Br. J. Nutr. (1970), **24**, 345

A study of the energy expenditure and food intake of five boys and four girls

By JEAN W. McNAUGHTON AND AUDREY J. CAHN
Russell Grimwade School of Biochemistry, University of Melbourne, Parkville, Victoria 3052, Australia

(*Received* 26 *August* 1969—*Accepted* 2 *September* 1969)

1. Assessments were made of the energy expenditure and food intake of five boys and four girls aged between 16 and 20 years.

2. The subjects recorded their activity over a 7-day period and weighed and recorded their food intake over the same period. The energy expended by them in performing specific activities, such as sitting, standing and walking, was measured by indirect calorimetry. The total daily energy expenditure of each subject was then counted. (Values were selected from the literature for the energy cost of the activities which we did not measure.)

3. The following range of values was obtained for the energy cost per min of various activities: sitting, 1·0–1·8 kcal, standing, 1·2–2·0 kcal; walking, 2·0–7·5 kcal; office work 1·1–1·9 kcal; laboratory work 1·4–2·3 kcal; playing table tennis, 4·6 kcal; riding a bicycle, 3·6–6·0 kcal; running, 5·2–7·5 kcal.

4. The means and standard deviations for daily energy expenditure and for calorie intake, respectively, expressed in kcal, of the individual subjects were: for the boys 2677 ± 184 and 3348 ± 668, 2285 ± 91 and 2652 ± 418, 2730 ± 263 and 2985 ± 625, 2638 ± 338 and 2379 ± 204, 2594 ± 244 and 3150 ± 692; for the girls 1939 ± 234 and 2340 ± 524, 2261 ± 175 and 2064 ± 376, 2131 ± 148 and 2011 ± 389, 2104 ± 171 and 2454 ± 469.

5. There was no correlation between the daily energy expenditure and calorie intake of any subject, nor was there any relation between the weight of individual subjects and either their total energy expenditure or calorie intake.

6. It is concluded that more precise methods of measuring the energy expenditure and calorie intake of individual subjects would need to be used in order to determine if there is any correlation between these two variables over short periods.

7. The results of this study tend to confirm the findings of other workers that calorie balance is only achieved over periods longer than 7 days.

No studies have been reported on the energy expenditure and calorie intake of adolescent and young adult Australians. Such information is needed to assist in establishing realistic dietary allowances for Australians of this age-group and to determine whether the energy costs of various activities undertaken by Australian subjects are similar to those reported for their counterparts in other countries. The National Health and Medical Research Council of Australia has, in the past, used values obtained for subjects in the United Kingdom and in the United States of America, to establish dietary allowances for this age-group (National Health and Medical Research Council: Australia, 1961). The aim of the present study was to obtain information on the energy expenditure, calorie intake and the energy cost of various activities, in a group of adolescents and young adults in Australia. The results of this and an earlier study (McNaughton & Cahn, 1970) were made available to the National Health and Medical Research Council for their revision of the Dietary Allowances for Australians (National Health and Medical Research Council: Australia, 1965).

Information on energy expenditure was obtained by combining a time-and-motion study over 7 days with the measurement of the energy cost of specific activities. This factorial approach to the estimation of energy expenditure has been advocated by Orr & Leitch (1938), Passmore & Durnin (1955) and the Food and Agricultural Organization (FAO: Second Committee on Calorie Requirements, 1957), and the method has been used by a number of workers (Passmore, Thomson & Warnock, 1952; Garry, Passmore, Warnock & Durnin, 1955; Edholm, Fletcher, Widdowson & McCance, 1955; Durnin, Blake, Brockway & Drury, 1961).

METHODS

Selection of subjects

The subjects were volunteers from a secondary school, a girls' technical college and a food processing factory. The supervisory personnel at these institutions stipulated that the study must not interfere with the normal work of the subjects.

The information was obtained over a period of several months. The time of year at which information was obtained from individual subjects and the range of maximum and mean daily temperatures for the months were: subjects C.A., R.W. and M.B., May (60–45 °F) and September (65–46 °F); M.Be., February–March (80–60 °F); A.G., G.K. and R.T., March (75–55 °F); C.S. and J.S., September (65–45 °F).

