A cross-sectional nutritional and anthropometric study, with an interval of 7 years, on 611 young adolescent schoolchildren

By J. V. G. A. DURNIN, M. E. LONERGAN, J. GOOD and A. EWAN

Institute of Physiology, University of Glasgow, Glasgow G12 8QQ

(*Received* 12 *October* 1973 – *Accepted* 5 *November* 1973)

1. A study of the food intake, during a period of 7 consecutive days, was made on 192 boys and girls, aged 14 years, attending Glasgow schools in 1964. A similar study was done in 1971 on 419 boys and girls of the same age. The children came from all the various socio-economic backgrounds and were subdivided into four social groups.

2. The heights and body-weights of the groups studied in 1964 and 1971 were similar but the percentage contribution of fat to the body-weight had increased in the boys.

3. Between 1964 and 1971 there had been a decrease in the mean energy intake of both boys and girls of between 0·8 and 1·0 MJ (200–250 kcal)/d. A similar proportionate decrease had also occurred in the protein, fat, carbohydrate, calcium and iron contents of the diet. However, no individual had a very low intake of protein.

4. Only the boys of the poorest social group (4) showed a lower intake of nutrients than the other groups. There were almost no differences between the girls from the different socio-economic groups.

5. Eating school meals did not affect levels of total energy and nutrient intake.

6. The proportion of energy and nutrients derived from different food groups did not appear to have appreciably altered in the two surveys, although the amount of milk drunk had become less. Fish, eggs and cheese contributed surprisingly little to the diet.

7. The combination, in both sexes, of a reduction in energy intake in 1971 compared to 1964, together with, for the boys, an increased body fat content, could be accounted for by a marked reduction in physical activity.

8. Although a comparison of the energy intake of the fattest and of the thinnest boys showed no clear differentiation, there was a consistently lower energy intake, in all social groups, by the fattest girls ('fattest' 7·07 MJ (1690 kcal)/d; 'thinnest' 9·23 MJ (2207 kcal)/d).

9. These and other recent results suggest that the national (UK) recommended energy requirements, at least for this group, are too high.

More information on the nutritional status of adolescents would be of value. Adolescence is a period of life when a sufficient intake of energy and nutrients in the diet would seem of importance in order to realize the full growth potential of the individual. In the highly industrialized and developed countries, it has been hitherto accepted that large quantities of food are needed to satisfy the apparent energy and nutrient requirements of adolescents. Thus the British Medical Association's Committee on Nutrition (British Medical Association, 1950) suggested that in Britain 14-year-old boys needed 13·1 MJ (3130 kcal)/d of energy and girls 11·7 MJ (2800 kcal)/d. The FAO Committee on Calorie Requirements (FAO, 1950) recommended, for the same age group, 13·4 MJ (3200 kcal)/d for boys and 10·9 MJ (2600 kcal)/d for girls. Although these recommendations were theoretically for world-wide use, in fact they were based largely on information relevant to the highly-developed countries. Since then, all these values have been reduced. The FAO Committee on

Calorie Requirements (FAO, 1957) recommended values of 13·0 MJ (3100 kcal)/d for boys and 10·9 MJ (2600 kcal)/d for girls of 14 years, and the most recent report of the Joint FAO/WHO Expert Committee on Energy and Protein Requirements (FAO/WHO, 1973) for 14-year-olds suggests 12·1 MJ (2900 kcal)/d for boys and 10·5 MJ (2500 kcal)/d for girls. The latest values recommended for populations in Britain (Department of Health & Social Security, 1969) are 11·7 MJ (2800 kcal)/d for boys and 9·6 MJ (2300 kcal)/d for girls.

However, various objections may be made to the uncritical acceptance of even current standards (some of these objections would be known and accepted by the members of the various committees). One point concerning the general philosophy behind the recommendations might at least be open to question and that relates to the desirability of adolescents reaching their 'full growth potential'. The implication is that small people are physically inferior to tall people – although, for normal life, there is little evidence to support this thesis. A second, and more obvious objection to the current recommendations is the inadequate experimental results on which they are based. Relatively few reliable assessments have been made of the normal daily energy and nutrient intakes of adolescents; some of the more recent published papers are those of Hodges & Krehl (1965), Huenemann, Shapiro, Hampton & Mitchell (1967), and Cook, Altman, Moore, Topp & Holland (1973). Most studies have given little information on the effects of socio-economic differences within the groups investigated.

