially desirable physical activity (FAO/WHO/UNU, 1985). The Consultation also concluded that energy needs are determined mainly by energy expenditure. Thus, they recommended a factorial approach to estimate the mean daily needs for dietary energy.

The factorial approach involves the summation of the energy expended during the periods that a person – or rather, a type of person – is sleeping and resting or engaged in occupational, discretionary or maintenance physical activities, plus the energy needed for tissue accretion in growing children. This requires two sets of data: (a) the time allocated to the various activities, and (b) the energy cost of those activities. The latter was expressed as multiples of the basal metabolic rate ($\times$ BMR), as this accounted for inter-individual variations related to age, sex, size, body composition, physiological conditions and climate or genetic factors that might influence energy expenditure. A set of formulas was agreed upon to estimate BMR from age, sex and body weight (SCHOFIELD *et al.*, 1985).

The mean energy requirements of adults were calculated in this manner. The same approach was followed for children older than 10 years, with the addition of energy needs associated with normal growth. Their energy needs for activity were estimated from the scarce information available and assumptions made on the time spent in those activities and their energy cost. Many of the estimates of energy expenditure were derived from the energy cost of activities performed by adults, expressed by unit of body weight. The validity of such estimates of energy costs is questionable (TORUN, 1983; TORUN *et al.*, 1983; MENDOZA and TORUN, unpublished data), and the accuracy of the estimates of energy requirements for 6- to 16-year-old children has recently been challenged (SPURR and REINA, 1989).

Factorial calculations were not done for younger children. Although much information was available on the BMR at all ages (DURNIN, 1981), the lack of information allowing to specify a desirable level of activity for young children, the scant information on the energy cost of that activity, and the variability in the energy needs for growth made it necessary to base the energy requirements on data from dietary energy intakes (FAO/WHO/UNU, 1985).

This paper summarizes most of the information currently available on the energy cost of activities commonly performed by children. Activities assessed under exercise laboratory con-

ditions, such as pedalling on an ergometer or walking on a treadmill with a fixed workload and constant speed, were not considered because they do not reflect the way in which children act and perform in everyday life.

2. Methodological considerations

The activities for which energy costs have been published, unpublished data from the Philippines, kindly provided by M.P. Guzman, and additional information from our group (MENDOZA and TORUN, unpublished), were compiled in eight Tables. Data were not included if the methodology involved was judged inappropriate and highly subjective, such as the use of energy costs of activities performed by adults to calculate energy costs of children's activities vaguely categorized by teachers or parents as being more or less energy-demanding.

To determine the energy cost of activities, most studies used open-circuit indirect calorimetry with portable respirometers of the Kofranyi-Michaelis (KM) type (MÜLLER and FRANZ, 1952), a collection of exhaled gas in a Douglas bag or latex balloon; the latter are all referred to as "Douglas bag" in the Tables. Mouthpieces and nose-clips were used in some studies and respiratory masks with small valves in others. Some investigators used a ventilated hood (DUGGAN and MILNER, 1986a, b) or closed-circuit indirect calorimetry (TAYLOR *et al.*, 1951; MAHADEVA *et al.*, 1953) for resting or sitting activities, an indirect calorimetry chamber where CO₂ production was measured (TAYLOR *et al.*, 1948a, b, 1949, 1951), heart-rate monitoring with individual heart rate to oxygen consumption calibrations (GANDRA and BRADFIELD, 1971; BRADFIELD *et al.*, 1971a, b) or an integrating motor pneumotachograph (MCNAUGHTON and CAHN, 1970).

Several researchers did not describe whether the respiratory quotient was measured, and they did not explain the manner in which the volumes of oxygen uptake or energy expenditure were calculated. Most publications describe the technique or equipment used to measure gas volume and composition, but few indicate whether the equipment was checked, standardized or calibrated periodically. Unless errors were clearly evident, it was assumed that the measurements and calculations were done correctly.

2.1. Age and sex

The children were categorized as follows:

1. Boys and girls of preschool age (1.5-6 years)
2. Boys of school age (7-12 years)
3. Girls of school age (7-12 years)

4. Boys in early adolescence (13-14 years)
5. Boys in mid-adolescence (15-16 years)
6. Boys in late adolescence (17-19 years)
7. Girls in early and mid-adolescence (13-16 years)
8. Girls in late adolescence (17-19 years)

The small number of studies in adolescent girls did not allow subclassifying them in three groups.

2.2. Number of children and measurements

These are given in the Tables when the information was available and when it was clearly stated whether measurements of energy costs were done once or more than once in the same child.

2.3. Weight, BMR and energy costs

These are shown in the Tables as given by the investigators in each study, or calculated as described below. When available, standard deviations and ranges were included. An asterisk (*) in the Tables indicates values calculated from published data. Other symbols indicate BMRs calculated with the formulas of Schofield *et al.* (#), and body weights estimated from NCHS standards (&).

2.4. Social, nutritional, national and ethnic characteristics

When available, they were included in the Tables. When the information was assumed, a question mark (?) was placed next to the presumed characteristic.

2.5. Description of activities

These were grouped in categories based on the description given by the authors or the expected level of energy expenditure. For example, sitting at ease, sitting and reading, and sitting and writing were considered as a single group of activities, as were activities performed while standing with changes in position but little body displacement.

2.6. Calculations and assumptions

Data have been published in a variety of manners, and some do not provide all methodological details or ancillary information. In order to organize the data in a uniform manner permitting analysis and comparison, the following calculations, transformations or assumptions were made in some instances:

1. Energy costs were expressed or calculated as kcal/min. When only the oxygen uptake was given by the investigators, energy expenditure was calculated assuming an equivalence of

4.82 kcal/L oxygen, STPD, for sedentary and light activities, and 4.92 kcal/L oxygen, STPD, for heavier activities.

2. When BMR was not measured, it was calculated using the formulas proposed by SCHOFIELD *et al.* (1985). When this involved combining data for boys and girls, weighted means were used applying the formulas for both sexes. Multiples of BMR ($\times$ BMR) were calculated from those figures.

3. When body weights were not given and could not be calculated from other data in the publication, but information was available on the children's nutritional status (e.g., "healthy, well-nourished", or "between the 50th and 75th percentile of weight-for-age"), it was assumed that the mean weight for the group was the corresponding percentile (or median for "well-nourished") in the U.S. NCHS tables of weight-for-age and sex adopted by WHO (1983).

4. When individual energy expenditures were not given per unit of body weight, the mean of the experimental group's body weight was used to estimate cal/kg/min and multiples of BMR.

5. Activities not properly described were assigned to categories of presumably similar activities. For example, "walking" was considered as "walking at free velocity on level ground", while "activities after school", in "school playground" and "games" were categorized as "leisure or play with low or moderate physical activity".

3. Results

Tables 1 to 8 show the energy cost of activities for boys and girls of different age groups, from each study. The footnotes in Table 1 explain the symbols and abbreviations common to all Tables. The names of the authors and year of publication of the numerical references shown in the first column, are listed in Table 9. The full bibliographic references appear in alphabetical order at the end of this paper.

Based on their characteristics and the circumstances of their performance, activities were classified in the following categories:

- lying down awake, resting or studying
- sitting quietly, reading, writing, playing
- standing quietly or with little movement
- standing and moving moderately
- walking at free velocity on level ground
- walking faster than usual, or uphill, or carrying a load
- at school (classroom activities and recess) or sedentary and light work

- light and moderate household work
- leisure time and play of low or moderate physical intensity
- running, exercise and sports

Within each category, Tables 1 to 8 show the data from developing countries followed by those from industrialized countries, and data from rural environments followed by those in urban settings.

Table 10 combines and summarizes the results of the studies described in Tables 1-8 for each age-and-sex group. It shows whether the research was done in developing or industrialized countries, the number of studies done with each type of activity, the number of children in each study and the range of the mean body weights in the various studies. The energy cost of each type of activity was computed as the mean of all studies performed, weighted by the number of children in each study. When the number of children was not given in a study, the energy cost was calculated as the arithmetic mean (i.e., non-weighted) of all studies. The range of the mean values in the different studies is also shown.

4. Discussion

4.1. Information gaps

There is still very little information on the energy cost of non-resting activities performed by children. In some age and sex groups there is an absolute lack of knowledge about activities that make an important contribution to the total daily energy expenditure. These include household work commonly done by school-age and adolescent children in many societies, agricultural chores and other tasks frequently executed by children in rural areas of developing countries, and many sports and games that children play. In general, there is even less information about girls than boys.