Table 1. *Description of the nine subjects*

Subject	Sex	Occupation	Age: Years	Age: Months	Height (cm)	Body-wt (kg): Initial	Body-wt (kg): Final
C.A.	♂	Schoolboy	16	9	173·0	68·3	68·4
M.B.	♂	Schoolboy	16	6	186·7	66·1	66·3
R.W.	♂	Schoolboy	16	9	177·2	62·8	62·2
G.K.	♂	Trainee draughtsman	19	6	189·9	85·7	85·7
R.T.	♂	Methods engineer	20	5	179·7	74·4	74·4
C.S.	♀	Student	18	3	162·5	53·5	53·5
J.S.	♀	Student	18	5	174·0	70·75	71·7
M.Be.	♀	Laboratory technician	19	2	156·8	52·2	52·7
A.G.	♀	Trainee chemist	19	11	166·4	48·6	47·8

The stumbling block both to obtaining information about a larger number of subjects and to obtaining more information about the energy cost of specific activities proved to be the need for subjects to be available and willing to wear the respirometer, a Wolff Integrating Motor Pneumotachograph (Wolff, 1958*a*, *b*), at specific times. Hereafter, this apparatus will be referred to as the IMP. The teachers in charge of the two schools were not willing for the subjects to wear the apparatus in class because they felt it would interfere with class discipline; therefore, the students were only available during periods when they had no classes, or after school hours. On the other hand, although the supervisory staff at the factory stated they had no objection to the subjects wearing the apparatus while performing their usual duties, some of the employees teased the volunteers to such an extent that three subjects who had taken part in an earlier study and who had volunteered for this one withdrew. The three subjects from the factory who completed the study were quite at ease wearing the IMP within their own offices or the administration block, but it became obvious during the study that they tried to avoid being seen by the workmen in the main factory.

A description of the volunteers who completed the study is given in Table 1.

Heights and weights

Height was measured without shoes, and weight was recorded with the subjects wearing indoor clothes.

Activity

The subjects recorded their activity over a 7-day period using charts similar to those described by Garry *et al.* (1955). Each chart covered a period of 24 h, from midnight to midnight, by intervals of 1 min and was subdivided into separate sections for each 2 h period. A suitable code letter was used to designate each activity.

As it was not possible to stay with a subject throughout the day, they were taught to be their own observers, and each was provided with a stop-watch. In most instances a second person acted as recorder when a subject was engaged in sport.

Considerable time was spent with G.K., R.T., M.Be. and A.G. recording their activities and observing their methods of recording. R.T. was accustomed to carrying out time-and-motion studies, and the other three habitually made precise measurements. They all proved to be conscientious and co-operative subjects.

It was not possible to observe the students for long periods because their supervisors felt an observer would disrupt classes, but they appeared to be conscientious about keeping the daily records.

Food intake

Subjects weighed and recorded the amounts of food and beverages consumed each day. They were provided with a set of Salter Scales which recorded weights in 0·25 oz (7·1 g) up to 1 lb (454 g), and above that, in oz.

Subjects C.A., M.B., R.W., J.S. and M.Be. either consumed all meals at home or took food from home for their midday meals, so that they were able to weigh all the food eaten. G.K. and R.T. purchased their midday meals from Monday to Friday from a canteen but were able to weigh their food. On four occasions meals were purchased from a restaurant, once each by G.K. and C.S. and twice by R.T. In these instances the subjects recorded the size of the servings, and an estimate of the quantities of food eaten was made by one of us (J.McN.).

Subjects were seen each weekday during the 7 days of the study, and the records of the previous day's activities and food intake were reviewed in detail.

The amounts of calories and nutrients provided by the diets were calculated from tables of food composition (Watt & Merrill, 1950; Woodhill, 1952; Wilson, 1957; Osmond & Wilson, 1961).

Energy cost of specific activities

The subjects measured the energy cost of their specific activities by indirect calorimetry, using the IMP. This apparatus is designed to be worn for several hours and to provide an integrated sample of the air expired during the period.