The purpose of our survey was to measure, in a group of 14-year-old boys and girls from a range of socio-economic backgrounds and attending schools in Glasgow, the normal food intake for a period of several consecutive days and also to assess the level of normal daily physical activity. Two separate studies were done, with an interval of about 7 years separating them.

EXPERIMENTAL

Subjects. A survey was carried out in 1964 on 192 boys and girls, mean age 14·5 years. In 1971, a similar study was done on 419 boys and girls, mean age 14·7 years. Table 1 gives some details of the subjects. Height, body-weight, skinfold thickness and limb girths were measured, when the subject was wearing underclothes, and body fat was calculated using the equations of Durnin & Rahaman (1967).

In the first study, the children were selected from eight schools and in the later study from eleven schools in the Glasgow area. They came from a variety of socio-economic backgrounds and results are given which subdivide the children into four socio-economic groups. These divisions were not based entirely on economic criteria and depended upon the wage-earning parent being in one of the following groups: (1) professional or managerial; (2) 'other' clerical workers; (3) skilled manual workers; (4) unskilled or unemployed. The groups approximately corresponded to the Registrar-General's classification.

Selection of subjects. No attempt was made to obtain a true random selection of subjects. However, it was hoped that undue bias was avoided to some extent by

Table 1. *Age, height, body-weight and percentage of body-weight as fat of Glasgow boys and girls in two studies* (1964 *and* 1971)

(Mean values and standard deviations)

		1964					1971				
		Combined groups	Social class*				Combined groups	Social class*			
			1	2	3	4		1	2	3	4
Boys											
No. of subjects ...		102	36	21	29	16	198	60	36	77	25
Age (years)	Mean	14·5	14·4	14·5	14·5	14·4	14·7	14·6	14·9	14·7	14·6
	SD	0·4	0·2	0·4	0·4	0·4	0·6	0·4	0·7	0·7	0·7
Height (m)	Mean	1·626	1·667	1·614	1·604	1·589	1·633	1·635	1·663	1·632	1·592
	SD	0·096	0·092	0·103	0·088	0·089	0·090	0·090	0·090	0·089	0·078
Body-wt (kg)	Mean	51·1	55·0	51·1	48·0	47·7	50·8	51·1	52·4	51·0	47·3
	SD	10·2	9·8	11·1	8·5	9·6	9·9	10·9	10·2	9·0	9·5
Skin-folds† (mm)	Mean	27·7	28·1	27·6	27·9	23·9	32·1	34·0	29·8	32·7	29·7
	SD	7·6	7·2	7·8	8·2	7·4	8·4	9·0	7·7	8·6	8·5
Fat (%)	Mean	16·3	16·4	16·3	16·4	14·9	18·4	19·1	17·4	18·6	17·4
	SD	4·1	3·9	4·2	4·5	4·0	5·1	5·4	4·2	5·2	5·1
Girls											
No. of subjects ...		90	43	27	10	10	221	64	36	88	33
Age (years)	Mean	14·5	14·3	14·7	14·7	14·6	14·7	14·7	14·8	14·7	14·7
	SD	0·5	0·6	0·2	0·3	0·4	0·6	0·5	0·6	0·6	0·6
Height (m)	Mean	1·587	1·594	1·581	1·567	1·578	1·592	1·615	1·586	1·578	1·590
	SD	0·060	0·049	0·066	0·061	0·074	0·060	0·051	0·055	0·063	0·061
Body-wt (kg)	Mean	51·8	52·9	51·4	50·1	51·9	50·7	52·6	49·8	49·8	50·0
	SD	7·7	8·5	7·4	9·5	7·1	7·7	7·4	8·3	8·0	6·1
Skin-folds† (mm)	Mean	47·0	48·8	47·1	44·7	42·8	45·0	44·4	43·3	45·9	46·1
	SD	6·0	6·2	5·5	5·1	7·5	6·1	6·5	6·1	6·1	5·0
Fat (%)	Mean	27·6	28·1	27·6	26·9	26·1	27·0	26·8	26·4	27·2	27·3
	SD	4·6	5·0	4·1	3·8	6·2	4·8	5·2	4·9	4·9	3·7

* Based on occupation of wage-earning parent, see p. 170.
† Sum of biceps, triceps, subscapular and supra-iliac skinfold thicknesses.

choosing schools in different areas of the city which were approximately representative of the various socio-economic groups and then trying to persuade as near as possible the total population of boys and girls in the required age group to volunteer. From the volunteers, a random selection was then made. The final response rate varied from 70 to 90 % in the various schools. Nevertheless, although we feel that no very large bias was introduced, we think that we did not succeed in obtaining the same percentage of the very poorest children (group 4) in the volunteers as for the other social groups.