4.2. Geographic or racial differences

The data summarized in Table 10 are similar in developing and industrialized countries when expressed per unit of body weight (cal/kg/min). But when they are expressed as multiples of BMR, there is a tendency for the energy cost of non-sedentary activities of 7- to 16-year-old children to be higher in industrialized than in developing countries. Where data were available for similar activities in both developing and industrialized countries, the mean energy costs ($\times$ BMR) were higher among the latter in 7 of 9 instances (Wilcoxon's rank test: $p < 0.05$). This, however, should be viewed with caution because of differences in methodology,

TABLE 1: ENERGY COST OF ACTIVITIES OF PRESCHOOL-AGED BOYS AND GIRLS (1.5 - 6 YEARS)

** Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	Activity	Methodology	n	Weight (kg)	BMR kcal/min	Energy cost		
												kcal/min	cal/kg/min	X BMR
LYING DOWN, RESTING														
1	M	[2.4±1.6 (0.5 - 6.5)]	M U	black	Kenya R?, D	L	RMR, lying down, several times through- out the day.	Ventilated hood	35 in 20 children	11.2 ± 3.7 (8.0 - 16.0)	# 0.48	*	45.3 ± 6.7	1.06
"	"	"	"	"	"	"	Post-prandial, lying down	" "	35 in 20 children	11.2 ± 3.7 (8.0 - 16.0)	# 0.48	*	50.2 ± 8.2	1.17
2	M	[2.2±1.2 (1.1 - 5.0)]	U	black	Kenya R?, D	L	RMR, lying, several times of day	" "	17	10.2 (6.1 - 16.8)	# 0.48	*	45.4 ± 5.9	1.06
3	M F	[2.6±0.7 (1.5 - 4)]	M N	Mayan, white, mixed	Guatemala U, D	L	Lying awake, resting or playing in bed	Douglas bag	131 in 23 ch.	11.2 ± 1.4	0.43	0.49	44 ± 5	1.16
SITTING														
"	M F	[2.6±0.7 (1.5 - 4)]	M N	Mayan, white, mixed	Guatemala U, D	L	Sitting quietly	Douglas bag	65 in 11 ch.	11.2 ± 1.4	0.43	0.53	47 ± 6	1.24
WALKING, FREE VELOCITY, LEVEL GROUND														
"	M F	[2.6±0.7 (1.5 - 4)]	M N	Mayan, white, mixed	Guatemala U, D	L	Walking, level ground, their own pace	Douglas bag	52 in 8 ch.	11.2 ± 1.4	0.43	0.88	78 ± 6	2.05

(.../cont, Table 1)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	Activity	Methodology	n	Weight (kg)	BMR kcal/min	Energy cost		
												kcal/min	cal/kg/min	X BMR
WALKING UPHILL														
3	M	2.6±0.7 (1.5 - 4)	M	Mayan, white, mixed	Guatemala U, D	L	Walking, uphill, constant pace	Douglas bag	134 in 23 ch.	11.2 ± 1.4	0.43	1.12	98 ± 11	2.58
ASCENDING AND DESCENDING RAMPS AND STAIRS														
"	M	2.6±0.7 (1.5 - 4)	M	Mayan, white, mixed	Guatemala U, D	L	Ascending and descending ramps	" "	44 in 7 ch.	11.2 ± 1.4	0.43	0.98	87 ± 7	2.29
"	"	"	"	"	"	"	Climbing stairs	" "	34 in 6 ch.	11.2 ± 1.4	0.43	1.06	94 ± 8	2.47
RIDING TRICYCLE INDOORS, SLOWLY														
"	M	3.5	M	Mayan	Guatemala U, D	L	Riding tricycle, indoors, slowly	Douglas bag	11 in 1 child	11.2	0.43	0.82	73 ± 5	1.92

Footnotes for Tables 1 - 8:

S Sex: M = male, F = female. Nutritional status: N = normal, U = underweight, D = obese. Country and region: R = rural, U = urban, D = developing, I = industrialized. Socioeconomic status (SES): L = lower, M = middle, U = upper. n = number of tests or children. BMR = basal metabolic rate. X BMR = multiples of BMR.

* Calculated by B. Torón from authors' data.

BMR calculated from sex and weight according to Schofield et al (FAO/WHO/UNU, 1985, p. 71).

& Weight calculated from sex, age and nutritional status using the NCHS standards (WHO, 1983).

** Authors and year of publication in Table 9. Complete bibliographic references at the end of the paper.

TABLE 2: ENERGY COST OF ACTIVITIES OF SCHOOL AGED BOYS (7 - 12 YEARS)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	Activity	Methodology	n	Weight (kg)	BMR kcal/min	Energy cost		
												kcal/min	cal/kg/min	X BMR
LYING DOWN, QUIETLY														
4	M	7.0-8.9	N	ladino	Guatemala U, D	L	Lying quietly	Douglas bag	14	21.0 ± 1.9	0.68 ± 0.03	0.74 ± 0.06	35 ± 4.0	1.08
SITTING QUIETLY, READING, WRITING, PLAYING														
"	M	7.0-8.9	N	ladino	Guatemala U, D	L	Sitting, reading, writing, resting	Douglas bag	14	21.0 ± 1.9	0.68 ± 0.03	0.81 ± 0.07	38 ± 3.9	1.19
5	M	6 - 8	N	latin?	Colombia U, D	L	Sitting quietly	" "	19	21.8 ± 1.4	0.73 ± 0.07	0.85	39.2	1.16
"	"	"	U	"	"	"	" "	" "	14	19.4 ± 2.3	0.68 ± 0.07	0.80	41.7	1.18
"	M	10 - 12	N	latin?	Colombia U, D	L	Sitting quietly	Douglas bag	23	32.4 ± 3.3	0.87 ± 0.12	1.02	31.4	1.17
"	"	"	U	"	"	"	" "	Douglas bag	26	25.9 ± 2.6	0.79 ± 0.11	0.92	35.9	1.16
6	M	9.7±1.0 (8.0 - 11.5)	N	white?	Canada, I	M?	Sitting quietly	Open circuit	22	33.4 ± 5.9	0.86	1.22 ± 0.10	36.5 ± 3.0	1.41

(.../cont. TABLE 2: Sitting quietly, reading, writing, playing)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	Activity	Methodology	n	Weight (kg)	BMR kcal/min	Energy cost			
												kcal/min	cal/kg/min	X BMR	
7	M	6.5-8.3	N	"varied"	U.S U, I	L	Quiet plays checkers, puzzles, games	Indirect calorimetry chamber; VCO ₂ ; assumed RQ = 0.82	19 in 6 ch.	21.6	0.72	1.12	51.7 ± 7.3	1.55	*
"	"	9.4 - 11.1	"	"	"	"	" " " "	" "	29 in 6 ch.	28.8	0.76	1.25	43.3 ± 2.8	1.62	*
8	M	9.3 - 11.5	N	?	U.S U, I	L	Sitting listening to the radio	Indirect calorimetry chamber; VCO ₂ ; assumed RQ = 0.82	10	37.2	0.90	1.30	34.5 ± 4.5	1.44	*
8	M	9.3 - 11.5	N	?	U.S U, I	M	Sitting and singing	Indirect calorimetry chamber; VCO ₂ ; assumed RQ = 0.82	10 in 6 ch.	37.2	0.90	1.37	37.2 ± 4.9	1.54	*
9	M	8.8 - 10.9	N	white?	U.S U, I	M	Sitting and drawing	Indirect calorimetry chamber (VCO ₂) + closed circuit VO ₂ assumed RQ = 0.82	27 in 12 ch.	34.2	0.85	1.21	35.5 ± 4.6	1.40	*

(.../cont. Table 2)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	Activity	Methodology	n	Weight (kg)	BMR kcal/min	Energy cost		
												kcal/min	cal/kg/min	X BMR
STANDING QUIETLY OR WITH LITTLE MOVEMENT														
8	M	9.3 - 11.4	N	white?	U.S. U, I	L	Standing and singing	Indirect calorimetry chamber; VCO ₂ ; assumed RQ = 0.82	11 in 8 ch.	37.2	0.90	1.45	39.2 ± 4.2	1.58 [*]
10	M	9.7 - 10.7	N	white	U.S. U, I	L	Standing and drawing	Indirect calorimetry chamber; VCO ₂ ; assumed RQ = 0.82	11 in 7 ch.	35.1	0.83	1.87	53.2 ± 8.4	2.24 [*]
STANDING AND MOVING														
4	M	7.0-8.9	N	ladino	Guatemala U, D	L	Standing, bending and tossing a ball	Douglas bag	14	21.0 ± 1.9	0.68 ± 0.03 [#]	1.47 ± 0.18	69 ± 10.3	2.15
10	M	9.7 - 10.7	N	white	U.S. U, I	L	Dressing and undressing continuously for 10'	Indirect calorimetry chamber; VCO ₂ ; assumed RQ = 0.82	11 in 7 ch.	35.1	0.83	2.51	71.5 ± 13.5	3.02
WALKING, FREE VELOCITY, LEVEL GROUND														
4	M	7.0-8.9	N	ladino	Guatemala U, D	L	Walking, 62 m/min	Douglas bag	14	21.0 ± 1.9	0.68 ± 0.03 [#]	1.84 ± 0.25	88 ± 8.0	2.70
11	M	5-13 [†]	N	?	U.S. U, I	?	Walking, free-velocity	" "	33	36.47	0.91 ^{#*}	2.79	76.6 ± 10.1	3.07
12	M	6 - 12	N?	?	U.S. ? I	?	Walking, free-velocity (71 ± 8 m/min)	Douglas bag	34	29.7	0.81 ^{#L}	2.26	76.2 ± 10.1	2.79