The gas samples were analysed for oxygen and carbon dioxide content in a Scholander gas analyser (Scholander, 1947). Values for the respiratory quotients and the percentage of oxygen absorbed were derived from the results by the use of line charts (Consolazio, Johnson & Marek, 1951). The calorie value of oxygen for any given respiratory quotient was taken from Lusk's (1924) modification of the table of Zuntz & Schumburg (1901). Protein metabolism was ignored in the calculations because the contribution from protein over the short periods during which oxygen consumption was measured would probably be small. The difference in the value for calorie expenditure per min obtained by the method described and by using Weir's formula containing a correction factor for protein metabolism (Weir, 1949) was less than 1 %.

Originally we had planned to carry out experiments over several hours, but when it proved difficult to arrange for our subjects to be available for more than 1–2 h at any one time, we measured the energy cost of specific activities such as sitting, standing, walking, and running over periods up to 30 min. In general two or three determinations of the energy cost of an activity were made on each individual. As far as possible the experiments were carried out on successive days during the week in which the subject recorded his food intakes. The experiments with C.S. and J.S. were spread over several weeks because of changes in their school time-table.

One series of measurements was made on subjects C.A., M.B. and R.W. during the first school term. Another series was done later in the year in order to determine the amount of variation in two sets of values for the same subject over an interval of several months.

A determination of the energy expenditure of each subject while lying at rest was made after the 7-day food intake record had been completed. The test was carried out in the morning after subjects had fasted from 22.00 h the previous day, and after they had lain at rest in bed for 30 min.

The ventilation rates of M.B., R.W., R.T., C.S., M.Be. and A.G. while lying at rest were all recorded as being less that 6 l./min. These results were discarded because tests showed that the IMP readings were not reliable at these rates of flow. Therefore, the resting metabolic rates of these subjects were calculated from the standards of Robertson & Reid (1952) for basal metabolic rate per m^2 of body surface. Surface area was estimated from height and weight by means of a nomogram constructed from the Du Bois & Du Bois formula for surface area (Du Bois, 1927; Consolazio *et al.* 1951).

Because of problems over the availability of the subjects the energy expenditure for the following recorded activities was not measured: C.A. washing windows, performing household tasks, playing basketball, dancing; M.B. playing the flute, raking leaves; R.T. driving a car, rowing; C.S. driving a car, playing table tennis, dancing; J.S. performing household tasks, playing squash; M.Be. ironing, swimming; A.G. doing laundry.

Table 2. *Amount of time each subject spent performing various activities during the 7 days of the study expressed as a percentage of the total*

Subject	In bed	Dressing	Sitting	Standing	Walking	Household tasks	Light manual labour	Dancing	Playing flute	Riding bicycle	Running	Other sports
C.A.	35·2	2·3	33·9	14·0	10·5	0·5	2·0	0·8	—	—	0·3	0·3
M.B.	37·2	0·7	34·7	10·1	14·8	—	0·8	—	1·7	—	—	—
R.W.	32·3	1·0	37·1	10·0	13·2	—	—	—	—	5·8	0·4	—
G.K.*	45·5	—	40·0	7·4	6·9	—	—	—	—	—	0·3	—
R.T.	32·2	2·9	41·7	6·7	13·6	—	—	—	—	—	—	3·0
C.S.	35·1	3·0	42·8	11·4	6·7	—	—	0·6	—	—	0·1	0·3
J.S.	44·1	4·4	36·6	9·6	4·5	0·2	—	—	—	—	0·2	0·3
M.Be.	31·3	2·5	39·7	2·7	21·3	2·4	—	—	—	—	—	0·2
A.G.	32·5	3·6	32·4	15·9	15·3	1·0	—	—	—	—	—	—

* Dressing is included in sitting, standing and walking for this subject.

Values for the energy expended in these activities were selected on the basis of the experimental results obtained for the energy cost of other activities for each subject and of values reported in the literature.

The daily energy expenditure of each subject was computed by multiplying the time, in min, spent in each activity by the energy cost in kcal/min, and summing these amounts.