Measurement of food intake. All of the food eaten by each individual was measured during a period of 7 consecutive days. The method was the 'weighed inventory' method of Widdowson (1947), adapted by Garry, Passmore, Warnock & Durnin (1955). Further modifications to this technique have been introduced (Lonergan, 1967).

All of the data was analysed using initially a KDF 9 and latterly an IBM 370/155 computer.

In this method each subject weighed each separate item of food eaten during the 7 d, usually just before it was eaten. Details of the method are given by Durnin, Blake, Brockway & Drury (1961). Some of the children ate school meals (lunch) and, in these instances, each item of food eaten by each individual was also weighed. The influence of school meals on the nutritional intake of the children is shown in the results.

The measurements were supervised by a team of dietitians who visited the home of each subject and explained how the various procedures were to be carried out and showed how to use the dietary balance and the plastic containers for milk, sugar, butter, marmalade and jam. The subjects were then revisited twice during the first 3 d of the survey to ensure that the measurements were being done accurately and to solve any problems that had arisen, and then another twice during the last 4 d of the survey. We have used the same method for several years on many hundreds of subjects and are moderately experienced in the difficulties which occur. An excellent review of the various methods of measuring food intake under field conditions is that of Marr (1971).

The energy and nutrient content at each meal, for the whole of each day and as an average for 7 d was calculated for each individual using tables of the composition of foods based on those of McCance & Widdowson (1960), with the addition of many extra items of newer foods.

Measurement of physical activity. In the first study on the 192 children, the total daily energy expenditure of each subject was measured by the method of Durnin & Brockway (1959). A timed record of all separate activities was obtained for the whole of each day and measurements by indirect calorimetry were done for the common 'activities', such as sitting, walking, housework, games and sport. In the second experiment on the 419 children, only an estimate of the time spent in physical activity was made but energy expenditure was not assessed. (This estimate seemed to result in very large errors in certain individuals and does not allow a direct comparison of the 1964 and 1971 studies.) The results of this part of the study have been published elsewhere (Durnin, 1971).

RESULTS

Energy and nutrient intakes

The energy and nutrient intakes for the adolescent boys and girls in the two surveys are shown in Table 2. Although the body-weights of the boys and girls were similar, the intake of energy and of all nutrients was, as expected, higher for the boys than for the girls. It was, however, perhaps unexpected that with both the boys and the girls there was a diminished intake of energy and of all the nutrients in 1971 compared to 1964, a reduction in the energy intake of 0·77 MJ (185 kcal)/d for the boys and 1·05 MJ (250 kcal)/d for the girls; this was mostly the result of a smaller carbohydrate intake.

Table 3 shows the relative energy value of the protein, fat and carbohydrate of the diets. These were very similar, both between the sexes and for the different surveys.

Table 2. *Mean daily intakes, and standard deviations, of energy and nutrients of 14-year-old Glasgow schoolchildren in 1964 and 1971 studies*

	1964 Boys		1971 Boys		1964 Girls		1971 Girls	
No. of subjects ...	102		198		90		221	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Energy (MJ)	11·69	2·07	10·92	2·33	9·50	1·42	8·45	1·95
(kcal)	2795	495	2610	555	2270	340	2020	465
Protein (g)	86	16	78	18	69	13	62	16
Fat (g)	119	24	115	29	101	18	93	25
Carbohydrate (g)	368	75	334	80	288	53	247	68
Calcium (mg)	1210	340	1020	370	938	260	796	310
Iron (mg)	16	3	14	3	13	2	11	3

Table 3. *Percentage contribution of protein, fat and carbohydrate to the total energy content of the diet of 14-year-old Glasgow schoolchildren in 1964 and 1971*