(....cont. TABLE 2)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
WALKING FAST, UPHILL OR CARRYING A LOAD														
4	M	7.0-8.9	M	ladino	Guatemala U, D	L	Walking; 75 m/min.	Douglas bag	14	21.0 ± 1.9	0.68 ± 0.03	2.28 ± 0.19	106 ± 7.9	3.34
"	"	"	"	"	"	"	Walking, 59 m/min, carrying 4.5 kg load	" "	14	21.0 ± 1.9	0.68 ± 0.03	2.27 ± 0.25	105 ± 10.5	3.31
"	"	"	"	"	"	"	Walking uphill, approx. 15 degrees, 54 m/minute	" "	14	21.0 ± 1.9	0.68 ± 0.03	2.54 ± 0.20	116 ± 7.6	3.71
LEISURE TIME, PLAY OF MODERATE INTENSITY														
13	?	10.2 (7-13)	U7	latin	Brazil R, D	L	4 hours after school; activities not described	Heart rate - VO2	37 in 19 ch.	25.7 ± 5.1	0.75	1.74 ± 0.64	67.7	2.32
14	M	10	U7	ceylonese	Ceylon U, D	?	Playing in school grounds, limited by Douglas bag	Douglas bag	25	24.0	0.64	1.47	61.2	2.30
15	M	8.4 (7-10)	M	white	U.K. U, I	U	1 h play + 30 min recess in school + 30 minutes of lunch	Heart rate - VO2	54	28.5	0.80	3.0	105.3	3.75
16	M	10	M	white	U.K. U, I	?	Workshop	Douglas bag	?	31.5	0.84	2.41	76.5	2.87
14	M	10	M	white	U.K. U, I	?	Games	" "	?	31.5	0.84	3.97	126.0	4.73

(.../cont. TABLE 2)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
AT SCHOOL (CLASSROOM ACTIVITIES, RECESS)														
13	F	10.2 (7-13)	U7	latin	Brazil R, D	L	4 hours in school, including 45 min. at play	Heart rate - VO2	71 in 19 ch.	25.7 ± 5.1	# 0.75	1.41 ± 0.46	54.9	*
15	M	8.4 (7-10)	M	white	U.K. U, I	U	280 min of classroom activities, AM and PM	" "	54	28.5	# 0.80	* 2.40	84.2	* 3.00

See footnotes on Table 1

TABLE 3: ENERGY COST OF ACTIVITIES IN EARLY ADOLESCENCE, BOYS (13-14 YEARS)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
LYING DOWN AT REST														
17	M	13.5 ± 1.0 (12-14)	M	Chinese	Singapore U, D	U	Lying at rest	K M	14	52.6 ± 9.4	1.09 [#]	1.08 ± 0.19	20.5 ± 3.7	0.99 [*]
18	M	13.0 ± 0.6 (12-14)	M	Dravidian Indian	Singapore U, D	M	Lying at rest	K M	16	31.3 ± 5.6	0.83 [#]	0.86 ± 0.20	27.3 ± 5.3	1.04 [*]
4	M	11.0 - 13.9	M	Iadino	Guatemala U, D	L	Lying at rest	Douglas bag	14	30.4 ± 4.4	0.82 ± 0.05 [#]	0.88 ± 0.12	29 ± 3.1	1.06
SITTING QUIETLY, READING, WRITING														
4	M	11.0 - 13.9	M	Iadino	Guatemala U, D	L	Sitting quietly, reading or writing	Douglas bag	14	30.4 ± 4.4	0.82 ± 0.05 [#]	0.91 ± 0.11	30 ± 2.2	1.10
17	M	13.5 ± 1.0 (12-14)	M	chinese	Singapore U, D	U	Sitting quietly, reading or writing	K M	42 in 14 ch.	52.6 ± 9.4	1.09 [#]	1.07 ± 0.18	20.3 ± 4.1	0.98 [*]
18	M	13.0 ± 0.6 (12-14)	M	Dravidian Indian	Singapore U, D	M	Sitting quietly, reading or writing	K M	48 in 16 ch.	31.3 ± 5.6	0.83 [#]	0.87 ± 0.19	27.9 ± 4.9	1.05 [*]

(.../cont. Table 3: Sitting quietly, reading, writing)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	Activity	Methodology	n	Weight (kg)	BMR kcal/min	Energy cost			
												kcal/min	cal/kg/min	X BMR	
7	M	12.3 - 14.1	N	"varied"	U.S. U, I	L	Quiet play: checkers, puzzles, games	Indirect calorimetry chamber; VCO ₂ ; assumed RQ = 0.82	22 in 10 ch.	41.0	0.89	1.44	35.0 ± 3.3	1.61	
16	M	13	N	white	U.K. U, I	M	Sitting	Douglas bag	7	45.0	1.00	1.25	27.8	1.25	
STANDING QUIETLY WITH LITTLE MOVEMENT															
17	M	13.5 ± 1.0 (12-14)	N	chinese	Singapore U, D	U	Standing	K M	14	52.6 ± 9.4	1.09	1.29 ± 0.15	24.5 ± 5.0	1.18	
18	M	13.0 ± 0.6 (12-14)	N	Dravidian Indian	Singapore U, D	M	Standing	K M	16	31.3 ± 5.6	0.83	1.03 ± 0.20	30.2 ± 4.0	1.24	
16	M	13	?	white	U.K. U, I	M	Standing	Douglas bag	7	45	1.00	1.40	31.1	1.40	
STANDING AND MOVING															
4	M	11.0 - 13.11	N	ladino	Guatemala U, D	L	Standing, bending and tossing a ball	Douglas bag	14	30.4 ± 4.4	0.82 ± 0.05	1.77 ± 0.41	58 ± 10.5	2.13	

(---/cont. Table 3, Standing and moving)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	Activity	Methodology	n	Weight (kg)	BMR kcal/min	Energy cost		
												kcal/min	cal/kg/min	X BMR
16	M	13	?	white	U.K. U, I	M	"Waiting about"	Douglas bag	?	45	1.00	2.14	47.6	2.14
19	F	13 - 14	?	?	USSR ? , I	?	Playing balalaika, mandolin and klavier	?	5	41	0.91	1.80	43.9	1.98
WALKING, FREE VELOCITY, LEVEL GROUND														
4	M	11.0 - 13.9	M	Iodine	Guatemala U, I	L	Walking, 66 m/min.	Douglas bag	14	30.4 ± 4.4	0.82 ± 0.05	2.38 ± 0.26	79 ± 8.5	2.89
17	M	13.5 ± 1.0 (12-14)	M	chinese	Singapore U, I	U	Walking, 67-115 m/min (mean = 85 m/min).	K M	14	52.6 ± 9.4	1.09	2.70 ± 0.49	51.3 ± 13.3	2.48
18	M	13.0 ± 0.6 (12-14)	M	Dravidian Indian	Singapore U, I	M	Walking, 67-115 m/min (mean = 85 m/min).	K M	16	31.3 ± 5.6	0.83	2.10 ± 0.44	61.0 ± 9.3	2.53
16	M	13	M	white	U.K. U, I	M?	Walking	Douglas bag	?	45.0	1.00	3.14	69.8	3.14

(.../cont. Table 3)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
WALKING FAST OR UPHILL OR CARRYING A LOAD														
4	M	11.0 - 13.9	M	ladino	Guatemala U, D	L	Walking, 82 m/min	Douglas bag	14	30.4 ± 4.4	0.82 ± 0.05	2.98 ± 0.34	99 ± 12.0	3.62
"	"	"	"	"	"	"	Walking , 68 m/min., carrying 6.8 kg	Douglas bag	14	30.4 ± 4.4	0.82 ± 0.05	2.92 ± 0.39	97 ± 12.0	3.55
"	"	"	"	"	"	"	Walking uphill, approx. 15 degrees, 56 m/minute	Douglas bag	14	30.4 ± 4.4	0.82 ± 0.05	3.38 ± 0.40	112 ± 11.5	4.11
LEISURE TIME, PLAY OF MODERATE INTENSITY														
19	F	13-14	?	?	USSR ? , I	?	Carpentry		11	41	0.91	3.00	75.0	3.30
14	M	13	M	white	U.K. ? , I	?	Playing cricket	Douglas bag	?	45.0	1.00	2.50	55.6.	2.50
RUNNING, EXERCISE, SPORTS														
17	M	13.5 ± 1.0 (12-14)	M	chinese	Singapore U, D	U	Running, 6.9 - 9.9 km/h (mean = 8.5)	K M	14	32.6 ± 9.6	1.09	5.07 ± 0.64	96.3 ± 14.3	4.65
18	M	13.0 ± 0.6 (12-14)	M	Dravidian Indian	Singapore U, D	M	Running, 6.9 - 9.9 km/h (mean = 8.5)	K M	16	31.3 ± 5.6	0.83	4.56 ± 0.60	132.3 ± 14.0	5.49