RESULTS

Activity

The amount of time each subject spent performing different activities during the experimental period is given in Table 2. There was considerable variation from day to day in the amount of time each subject spent in any activity. Several types of activity, particularly active pursuits such as sport or dancing, were sometimes engaged in only once or twice during the 7 days of the study.

Table 3. *Amount of time each subject spent in organized sports, running or riding a bicycle during the study*

Day of the week	Time (min) C.A.	M.B.	R.W.	G.K.	R.T.	C.S.	J.S.	M.Be.	A.G
Sunday	—	1	298	—	35	—	—	—	—
Monday	1	1	40	—	62	1·5	—	—	—
Tuesday	4	—	36	21	28	3	6	16	—
Wednesday	6	—	55	—	125	—	6	—	—
Thursday	5	—	31	6	25	2·5	38	—	—
Friday	28	1	89	—	27	34	5	—	—
Saturday	16	—	77	—	—	—	—	—	—
Total for week	60	3	626	27	302	41	55	16	Nil

Two subjects, G.K. and J.S., who spent more time in bed than did the other subjects, each spent much longer in bed at the weekend than on weekdays. The amount of time spent in bed by R.W. ranged from 285 to 836 min daily. He arose by 05.00 h on six mornings during the study in order to deliver newspapers by bicycle before his breakfast.

There was no particular pattern about the time spent sitting, standing and walking. With the exception of A.G., subjects whose occupations included more standing and walking spent more of their leisure time seated than those with sedentary occupations. Therefore, there was no marked difference between the total energy expenditure of subjects due to type of occupation.

R.W., G.K., R.T. and C.S. did not spend any time performing household tasks or other light manual labour during the study.

C.A. spent 202 min washing windows and 47 min helping with other household tasks on Sunday, but did not perform any manual labour during the rest of the week.

M.B. spent 75 min on one day, and 9 min on another raking leaves in the garden.

J.S., M.Be. and A.G. each performed some household tasks such as bed-making, ironing and washing clothes.

https://doi.org/10.1079/BJN19700033 Published online by Cambridge University Press

Table 4. *Means and standard deviations for the daily intake of calories and nutrients by the nine subjects*

Subject	Age (years)	Sex	Calories (kcal)	Protein (g)	Fat (g)	Carbo-hydrate (g)	Calcium (g)	Iron (mg)	Vitamin A activity (i.u.)	Thiamine (mg)	Riboflavine (mg)	Nicotinic acid equivalent (mg)	Ascor-bic acid (mg)
C.A.	16.75	♂	3348 ± 668	120 ± 23	154 ± 28	392 ± 158	0.4 ± 0.15	15.0 ± 3.7	2057 ± 473	1.2 ± 0.25	1.2 ± 0.40	47 ± 9.0	26 ± 13
M.B.	16.5	♂	2652 ± 418	94 ± 23	122 ± 31	299 ± 52	1.2 ± 0.35	11.5 ± 3.5	4058 ± 1006	1.1 ± 0.21	2.0 ± 0.40	31 ± 10.9	76 ± 50
R.W.	16.75	♂	2985 ± 625	86 ± 21	146 ± 35	343 ± 74	1.2 ± 0.56	12.4 ± 3.7	5409 ± 2757	0.9 ± 0.41	2.2 ± 0.84	30 ± 8.0	36 ± 23
G.K.	19.5	♂	2379 ± 204	89 ± 32	119 ± 46	236 ± 98	0.7 ± 0.64	12.2 ± 2.9	4045 ± 3951	1.5 ± 0.89	1.5 ± 0.96	32 ± 8.1	64 ± 55
R.T.	20.4	♂	3150 ± 692	112 ± 27	172 ± 39	321 ± 112	1.3 ± 0.52	15.2 ± 4.5	3928 ± 921	1.4 ± 0.57	2.4 ± 0.77	39 ± 10.1	76 ± 46
C.S.	18.25	♀	2340 ± 524	91 ± 18	139 ± 29	205 ± 45	1.0 ± 0.55	11.9 ± 2.1	5858 ± 2727	1.0 ± 0.19	2.0 ± 0.67	30 ± 6.4	77 ± 48
J.S.	18.4	♀	2064 ± 376	73 ± 22	106 ± 24	216 ± 107	0.6 ± 0.12	11.6 ± 3.1	3143 ± 1214	1.1 ± 0.29	1.7 ± 0.34	27 ± 8.7	55 ± 23
M.Be.	19.2	♀	2011 ± 389	71 ± 17	112 ± 30	176 ± 43	1.0 ± 0.57	8.8 ± 1.9	2089 ± 919	1.1 ± 0.37	1.7 ± 0.85	21 ± 5.6	53 ± 33
A.G.	19.9	♀	2454 ± 469	96 ± 37	128 ± 25	247 ± 71	0.8 ± 0.27	12.6 ± 2.5	3927 ± 1075	0.9 ± 0.15	2.0 ± 0.79	31 ± 10.8	74 ± 20