	1964 Boys	1971 Boys	1964 Girls	1971 Girls
No. of subjects ...	102	198	90	221
Energy from:				
Protein	12·3	12·0	12·2	12·3
Fat	38·4	40·0	40·2	41·4
Carbohydrate	49·3	48·0	47·6	46·3

The proportions of dietary protein were moderate and did not indicate a high proportion of protein foods. On the other hand, very few individuals had low protein intakes: the lowest value for the boys was 43 g/d in the 1971 study and only four boys, all in social group 4, had intakes of less than 50 g/d. Three girls in the 1971 study ate less than 40 g/d of protein; these values were 32, 37 and 39 g/d and only eight of the 221 girls had less than 50 g/d. In the 1964 study, none of the boys had less than 50 g/d and none of the girls less than 40 g/d of protein. There were no extraordinary intakes of fat although several girls and a few boys obtained almost 50 % of their energy from fat.

Intakes by social group

Table 4 shows the intakes of energy and nutrients for the boys and the girls in each of the four social groups. For the boys, there were no significant differences between values for social groups 1, 2 and 3 although the intakes of energy and nutrients, except iron, were lowest in group 3. However the boys in group 4 had markedly lower intakes of protein, energy, calcium and Fe than those of any other group. Nevertheless, they were only comparatively deprived and the mean intakes of protein and of the minerals were higher than the national and international recommended levels. The energy intakes were considerably lower than either the UK recommendations (11·7 MJ/d (2800 kcal/d)) or the latest FAO/WHO value (12·1 MJ/d (2900 kcal/d)).

The results for the girls were quite different from those for the boys (Table 4). There were no marked differences between values for the various social groups except

Table 4. *Mean daily energy and nutrient intakes of 14-year-old Glasgow boys and girls, subdivided into four social classes on the basis of the occupation of the wage-earning parent,* in 1964 and 1971*

	Social class	No. of subjects	Protein (g)	Fat (g)	Carbohydrate (g)	Energy (MJ)	Energy (kcal)	Calcium (mg)	Iron (mg)
					Boys				
1964	1	36	91	128	382	12·33	2947	1333	17
	2	21	87	127	366	11·97	2860	1218	16
	3	29	82	114	348	11·11	2656	1147	16
	4	16	83	108	376	11·37	2718	1079	15
1971	1	60	83	119	332	11·10	2652	1064	14
	2	36	80	119	353	11·39	2723	1087	14
	3	77	77	115	337	10·93	2614	987	14
	4	25	69	103	302	9·81	2345	925	12
					Girls				
1964	1	43	68	102	275	9·31	2225	933	13
	2	27	68	98	299	9·51	2274	891	13
	3	10	72	106	309	10·02	2396	1031	13
	4	10	70	99	303	9·64	2303	949	13
1971	1	63	67	98	235	8·52	2035	904	11
	2	37	66	94	247	8·54	2042	800	12
	3	88	58	88	248	8·21	1962	754	10
	4	33	61	97	266	8·86	2118	695	11

* For details see p. 170.

Table 5. *Influence of school lunches on total daily energy intake (MJ, kcal in parentheses) of 14-year-old Glasgow schoolchildren in 1964 and 1971*

		1964		1971			
		No. of subjects	Combined groups*	No. of subjects	Combined groups*	No. of subjects	Social group* 4
Boys	School lunch	41	11·88 (2839)	69	11·08 (2648)	9	9·63 (2301)
	No school lunch	61	11·57 (2766)	129	10·84 (2590)	16	9·92 (2370)
Girls	School lunch	24	9·57 (2287)	32	8·33 (1990)	10	9·41 (2250)
	No school lunch	66	9·45 (2259)	189	8·47 (2025)	23	8·62 (2061)

* Children subdivided into four social groups based on the occupation of the wage-earning parent, see p. 170.

that in the 1971 survey there was a considerably lower Ca intake for social group 4 and a higher intake of carbohydrate.

All intake values satisfied the UK and the international recommendations except that the energy intake in the 1971 study was reduced to a level which is now less than the recommended value.

School lunches

The relationship between school lunches and the total energy intake is shown in Table 5.