(.../cont. Table 3: Burning, exercise, sports)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
18	M	13.0 ± 0.6 (12-14)	M	Dravidian Indian	Singapore U, D	M	Ascending stairs 3 min, and descending 3 min; 16.5 cm high, 100-199 steps/min (n = 150) (mean of ascending and descending)	K M	32 in 16 ch.	31.3 ± 5.6	0.83	3.48 ± 1.06	101.6 ± 27.9	4.19
16	M	13	M	white	U.K. 7, I	?	Gymnastics	Douglas bag	?	45.0	1.00	3.06	68.0	3.06
"	"	"	"	"	"	"	Quad games	" "	?	45.0	1.00	4.75	105.6	4.75
"	"	"	"	"	"	"	Soccer football	" "	?	45.0	1.00	5.60	124.4	5.60

See footnotes on Table 1

TABLE 4: ENERGY COST OF ACTIVITIES IN MID-ADOLESCENCE, BOYS (15 - 16 YEARS)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	Activity	Methodology	n	Weight (kg)	BMR kcal/min	Energy cost			
												kcal/min	cal/kg/min	X BMR	
LYING DOWN, AT REST															
4	M	15.0 - 16.9	N	ladino	Guatemala U, D	L	Lying at rest	Douglas bag	14	48.9 ± 5.8	1.05 ± 0.07 [#]	1.18 ± 0.11	25 ± 2.7	1.13	
20	M	13 - 15	N	white	U.K. U, D	M?	Lying down, resting	Douglas bag or Benedict-Roth respirometer	5	57.2 ± 6.6	1.07 [#]	1.16 ± 0.11	20.5 ± 2.9	1.08	
SITTING QUIETLY, READING, WRITING															
5	M	14-16	N	latin	Colombia U	L	Sitting quietly	Douglas bag	15	46.7 ± 3.5	1.05 ± 0.14	1.23 [*]	26.4 [*]	1.17	
"	"	"	U	"	"	"	"	"	17	34.8 ± 5.1	0.94 ± 0.18	1.10 [*]	31.8 [*]	1.17	
4	M	15.0 - 16.9	N	ladino	Guatemala U, D	L	Sitting quietly, reading or writing	Douglas bag	14	48.9 ± 5.8	1.05 ± 0.07 [#]	1.24 ± 0.15	26 ± 3.3	1.18	
21	M	13-15	N	Filipino	Philippines U, D	U	Sitting quietly	K M	12	48 ± 6	1.04 [#]	1.37 ± 0.45	28.5	1.32	
STANDING QUIETLY WITH LITTLE MOVEMENT															
21	M	13-15	N	Filipino	Philippines U, D	U	Standing quietly	K M	12	48 ± 6	1.04 [#]	1.60 ± 0.56	33.3	1.54	

(.../cont. Table 4)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
STANDING AND MOVING														
4	M	15.0 - 16.9	M	ladino	Guatemala U, D	L	Standing, bending and tossing a ball	Douglas bag	14	48.9 ± 5.8	1.05 ± 0.07 #	2.53 ± 0.47	52 ± 7.5	2.40
WALKING, FREE VELOCITY, LEVEL GROUND														
4	M	15.0 - 16.9	M	ladino	Guatemala U, D	L	Walking, 72 m/min	Douglas bag	14	48.9 ± 5.8	1.05 ± 0.07 #	3.36 ± 0.51	69 ± 4.7	3.19
21	M	13-15	M	Filipino	Philippines U	U	Walking	K M	12	48 ± 6	1.04 #*	3.06 ± 0.74	63.8	2.94
12	M	13-19	M?	?	U.S. ?	?	Walking, free velocity (73 ± 12 m/min)	Douglas bag	25	64.0	1.23 #L	4.08	63.7 ± 9.2	3.32
20	M-3 F-2	13-15	M?	white	U.K. U7, I	M?	Walking, indoor track, 80 m/min	K M	5	57.2 ± 6.6	1.07 #	3.88 ± 0.34	68.4 ± 7.8	3.63
WALKING FAST, UPHILL OR CARRYING A LOAD														
4	M	15.0 - 16.9	M	ladino	Guatemala U, D	L	Walking, 96 m/min.	Douglas bag	14	48.9 ± 5.8	1.05 ± 0.07 #	4.63 ± 0.54	94 ± 8.5	4.41
"	M	15.0 - 16.9	M	ladino	Guatemala U, D	L	Walking, 79 m/min, carrying 9 kg	Douglas bag	14	48.9 ± 5.8	1.05 ± 0.07 #	4.53 ± 0.68	93 ± 10.8	4.32

(.../cont. Table 4)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
LEISURE TIME, PLAY OF MODERATE INTENSITY														
14	M	14	U7	ceylonese	Ceylon U, D	7	Playing in school playground, limited by Douglas bag	Douglas bag	25	33.7	0.74	1.82	34.0	2.46
EXERCISE														
20	M-3 F-2	13-15	M	white	U.K. U, I	M7	Step test, 10 min. at 15 steps/min, 25.4 cm stool	K M	5	57.2 ± 6.6	1.07	3.84 ± 0.36	67.4 ± 4.4	3.59

See footnotes on Table 1

TABLE 5: ENERGY COST OF ACTIVITIES IN LATE ADOLESCENCE, BOYS (17 - 19 YEARS)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, O/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	% BMR
LYING DOWN, RESTING OR STUDYING														
22	M	17-19=5 20-21=4	N	Indian	India U, D	M	Lying down, resting or studying	K M	9	55.7 ± 8.8	0.97 ± 0.12	1.21 ± 0.16	22.3 ± 3.3	1.24
23	M	15-18	N	white	U.S. U, I	L U	Overnight fast, 30 min bed rest	Douglas bag	95	67.5 ± 13.0	# 1.27	* 1.33 ± 0.17	* 19.7	* 1.05
20	M	18	O	white	U.K. U, I	M?	Lying down, resting	Douglas bag or Benedict-Ruth respirometer	1	110	# 1.71	* 1.80	* 16.4	* 1.05
SITTING QUIETLY, READING, WRITING														
21	M	16-19	N	Filipino	Philippines U, D	U	Sitting quietly	K M	15	56 ± 5	# 1.10	* 2.02 ± 0.62	* 36.1	* 1.84
24	M	16-18	N	white?	Australia U, D	M	Sitting	Douglas bag, integr. pneumotachograph (IMP)	3	65.7 ± 3.0	# 1.25	* 1.30 ± 0.17	* 20 ± 1.7	* 1.04
22	M	17-19=5 20-21=4	N	Indian	India U, D	M	Sitting while resting, studying or writing	K M	9	55.7 ± 8.8	0.97 ± 0.12	1.27 ± 0.12	23.4 ± 3.4	1.30

(.../cont. Table 5)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
STANDING QUIETLY WITH LITTLE MOVEMENT														
21	M	16-19	N	Filipino	Philippines U, I	U	Standing quietly	X M	15	56 ± 5	1.10	1.94 ± 0.55	34.6	1.76
24	M	16-18	N	white?	Australia U, I	M	Standing	Douglas bag, IMP	3	65.7 ± 3.0	1.25	1.38 ± 0.20	21 ± 1.7	1.10
22	M	17-19=5 20-21=4	N	Indian	India U, I	M?	Standing while resting	K M	9	55.7 ± 8.8	0.97 ± 0.12	1.43 ± 0.31	25.7 ± 4.1	1.47
"	"	"	"	"	"	"	Standing while washing, dressing, shaving	"	9	55.7 ± 8.8	0.97 ± 0.12	1.55 ± 0.29	28.0 ± 3.9	1.60
WALKING, FREE VELOCITY, LEVEL GROUND														
21	M	16-19	N	Filipino	Philippines U, O	U	Walking	K M	15	56 ± 5	1.10	3.69 ± 0.96	65.9	3.35
24	M	16-18	N	white?	Australia U, O	M	Walking	Douglas bag, IMP	3	65.7 ± 3.0	1.25	2.97 ± 0.41	45 ± 7.5	2.38
22	M	17-19=5 20-21=4	N	Indian	India U, O	M	Walking, 89 m/min.	K M	9	55.7 ± 8.8	0.97 ± 0.12	2.73 ± 0.47	49.3 ± 8.6	2.80
20	M	18	O	white	U.K. U, I	M?	Walking	X M	1	110	1.71	6.50	59.1	3.80