https://doi.org/10.1079/BJN19700033 Published online by Cambridge University Press

Table 5. *Energy cost of various activities (kcal/min) for each subject*

Subject and body-weight	Sleeping or lying at rest	Sitting	Standing	Walking on level	Walking upstairs	Office work	Laboratory work	Playing table tennis	Riding a bicycle	Running
Male										
C.A.	1·14	1·4	1·5	2·7	—	—	—	—	—	—
(68·3 kg)		1·5	1·7	2·6	—	—	—	—	—	6·9
		1·6	1·7	4·0	—	—	—	—	—	—
M.B.	1·2*	1·2	1·3	2·0	—	—	—	—	—	—
(66·1 kg)		1·2	1·3	3·0	—	—	—	—	—	—
		1·3	1·4	—	—	—	—	—	—	—
R.W.	1·2*	1·0	1·2	3·1	—	—	—	—	3·6	5·2
(62·8 kg)		1·2	1·3	3·5	—	—	—	—	6·0	7·0
		1·3	1·3	—	—	—	—	—	—	—
G.K.	1·4	1·6	1·97	3·0	—	1·7	—	—	—	7·54
(85·7 kg)		1·7	—	5·1	—	1·8	—	—	—	—
		1·8	—	7·5	—	1·9	—	—	—	—
R.T.	1·05*	1·1	1·60	4·0	—	1·15	—	4·6	—	—
(74·4 kg)		1·14	—	—	—	1·2	—	4·64	—	—
		1·2	—	—	—	—	—	—	—	—
Female										
C.S.	0·9*	1·0	1·3	3·3	—	—	—	—	—	—
(53·5 kg)		1·1	1·4	—	—	—	—	—	—	—
		1·25	—	—	—	—	—	—	—	—
J.S.	1·2	1·1	1·3	3·9	7·1	—	—	—	—	—
(70·75 kg)		1·35	1·75	4·7	—	—	—	—	—	—
		1·62	—	—	—	—	—	—	—	—
M.Be.	0·73*	1·0	1·5	2·9	—	1·1	—	—	—	—
(52·2 kg)		1·2	—	2·9	—	1·2	—	—	—	—
A.G.	0·87*	1·0	1·6	3·1	—	—	1·4	—	—	—
(48·6 kg)		1·1	—	—	—	—	1·6	—	—	—
		—	—	—	—	—	2·3	—	—	—

* Calculated from the standards for basal metabolic rate of Robertson & Reid (1952) and the Du Bois formula for surface area (Du Bois, 1927).

The amount of time the subjects spent in sport, running or riding a bicycle is shown in Table 3. R.W., who was the most active, spent at least 31 min daily riding a bicycle, and 38 min during the week running. R.T. was in training as an oarsman, and also played table tennis.