(.../cont. Table 5)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
SEDENTARY AND LIGHT WORK														
22	M	17-19=5 20-21=4	M	Indian	India U, D	M	Laboratory work; dissection, polishing shoes, washing cloths, dressing, shaving		36 in 9 subjects	55.7 ± 8.8	0.97 ± 0.12	1.64 ± 0.53	29.6 ± 8.5	1.68
RUNNING, EXERCISE, SPORTS														
24	M	16-18	M	white?	Australia U, D	M	Running	Douglas bag, IMP	2	65.5	1.25	6.50 ± 0.56	99 ± 2.0	5.20
22	M	17-19=5 20-21=4	M	Indian	India U, D	M	Ascending and descending stairs	K M	9	55.7 ± 8.8	0.97 ± 0.12	5.22 ± 1.35	93.0 ± 17.2	5.37
"	"	"	"	"	"	"	Playing games: volley ball, table tennis, etc.	"	9	55.7 ± 8.8	0.97 ± 0.12	3.97 ± 0.37	72.0 ± 13.3	4.10
"	"	"	"	"	"	"	Riding bicycle, 10.9 km/h	"	9	55.7 ± 8.8	0.97 ± 0.12	4.04 ± 0.57	72.2 ± 10.2	4.16
24	M	17	M	white	Australia U, D	M	Riding bicycle	Douglas bag, IMP	1	62.8	1.22	4.80	76.4	3.93
20	M	18	D	white	U.K. U, I	M7	Step tests: 10 min, 15 steps/min., 24.5 cm stool	K M	1	110	1.71	7.60	69.1	4.44

See footnotes on Table 1

TABLE 6: ENERGY COST OF ACTIVITIES OF SCHOOL-AGED GIRLS (7-12 YEARS)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	Activity	Methodology	n	Weight (kg)	BMR kcal/min	Energy cost			
												kcal/min	cal/kg/min	X BMR	
SITTING QUIETLY, SEWING, DRAWING, SINGING															
6	F	9.5±0.7 (8.0 - 11.2)	N	white?	Canada U, I	M?	Sitting quietly	Open circuit	15	30.9 ± 4.2	0.80	0.98 ± 0.12	31.6 ± 3.9	1.22	*
8	F	8.8 - 10.9	N	"varied"	U.S. U, I	L M	Sitting, listening to radio	Indirect calorimetry chamber; VCO ₂ ; assumed RQ = 0.82	12 in 10 ch.	34.4	0.84	1.00	30.0 ± 3.2	1.20	*
"	"	"	"	"	"	"	Sitting and singing	" "	12 in 9 ch.	34.4	0.84	1.22	34.3 ± 6.0	1.41	*
9	F	8.6 - 11.1	N	white?	U.S. U, I	M	Sitting and drawing	Indirect calorimetry (VCO ₂) + closed circuit VQ ₂ ; assumed RQ = 0.82	29 in 21 ch.	34.0	0.83	1.13	33.2 ± 4.1	1.34	*
"	"	"	"	"	"	"	Sitting and sewing	" "	26 in 17 ch.	34.0	0.83	1.04	30.6 ± 2.9	1.24	*
STANDING QUIETLY OR WITH LITTLE MOVEMENT															
10	F	8.8 - 11.4	N	white	U.S. U, I	L M	Standing drawing	see 20, above	14 in 12 ch.	33.6	0.82	1.47	43.7 ± 4.2	1.76	*
8	F	8.8 - 10.9	N	"varied"	U.S. U, I	L M	Standing and singing	see 20, above	13 in 9 ch.	34.4	0.84	1.26	35.5 ± 5.0	1.46	*

(.../cont. Table 6)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
STANDING AND MOVING														
10	F	8.8 - 11.4	N	white?	U.S. U, I	I, M	Dressing + undressing continuously for 10 minutes	see 20, above	14 in 12 ch.	33.6	0.82	2.26	67.3 ± 12.2	2.72 ^a
WALKING, FREE VELOCITY, LEVEL GROUND														
11	F	5-13 ⁷	N	?	U.S. U, I	?	Walking, free velocity	Douglas bag	27	36.4 ⁷	0.87 [#]	2.57 [*]	70.5 ± 13.8	2.95 [*]
25	F	9.8 - 11.7	N	?	U.S. U, I	?	Walking, free velocity (43 - 71 m/min)	K M carried by an observer	12	34.4 ± 4.4	0.88 ± 0.08	2.23 ± 0.22 [*]	65.0 ± 6.3 [*]	2.56 [*]
12	F	6-12	N ⁷	?	U.S. ? , I	?	Walking, free velocity (68 ± 9 m/min)	Douglas bag	27	30.1 ^L	0.79 ^{#L}	2.11 [*]	70.0 ± 13.5 [*]	2.67 [*]

See footnotes on Table 1

TABLE 7: ENERGY COST OF ACTIVITIES IN EARLY AND MID-ADOLESCENCE, GIRLS (13 -15 YEARS)

Ref No.	Sex	Age y	Mat. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
SITTING QUIETLY														
21	F	13-15	M	Filipino	Philippines U, D	U	Sitting quietly	K M	13	47 ± 3	0.92	1.25 ± 0.49	26.6	1.36
STANDING QUIETLY														
21	F	13-15	M	Filipino	Philippines U, D	U	Sitting quietly	K M	13	47 ± 3	0.92	1.32 ± 0.48	28.1	1.43
WALKING, FREE-VELOCITY, LEVEL GROUND														
21	F	13-15	M	Filipino	Philippines U, D	U	Walking	K M	13	47 ± 3	0.92	2.55 ± 0.85	54.3	2.77
12	F	13-19	N7	?	U.S. ?, I	?	Walking, free velocity (73 ± 9 m/min)	Douglas bag	28	56.4	1.00	3.43	60.8 ± 8.2	3.43

See footnotes on Table 1

TABLE 8: ENERGY COST OF ACTIVITIES IN LATE ADOLESCENCE, GIRLS (17-19 YEARS)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
LYING DOWN AT REST, STUDYING														
26	F	19 (18-23)	N	Indian	India U, D	N	Lying at rest	K M	24	47.7 ± 2.2	0.75 ± 0.07	0.81 ± 0.07	17.0	1.08
27	F	17-19	N	Indian	India U, D	N	Lying at rest or studying	K M	9	44.3 ± 6.6	0.73 ± 0.13	0.82 ± 0.53	18.4 ± 11.8	1.13
20	F	17-18	07	white	U.K. U, I	M?	Resting, lying down	Benedict-Roth resp., or Douglas bag	2	63.0	1.03	1.10	18.3	1.07
SITTING QUIETLY, READING, WRITING														
21	F	16-19	N	Filipino	Philippines U, D	U	Sitting quietly	K M	8	48 ± 3	0.88	1.28 ± 0.45	26.7	1.39
24	F	18-19	N	white	Australia U, D	N	Sitting	Integrating pneumo-tachograph (IMP)	4	56.4 ± 10.4	0.92 ± 0.10	1.16 ± 0.14	20.9 ± 1.2	1.22
27	F	17-19	N	Indian	India U, D	N	Sitting at rest, studying or writing	K M	9	44.3 ± 6.6	0.73 ± 0.13	0.90 ± 0.23	20.3 ± 4.3	1.23
26	F	19 (18-23)	N	Indian	India U, D	N	Sitting at rest or studying	K M	24	47.7 ± 2.2	0.75 ± 0.07	0.88 ± 0.12	18.8 ± 3.4	1.18

(.../cont. Table 8)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	Activity	Methodology	n	Weight (kg)	BMR kcal/min	Energy cost		
												kcal/min	cal/kg/min	X BMR
STANDING QUIETLY WITH LITTLE MOVEMENT														
21	F	16-19	N	Filipino	Philippines U	U	Standing quietly	K M	8	48 ± 3	0.88	1.57 ± 0.56	32.7	1.71
24	F	18-19	N	white	Australia U, D	M	Standing	Integrating pneumo-tachograph	4	56.4 ± 10.4	0.92 ± 0.10	1.49 ± 0.10	27.1 ± 4.9	1.56
27	F	17-19	N	Indian	India U, D	M	Standing at rest	K M	9	44.3 ± 6.6	0.73 ± 0.13	0.90 ± 0.07	20.1 ± 1.5	1.24
26	F	(18-23)	N	Indian	U, D	M	Standing at rest	K M	24	47.7 ± 2.2	0.75 ± 0.07	0.95 ± 0.05	20.7	1.27
WALKING, FREE VELOCITY, LEVEL GROUND														
21	F	16-19	N	Filipino	Philippines U, D	U	Walking	K M	8	48 ± 3	0.88	2.41 ± 0.54	50.2	2.62
24	F	18-19	N	white	Australia U, D	M	Walking	Integrating pneumo-tachograph	4	56.4 ± 10.4	0.92 ± 0.10	3.40 ± 0.62	59.6 ± 5.1	3.58
27	F	17-19	N	Indian	India U, D	M	Walking	K M	9	44.3 ± 6.6	0.73 ± 0.13	2.09 ± 0.40	46.5 ± 9.0	2.88
26	F	19 (18-23)	N	Indian	India U, D	M	Walking	K M	24	47.7 ± 2.2	0.75 ± 0.07	2.91 ± 0.45	61.2 ± 2.6	3.07
20	F	17-18	07	white	U.K. U, I	M7	Walking	K M	2	63	1.03	4.20	70	4.08

(....cont. Table 8)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
AT SCHOOL OR LIGHT WORK														
27	F	17-19	N	Indian	India U, D	M	Standing during laboratory work or dissection	K M	9	44.3 ± 6.6	0.73 ± 0.13	1.22 ± 0.35	27.2 ± 7.8	1.68
26	F	19 (18-23)	N	Indian	India U, D	M	Standing laboratory work	K M	24	47.7 ± 2.2	0.75 ± 0.07	1.24 ± 0.18	26.0 ± 4.7	1.65
28	F	16.8 ± 0.8 (16.0-17.8)	6-N	?	U.S. U, I	?	Classroom activities, 106 minutes	Heart rate • VO2	10	60.3	1.03	1.89 ± 0.46	31.4	1.83
24	F	19	N	white	Australia U, D	M	Laboratory and office work	Integrating pneumo-tachograph	2	50.4	0.80	1.46	29.2	1.82
LIGHT AND MODERATE HOUSEHOLD WORK														
27	F	17-19	N	Indian	India U, D	M	Sweeping floor; washing cloths	K M	9	44.3 ± 6.6	0.73 ± 0.13	2.60	57.9	3.57
26	F	19 (18-23)	N	Indian	India U, D	M	Sitting, household work	K M	24	47.7 ± 2.2	0.75 ± 0.07	2.21 ± 0.37	45.7 ± 9.1	2.94

(.../cont. Table 8)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t		
												kcal/min	cal/kg/min	X BMR
LEISURE TIME, PLAY OF MODERATE INTENSITY														
27	F	17-19	N	Indian	India U, D	M	Dancing, jumping, running, parading	K M	9	44.3 ± 6.6	0.73 ± 0.13	2.24 ± 1.01	50.0 ± 22.4	3.08
		16.8 ± 0.8	6-M		U.S.		After school, including play, for 300 minutes				#			
28	F	(16.0 - 17.8)	11-D	?	U, I	?		Heart rate - VO2	10	60.3	1.03	1.92 ± 0.45	31.9	1.86
							Physical education class: 25 min activity + 28 minutes leisure	" "	10	60.3	1.03	2.57 ± 0.59	42.6	2.49
RUNNING, EXERCISE, SPORTS														
26	F	18	N	white	Australia U, D	M	Climbing stairs	Integrated pneumo-tachograph	1	70.8	1.20	7.10	100	5.92
					India									
27	F	17-19	N	Indian	U, D	M	Ascending and descending stairs	K M	9	44.3 ± 6.6	0.73 ± 0.13	3.46 ± 0.73	77.0 ± 16.2	4.75

(.../cont. Table 8)

Ref No.	Sex	Age y	Nut. st.	Ethnic group	Country or region, R/U, D/I	SES	A c t i v i t y	Methodology	n	Weight (kg)	BMR kcal/min	E n e r g y c o s t			
												kcal/min	cal/kg/min	X BMR	
27	"	"	"	"	"	"	Riding bicycle	"	9	44.3 ± 6.6	0.73 ± 0.13	3.40 ± 0.53	75.8 ± 11.9	4.68	"
26	F	19 (18-23)	"	Indian	India U, D	M	Ascending and descending stairs	K M	24	47.7 ± 2.2	0.75 ± 0.07	3.02 ± 0.83	61.9 ± 16.7	4.02	"
20	F	17-18	07	white	U.K. U, I	M?	Step test, 10 min. at 15 steps/min. 25.4 cm stool	k M	2	63.0	1.03	4.00	66.7	3.88	"

See footnotes on Table 1

Table 9. Authors and year of publication of numerical references in Tables 1 to 8

1. DUGGAN and MILNER, 1986a.
2. DUGGAN and MILNER, 1986b.
3. TORUN, CHEW and MENDOZA, 1983.
4. MENDOZA and TORUN, unpublished data.
5. SPURR, REINA and BARAC-NIETO, 1986.
6. SPADY, 1980.
7. TAYLOR, LAMB, ROBERTSON and MCLEAD, 1948a.
8. TAYLOR, PYE, CALDWELL and SOSTIMAN, 1949.
9. TAYLOR, PYE, ELLIS and GODSHALL, 1951.
10. TAYLOR, PYE and CALDWELL, 1948b.
11. LERCH, 1973.
12. WATERS, HISLOP, THOMAS and CAMPBELL, 1983.
13. GANDRA and BRADFIELD, 1971.
14. CULLUMBINE, 1950.
15. BRADFIELD, CHAN, BRADFIELD and PAYNE, 1971a.
16. BEDALE, 1923.
17. BANERJEE and SAHA, 1982.
18. BANERJEE and SAHA, 1972.
19. LEGUN and MOLTSCHANOWA, 1935.
20. MAHADEVA, PASSMORE and WOOLF, 1953.
21. GUZMAN, unpublished data.
22. BHATTACHARYA and BANERJEE, 1953.
23. KNUTTGEN, 1967.
24. McNAUGHTON and CAHN, 1970.
25. MOORE, POND and KORSLUND, 1956.
26. BANERJEE, BARUA and GHOSH, 1961.
27. BANERJEE and MAHINDRA, 1962.
28. BRADFIELD, PAULOS and GROSSMAN, 1971b.

lack of standardization in the activities performed, socioeconomic conditions of the children, the small number of studies in each category of activities, and the small number of children in some studies. There were no differences in the energy cost of the activities assessed among older adolescent girls in developing and industrialized countries, and there were no data to compare older adolescent boys or children under 7 years of age.

Table 10 also suggests that the energy cost of sedentary activities while sitting, expressed as multiple of BMR, was greater in industrialized countries among 7- to 14-year-old boys. In addition to the caveats mentioned above, it should be noted that these differences are largely or exclusively based on studies by TAYLOR *et al.* (1948a, 1949, 1951), whose data on the energy costs of sedentary and light activities of boys (Tables 2 and 3), and girls (Table 6) were higher than similar activities assessed by other investigators in developing and industrialized countries, specially when expressed as multiples of BMR. This could be due to methodological reasons, since Taylor and collaborators were the only investigators who calculated energy expenditures from the carbon dioxide produced by children in an indirect calorimetry

chamber, and some experiments were done with more than one child in the chamber (TAYLOR *et al.*, 1948b).

Adequately designed comparative studies must be done to confirm whether there are, in fact, differences in the energy cost of activities of children with different racial, geographic, socio-economic or nutritional backgrounds. In adults, GEISSLER and ALDOURI (1985) found that the energy costs of standardized sedentary activities (lying down, sitting, standing) measured in persons who lived in Britain, were 10-17% higher in English and Greek individuals than in Asians and negroid Africans.

4.3. Energy costs in relation to age and sex

A summary of the energy costs of the ten categories of activities described in Table 10 is shown in Tables 11 and 12, expressed as X BMR or cal/kg/min, respectively. They are the mean values, weighted for the number of children in each study and rounded to one decimal place, from combined data of developing and industrialized countries. When the number of children was not given in a study, the mean value was weighted for the number of studies in that category of activities. Based on the preceding comments about the studies of Taylor and collaborators, the weighted means were calculated excluding or including (in brackets) data from those studies. For purposes of comparison, the energy costs of similar activities for adults are also shown (FAO/WHO, 1973; FAO/WHO/UNU, 1985).

The gaps in knowledge are evident in Tables 11 and 12. For some ages the existing data derive from only one or two studies, and some investigations only included 5 or less children (Table 10).

With those limitations in mind, the data in Table 11 suggest the following when energy costs are calculated in relation to BMR:

(a) Sedentary activities that do not involve body displacement have similar energy costs from preschool to adult age.

(b) The energy cost of walking and moving around increases with age from preschool years to mid-adolescence.

(c) The energy costs of the activities that have been assessed in adolescents beyond 15 years of age, are similar to those of adults.

(d) The few activities assessed in girls and boys had similar energy costs in all age groups.

The data in Table 12 indicate that:

(a) The energy cost per unit of body weight of activities performed by adults should not be used to calculate the cost of children's activities, as discussed in a previous publication (TORUN, 1983). The errors will be greater the younger the children are.