Food intake

The mean daily intake of calories and nutrients of the nine subjects is given in Table 4. It can be seen from the magnitude of the standard deviations that there was considerable day-to-day variation in each subject's intake of calories and individual

Table 6. *Daily energy expenditure (kcal) and calorie intake of nine subjects over a period of 7 days*

	Subject	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Mean	Mean calorie 'balance'
Male										
C.A.	Expenditure	2613	2917	2573	2597	2491	2962	2584	2677	
	Intake	2838	2348	3530	3744	2907	4240	3829	3348	+671
M.B.	Expenditure	2415	2349	2289	2263	2281	2283	2116	2285	
	Intake	2333	3325	2992	2106	2601	2793	2412	2652	+367
R.W.	Expenditure	2657	2548	2641	2515	2848	2625	3276	2730	
	Intake	3922	3167	3254	3422	2248	2561	2319	2985	+255
G.K.	Expenditure	2637	2446	2346	2207	3188	2890	2753	2638	
	Intake	3215	2530	1400	2238	3069	2154	2045	2379	−259
R.T.	Expenditure	3064	2391	2650	2311	2510	2647	2586	2594	
	Intake	2695	3158	4297	3272	2781	2045	3534	3150	+556
Female										
C.S.	Expenditure	1891	1943	2057	1963	2037	1774	1906	1939	
	Intake	1735	2992	2247	2160	3109	2261	1873	2340	+401
J.S.	Expenditure	2261	2346	2260	2592	2041	2145	2179	2261	
	Intake	2341	2489	2406	1482	2029	1995	1708	2064	−197
M.Be.	Expenditure	2028	1976	2227	2406	2059	2165	2055	2131	
	Intake	1545	1658	1943	2129	2708	2221	1873	2011	−120
A.G.	Expenditure	2394	2041	1825	2121	2192	2093	2061	2104	
	Intake	1771	2679	2237	2773	2797	1946	2987	2454	+350

nutrients. Fluctuations in the intake of the majority of nutrients usually reflected a change in calorie intake. This was not always true as several subjects (most notably G.K.) varied their pattern of food intake widely during the study. This in turn affected the relative amounts of nutrients provided on one day compared with another even when the number of calories provided by the food consumed on the two days did not vary very greatly. A single food item, carrots, was responsible for the variation in the daily vitamin A intake of subjects R.W., G.K. and C.S.

Energy cost of specific activities

The results obtained for the energy cost per min of various activities are shown in Table 5; the range of values obtained for each subject is also shown.

The values obtained for M.B.'s energy expenditure while walking were lower than would be expected. He was observed several times without his knowledge and each time was noted to be a very slow walker. The value of 7·5 kcal/min for the energy expended by G.K. was obtained on a warm day when the subject was walking rapidly in the open.

Energy expenditure and calorie intake

Both expenditure and intake showed considerable variation from day to day, but fluctuations in intake were greater than differences in energy expenditure (Tables 6 and 7).

Statistical analysis of the results for each individual showed that there was no correlation between the daily energy expenditure and calorie intake of any subject. On the other hand, there was a significant correlation between the mean calorie and the mean energy expenditure of the group as a whole ($r = 0{\cdot}714$, $P < 0{\cdot}05$).

There was no relation between the weight of individual subjects and either their total energy expenditure or calorie intake.

Table 7. *Individual changes in calorie balance intake minus expenditure (kcal) from day to day over a period of 7 days*

Subject	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Mean
Male								
C.A.	+225	−569	+957	+947	+416	+1278	+1245	+671
M.B.	−82	+976	+703	−157	+320	+510	+296	+367
R.W.	+1265	+619	+613	+907	−600	−64	−957	+255
G.K.	+578	+84	−946	+31	−119	−736	−708	−259
R.T.	−369	+767	+1647	+961	+271	−602	+948	+556
Female								
C.S.	−156	+1049	+190	+197	+1072	+487	−33	+401
J.S.	+80	+143	+146	−1110	−12	−150	−471	−197
M.Be.	−483	−318	−284	−277	+649	+56	−182	−120
A.G.	−623	+638	+412	+652	+605	−147	+926	+350

DISCUSSION

In spite of the differences between the activity of the individual subjects, the general trend was similar to that in our earlier study of the food intake and activity of a larger group of urban adolescents (McNaughton & Cahn, 1970); the majority of the subjects spent the greater part of their time in sedentary occupations, and very little time in activities requiring much physical exertion.