TABLE 10: ENERGY COST OF ACTIVITIES-GROUPED BY CATEGORIES

Type of activity	a		b	c Energy cost of activities		
	Country	No. of studies (children)		Weight (kg)	kcal/min	cal/kg/min

PRESCHOOL AGE (1.5 - 6 y) -- COMBINED SEXES						
		d		0.52	46	1.11
Lying down, resting or playing	D	4(17,20,20,23)	10 - 11	(0.49-0.56)	(44 - 50)	(1.06-1.17)
Sitting quietly	D	1 (11)	11	0.53	47	1.24
Walking, free velocity, level ground	D	1 (8)	11	0.88	78	2.05
Walking, constant pace, uphill	D	1 (23)	11	1.12	98	2.58
Ascending and descending ramps	D	1 (7)	11	0.98	87	2.29
Riding tricycle slowly, climbing staircase slowly	D	2 (1, 6)	11	1.03 (0.82-1.06)	91 (73 - 94)	2.39 (1.52-2.47)

SCHOOL-AGE (7 - 12 y) -- BOYS						
Lying down	D	1 (14)	21	0.74	35	1.68
Sitting quietly, reading, writing, playing, etc.	D	5(14,14,19,23,26)	19 - 32	0.88 (0.80-1.02)	37 (31 - 42)	1.17 (1.16-1.19)
	I	6(6,6,6,10,12,22)	22 - 37	1.24 (1.12-1.37)	40 (34 - 52)	1.49 (1.40-1.62)
Standing quietly, little movement	I	2 (7, 8)	35 - 37	1.66 (1.45-1.87)	46 (39 - 53)	1.91 (1.58-2.24)
	D	1 (14)	21	1.47	69	2.15
Standing and moving	I	1 (7)	35	2.51	72	3.62
	D	1 (14)	21	1.84	88	2.70

Type of activity	a		b	c Energy cost of activities		
	Country	No. of studies (children)		kcal/min	cal/kg/min	X BMR
Walking, free velocity, level ground	I	2 (33, 34)	f 30 - 36	2.52 (2.26-2.79)	76 (76 - 77)	2.93 f (2.79-3.07)
Walking fast, uphill or carrying a load	D	d 3 (14, 14, 14)	21	2.36 (2.27-2.54)	110 (105 - 118)	3.45 (3.31-3.71)
Leisure time, moderate play	D	2 (19, 25)	24 - 26	1.60 (1.47-1.74)	64 (61 - 68)	2.31 (2.30-2.32)
	I	3 (7, 7, 54)	g 28 - 32	3.13 (2.41-3.97)	103 (76 - 126)	3.78 (2.87-4.73)
At school (classroom)	D	1 (19)	26	1.41	55	1.88
	I	1 (54)	f 28	2.40	84	f 3.00
EARLY ADOLESCENCE (13 - 14 y) - BOYS						
Lying down	D	3 (14, 14, 16)	30 - 53	0.94 (0.88-1.08)	26 (20 - 29)	1.03 (0.99-1.06)
Sitting quietly, reading, writing	D	3 (14, 14, 16)	30 - 53	0.95 (0.87-1.07)	26 (20 - 30)	1.04 (0.98-1.10)
	I	2 (7, 10)	f 41 - 45	1.34 (1.25-1.44)	32 (28 - 35)	e f 1.43 (1.25-1.61)
Standing quietly, little movement	D	2 (14, 16)	31 - 53	1.16 (1.03-1.29)	27 (24 - 30)	1.21 (1.18-1.24)
	I	1 (7)	f 45	1.40	31	f 1.40
Standing and moving	D	1 (14)	30	1.77	58	2.13
	I	2 (7, 5)	f 41 - 45	1.97 (1.80-2.14)	46 (44 - 48)	2.06 f (1.98-2.14)

Type of activity	a		b	c Energy cost of activities		
	Country	No. of studies (children)		Weight (kg)	kcal/min	cal/kg/min
Walking, free velocity, level ground	D	3 (14, 14, 16)	30 - 53	2.39 (2.10-2.70)	64 (51 - 79)	2.3 (2.41 2.85)
	I	1 (?)	45	3.14	70	3.14 f
Walking fast, uphill or carrying a load	D	3 (14) d	30	3.09 (2.92-3.38)	103 (97 - 112)	3.76 (3.55-4.11)
Leisure time, moderate play	I	2 (7, 11)	41 - 45 f	2.75 (2.50-3.00)	65 (56 - 75)	2.90 (2.50-3.30)
Running, exercise, sports	D	3 (14, 14, 16)	31 - 53	4.37 (3.48-5.07)	110 (96 - 132)	4.78 (4.19-5.40)
		d	g			
	I	3 (?)	45	4.47 (3.06-5.60)	99 (68 - 124)	4.47 (3.06-5.60)
MID - ADOLESCENCE (15 - 16 y) - BOYS						
Lying down	D	1 (14)	49	1.18	25	1.13
	I	1 (5)	57	1.16	20	1.08
Sitting quietly, reading, writing	D	4 (12,14,15,17)	45 (35 - 49)	1.24 (1.10-1.37)	28 (26 - 32)	1.21 (1.17-1.32)
Standing quietly, little movement	D	1 (12)	48	1.60	33	1.54
Standing and moving	D	1 (14)	49	2.53	52	2.40

Type of activity	a		b	c Energy cost of activities		
	Country	No. of studies (children)		Weight (kg)	kcal/min	cal/kg/min
Walking, free velocity, level ground	D	2 (12, 14)	48 - 49	3.21 (3.06-3.36)	66 (64 - 69)	3.06 (2.94-3.19)
	I	2 (5, 25)	57 - 64	3.98 (3.88-4.08)	66 (64 - 68)	3.48 f (3.32-3.63)
Walking, uphill or carrying a load	D	^d 3 (14,14)	49	4.58 (4.53-4.63)	94 (93 - 94)	4.36 (4.32-4.41)
Leisure time, moderate play	D	1 (25)	34	1.82	54	2.46
Running, exercise, sports	I	1 (5)	57	3.84	67	3.59
LATE ADOLESCENCE (17 - 19 y) - BOYS						
Lying down	D	1 (9)	56	1.21	22	1.24
	I	1 (95)	68	1.33	20	1.05
Sitting quietly, reading, writing	D	3 (3, 9, 15)	56 - 66	1.53 (1.27-2.02)	26 (20 - 36)	1.39 h (1.04-1.84)
Standing quietly, little movement	D	^d 4 (3,9,9,15)	56 - 66	1.58 (1.38-1.94)	27 (21 - 35)	1.48 h (1.10-1.76)
Walking, free velocity, level ground	D	4 (1,3,9,15)	56 - 66	3.13 (2.73-3.65)	53 (45 - 66)	3.09 h (2.38-3.80)
Sedentary and light work	D	1 (9)	56	1.64	30	1.68
Running, exercise, sports	D	^d 5 (1,2,9,9,9)	56 - 66	4.91 (3.97-6.50)	82 (72 - 99)	4.57 (3.93-5.37)

Type of activity	a		b	c Energy cost of activities		
	Country	No. of studies (children)		Weight (kg)	kcal/min	cal/kg/min
----- SCHOOL-AGE (7 - 12 y) -- GIRLS						
Sitting quietly, drawing, singing	I	5 (9, 10, 15 17, 21)	31 - 34	1.07 (0.98-1.22)	32 (30 - 34)	1.28 ^e (1.25-1.41)
Standing quietly, little movement	I	2 (9, 12)	34	1.36 (1.26-1.47)	40 (36 - 44)	1.61 ^e (1.44-1.76)
Standing and moving	I	1 (12)	34	2.26	67	2.72 ^e
Walking, free velocity, level ground	I	3 (12,27,27)	30 - 36	2.30 (2.11-2.57)	68 (65 - 70)	2.72 (2.56-2.88)
----- EARLY AND MID-ADOLESCENCE (13 - 15 y) -- GIRLS						
Sitting quietly	D	1 (13)	47	1.05	27	1.28 ^h
Standing quietly	D	1 (12)	47	1.32	28	1.43
Walking	D	1 (13) ^f	47	2.55	54 ^f	2.77 ^f
	I	1 (28)	56	3.23	61	3.23
----- LATE ADOLESCENCE (16 - 19 y) - GIRLS						
Lying down	D	2 (9, 24)	48 - 48	0.82 (0.81-0.82)	18 (17 - 18)	1.00 (1.00-1.00)
	I	1 (2)	43	1.10	18	1.07
Sitting quietly, reading, writing	D	4 (4,8,9,24)	44 - 56	0.98 (0.88-1.16)	21 (19 - 27)	1.24 (1.18-1.37)