The wide scatter of values we obtained for the energy expenditure and calorie intake of individual subjects was similar to the findings of other workers (Edholm *et al.* 1955; Durnin, 1957; Harries, Hobson & Hollingsworth, 1962). The differences were greater for calorie intake than for energy expenditure. Positive or negative calorie balances over the 7 days could not be explained in terms of changes in weight during the study.

The findings indicated that, for individual subjects there were no correlations between energy expenditure, calorie intake and body-weight during the short periods studied, nor was there any relation between body size and calorie intake. These findings are in accord with the observations of other workers cited in this paper and with the studies reviewed by Thomson, Billewicz & Passmore (1961). Our subjects differed slightly from those studied by these workers in that they were, on the whole, younger and included schoolboys. However, this difference did not appear to have any importance in relation to the findings discussed in this paper.

We wish to thank Dr G. H. Jowett and Miss Betty Laby, Statistics Department, University of Melbourne, for carrying out the statistical analyses of the results. This work was supported by a Research Grant from the University of Melbourne.

REFERENCES

Consolazio, C. F., Johnson, R. E. & Marek, E. (1951). *Metabolic Methods*. St Louis: The C. V. Mosby Co.
Du Bois, E. F. (1927). *Basal Metabolism in Health and Disease*, 2nd ed. London: Baillière, Tindall and Cox.
Durnin, J. V. G. A. (1957). *J. Physiol., Lond.* **136**, 34 *P*.
Durnin, J. V. G. A., Blake, E. C., Brockway, J. M. & Drury, E. A. (1961). *Br. J. Nutr.* **15**, 499.
Edholm, O. G., Fletcher, J. G., Widdowson, E. M. & McCance, R. A. (1955). *Br. J. Nutr.* **9**, 286.
FAO: Second Committee on Calorie Requirements (1957). *F.A.O. nutr. Stud.* no. 15.
Garry, R. C., Passmore, R., Warnock, G. M. & Durnin, J. V. G. A. (1955). *Spec. Rep. Ser. med. Res. Coun., Lond.* no. 289.
Harries, J. M., Hobson, E. A. & Hollingsworth, D. F. (1962). *Proc. Nutr. Soc.* **21**, 157.
Lusk, G. (1924). *J. biol. Chem.* **59**, 41.
McNaughton, J. W. & Cahn, A. J. (1970). *Br. J. Nutr.* **24**, 331.
National Health and Medical Research Council: Australia (1961). *Med. J. Aust.* ii, 1052.
National Health and Medical Research Council: Australia (1965). *Dietary Allowances for Australians—1965 Revision*. Reprinted from Report of 60th Session, Oct. 1965. Canberra: Government Printer.
Orr, J. B. & Leitch, I. (1938). *Nutr. Abstr. Rev.* **7**, 509.
Osmond, A. & Wilson, W. (1961). *Tables of Composition of Australian Foods*. Canberra: Government Printer.
Passmore, R. & Durnin, J. V. G. A. (1955). *Physiol. Rev.* **35**, 801.
Passmore, R., Thomson, J. G. & Warnock, G. M. (1952). *Br. J. Nutr.* **6**, 253.
Robertson, J. D. & Reid, D. D. (1952). *Lancet* i, 940.
Scholander, P. F. (1947). *J. biol. Chem.* **167**, 235.
Thomson, A. M., Billewicz, W. Z. & Passmore, R. (1961). *Lancet* i, 1027.
Watt, B. K. & Merrill, A. L. (1950). *Agric. Hdbk U.S. Dep. Agric.* no. 8.
Weir, J. B. de V. (1949). *J. Physiol., Lond.* **109**, 1.
Wilson, W. (1957). *Simplified Food Composition Tables*. Canberra: Government Printer.
Wolff, H. S. (1958*a*). *J. Physiol., Lond.* **141**, 36 *P*.
Wolff, H. S. (1958*b*). *Q. Jl exp. Physiol.* **43**, 270.
Woodhill, J. (1952). *Med. J. Aust.* ii, 188.
Zuntz, N. & Schumburg, H. (1901). *Studien zu einer Physiologie des Marsches*. Berlin: A. Heischwald.

Printed in Great Britain