Type of activity	a Country	b No. of studies (children)	c Weight (kg)	Energy cost of activities		
				kcal/min	kcal/kg/min	x BMR
Standing quietly, little movement	D	4 (4, 8, 9, 24)	44 - 56	1.08 (0.95-1.57)	24 (20 - 33)	1.37 (1.24-1.71)
Walking, free velocity, level ground	D	4 (4, 8, 9, 24)	44 - 56	2.93 (2.09-3.40)	56 (46 - 69)	3.42 (2.62-3.55)
	I	1 (2)	63	4.20	70	4.08
At school or light work (class-room, laboratory)	D	3 (2, 9, 24)	44 - 50	1.26 (1.22-1.46)	27 (26 - 29)	1.68 (1.65-1.82)
	I	1 (10)	60	1.89	31	1.83
Light and moderate household work	D	2 (9, 24)	44 - 48	2.40 (2.2*-2.60)	49 (46 - 58)	3.11 (2.94-3.57)
Leisure time, moderate play	D	1 (9)	44	2.24	50	3.08
	I	2 (10, 10)	60	2.24 (1.92-2.57)	37 (32 - 43)	2.18 (1.86-2.49)
	D	4 (1, 9, 9, 24)	44 - 70	3.32 (3.02-7.10)	71 (62 - 103)	4.44 (4.02-5.90)
Running, exercise, sports	I	1 (2)	63	4.03	47	3.88

a D = developing; I = industrialized

b Range of mean weights of the various studies

c Mean (range) of study means; weighted by the number of children or number of studies;

x BMR = multiples of BMR

d Different activities measured within the same category on the same children

e Mean of all studies by Taylor et al. (1924a,b, 1949, 1951)

f Using estimates of weight for kcal/kg/min and x BMR in one study

g Using estimates of weight for kcal/kg/min and x BMR in all studies

TABLE 11: ENERGY COST OF CATEGORIES OF ACTIVITIES AT DIFFERENT AGES,

EXPRESSED AS MULTIPLES OF BASAL METABOLIC RATE (X BMR)

	lying awake	sitting quietly	standing quietly	standing, moderate movement	walking free vel., level gr.	walking fast, up or w/load	at school or light work	light and moderate house work	leisure and moderate play	running, exercise sports
MALE AND FEMALE										
^b Preschool	1.1 (4)	1.2			2.1	2.6			1.9 - 2.5 (2)	
MALE										
School age	1.1	[1.5] (5)	[1.9] (2)	[3.0]	2.9 (2)	3.4 (3)	1.9 - 3.0		2.3 - 4.7 (5)	
Early adolescence	1.0	[1.6]	1.3 (3)	2.1 (3)	2.8 (4)	3.8 (3)			2.5 - 3.3 (2)	3.1 - 3.6 (4)
Mid adolescence	1.1 (2)	1.2 (4)	1.5	2.4	3.3 (4)	4.4 (2)			2.5	3.6
Late adolescence	1.1 (2)	1.4 (3)	1.5 (4)		3.1 (4)		1.7			3.8 - 4.1 (1)
^d Adult	1.2	1.2	1.4	2.2 - 2.7	2.8 - 3.2	3.5 - 5.7	1.3 - 2.7	2.7 - 3.7	2.2 - 4.4	4.4 - 5.6
FEMALE										
School age		[1.3] (4)	[1.6] (2)	[2.7]	2.7 (3)					
Early and mid adolesc.		1.4	1.4		3.2 (2)					
Late adolescence	1.1 (3)	1.2 (4)	1.4 (4)		3.4 (4)		1.6 - 1.8 (4)	2.9 - 3.6 (2)	1.9 - 3.1 (3)	3.9 - 5.9 (5)
^d Adult	1.2	1.2	1.5	1.5 - 2.5	3.0 - 3.4	4.0 - 4.6	1.4 - 2.7	2.7 - 3.7	2.1 - 4.2	4.2 - 6.3

a Weighted averages from tables 1-8, combining data from developing and industrialized countries. Number in parentheses: more than one activity measured in a study or more than one study done within a category of activities. Data from studies of Taylor et al. (1948a,b, 1949, 1951).

b Combined data for males and females of preschool age.

c Two studies by the same investigators, with very different results (Gandra and Bradfield, 1971; Bradfield et al., 1971).

d From FAO/WHO/UNU (1985).

TABLE 12: ENERGY COST OF CATEGORIES OF ACTIVITIES AT DIFFERENT AGES.

EXPRESSED PER UNIT OF BODY WEIGHT (CAL/KG/H)

	lying awake	sitting quietly	standing quietly	standing, moderate movement	walking free vel., level gr.	walking fast, up or w/load	at school or light work	light and moderate house work	leisure and moderate play	running, exercise sports
MALE AND FEMALE										
^b Preschool	46	47			78	98			73 - 94	
MALE										
School	35	[32] 37	[6]	[72] 69	78	110	55 - 84		61 - 126	
Early adolescence	26	[33] 28	29	52	66	103			56 - 75	68 - 122
Mid adolescence	24	28	33	52	66	94			54	67
Late adolescence	20	26	27		53		30			72 - 99
^d Adult	20	21	27	35 - 45	57	62 - 78	28 - 46	32 - 66	38 - 77	77 - 115
FEMALE										
School		[32] 32	[40]	[67]	68					
Early and mid adolesc.		27	28		59					
Late adolescence	18	21	24		57		24 - 31	41 - 58	32 - 50	67 - 100
^d Adult	20	21	25		55	62 - 75	29 - 49	31 - 64	36 - 73	73 - 109

a Weighted averages from tables 1-8, combining data from developing and industrialized countries. In brackets: data of Taylor et al. (1954a,b, 1959, 1961).

b Combined data for males and females of preschool age.

c Not studied by the same investigators, with very different results (Gandhi and Bradfield, 1971; Bradfield et al., 1971a).

d From FAO/WHO/UNU (1985).

(b) The energy costs of the activities assessed in 17- to 19-year-old boys and girls are similar to those of adults.

(c) In the few activities assessed in over-6-year-old girls and boys, girls seem to spend about 10% less energy than boys per unit of body weight.

4.4. Suggestions to estimate the energy cost of activities

In conclusion, more investigations are needed to assess the energy cost of activities performed by healthy, free-living children of all ages. In the meantime, from the data currently available, the following is suggested to estimate the energy cost of activities that have not been measured:

1. If the child's BMR is not known, calculate it with appropriate local formulas or with those of SCHOFIELD *et al.* suggested by FAO/WHO/UNU (1985).

2. For children, 15 years or older, apply to the child's BMR the same multiple of BMR determined for equivalent activities in adults.

3. For children under 15 years of age:

- (a) For sedentary activities (with little or no movement), lying down, sitting or standing without displacement, use a factor of 1.1, 1.2 or 1.4, respectively, for all children under 15 years.
- (b) For non-walking light activities, use a factor of 2.0 or 2.2 X BMR for ages 1.5-5.9 or 6.0-14.0 years, respectively.
- (c) For walking at a normal pace on level ground and for moderate activities, use a factor of 2.2 or 2.9 X BMR for ages 1.5-5.9 or 6.0-14.9 years, respectively.
- (d) For heavier activities, apply to the child's BMR the multiple of BMR determined for equivalent activities in adults, multiplied by 0.5, 0.65 or 0.8 for ages 1.5-5.9, 6.0-12.9 and 13.0-14.9 years, respectively.

These calculations will probably have a smaller error when used to estimate the energy expenditure of a group or population of children than of a single specific child.

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Discussion (summarized by B. Schürch)

Durnin's initial impression was that the estimates in Torun's Tables of energy expenditure in moderate and heavy activity might be too low. He would have expected that walking on a level surface would cost more than 3 kcal/min. The highest values for heavy activities to be found in Torun's Tables are between 30 and 40% of physical work capacity ($\dot{V}O_2$ max). Adults would occasionally expend more energy than that, and the same could be expected in children.

An important issue in this connection is, of course, if occasional pauses are included in the estimates or not. The sources from which Torun took his figures unfortunately do not always clearly indicate whether this is the case or not.

If energy cost data are used in conjunction with results of time-motion studies to make estimates of 24-hour energy expenditure it would be interesting to know if errors are more likely to be greater in energy cost or time-allocation estimates. Torun believes that both kinds of errors can be considerable, but probably more so in time-allocation data. In a time-motion study, McGregor and her colleagues observed and recorded the activity of 12- to 24-month-old children, first once every 10 minutes, then once every minute. The latter procedure made the children appear less active than the former one. Shetty argues that using BMR equations and BMR factors tends to result in overestimates of energy expenditure in the generally lighter adults of developing countries. The same as yet unexplained phenomenon might lead to overestimates of energy expenditures in children living in tropical countries.

Torun's Tables still contain many gaps and the question is raised, as to whether one could not fill them by simulating these activities in a calorimetric chamber and measuring the corresponding energy expenditure. Torun believes that energy expenditure for simulated and real-life activities would differ too much and that only data collected in free-living individuals should be used to predict energy expenditure in real life. Even if one collects energy expenditure data for free-living individuals, biases cannot be completely excluded. Torun and his colleagues usually eliminated data collected during the first 4 to 8 weeks to reduce the Hawthorne effect (which stipulates that individuals under observation act differently from individuals who are not under observation).