For the 1964 study the combined results for the four groups are given, but for the

Table 6. *Mean daily intakes of protein, energy, calcium and iron, and the percentage of the total intake of protein and energy, from various foodstuffs by* 14*-year-old Glasgow schoolchildren studied in* 1964 (102 *boys and* 90 *girls*) *and in* 1971 (198 *boys and* 221 *girls*)

	Protein				Energy						Ca		Fe	
	(g)		(% total)		(MJ)		(kcal)		(% total)		(mg)		(mg)	
	1964	1971	1964	1971	1964	1971	1964	1971	1964	1971	1964	1971	1964	1971
						Boys								
Meat	26·3	26·2	30·6	33·6	1·54	1·57	368	375	13·3	14·3	25	24	5·4	5·2
Fish	4·0	3·4	4·7	4·4	0·14	0·12	33	28	1·2	1·0	19	14	0·2	0·2
Eggs	4·0	3·6	4·7	4·6	0·28	0·25	68	61	2·5	2·3	20	17	0·8	0·7
Cheese	2·4	2·4	2·8	3·1	0·18	0·17	44	42	1·6	1·6	72	72	0·1	0·1
Milk	17·8	12·0	20·7	15·4	1·77	1·09	423	260	14·9	9·9	662	452	0·5	0·3
Fats	0·1	0·2	1·2	0·2	0·78	0·82	187	196	6·7	7·5	3	3	0·1	0·1
Potatoes	4·0	4·2	4·7	5·4	1·07	1·13	256	270	9·2	10·4	19	19	1·4	1·5
Bread	12·0	10·2	14·0	13·1	1·55	1·32	370	315	13·3	12·1	137	116	2·8	2·2
Cereals	2·1	2·1	2·4	2·7	0·38	0·06	91	14	3·3	0·5	5	5	0·5	0·1
Puddings	0·7	2·7	0·8	3·5	0·20	0·53	47	128	1·7	4·9	18	87	0·1	0·2
Sugar, sweets and beverages	1·8	1·9	2·1	2·5	1·61	1·59	385	381	13·6	14·5	67	67	0·7	0·7
Cakes and biscuits	5·0	3·0	5·8	3·8	1·45	0·93	346	222	12·1	8·5	95	64	1·1	0·6
Miscellaneous	5·3	6·1	5·5	7·7	0·74	1·34	177	318	6·6	12·5	69	79	2·3	2·1
						Girls								
Meat	22·1	21·2	31·9	33·9	1·25	1·27	298	302	13·2	15·0	19	20	4·4	4·1
Fish	3·2	3·0	4·6	4·9	0·11	0·11	27	26	1·2	1·3	14	13	0·2	0·2
Eggs	4·3	3·4	6·2	5·4	0·31	0·24	73	57	3·2	2·8	21	17	0·8	0·6
Cheese	1·9	2·3	2·7	3·8	0·14	0·17	34	40	1·5	2·0	57	70	0·1	0·1
Milk	13·0	9·2	18·8	14·9	1·31	0·84	312	200	13·6	9·9	480	350	0·4	0·3
Fats	0·1	0·2	0·1	0·2	0·67	0·67	160	161	7·2	8·0	3	3	0·0	0·1
Potatoes	3·0	3·5	4·3	5·7	0·83	0·95	198	228	8·8	11·3	14	16	1·2	1·3
Bread	8·8	7·2	12·7	11·5	1·15	0·93	276	221	12·3	11·0	102	80	2·1	1·6
Cereals	1·2	1·2	1·7	1·9	0·23	0·23	54	54	2·3	2·7	3	3	0·3	0·2
Puddings	0·4	1·4	0·6	2·2	0·12	0·27	28	63	1·2	3·1	11	41	0·1	0·1
Sugar, sweets and beverages	1·6	1·7	2·3	2·7	1·26	1·21	300	289	13·1	14·3	49	59	0·6	0·6
Cakes and biscuits	4·7	3·4	6·8	5·4	1·39	0·97	332	231	14·4	11·4	95	62	1·1	0·8
Miscellaneous	4·7	4·3	7·3	7·5	0·73	0·59	178	148	8·0	7·2	70	62	1·7	1·0

1971 study separate results are also given for social group 4; it was considered that values for the poorest boys and girls (group 4) might be affected by the consumption of school meals. However, Table 5 shows clearly the apparently negligible effect of school lunches. In the 1964 and in the 1971 surveys, the mean values for all the boys and girls who had eaten school meals were no different from those who did not eat a school lunch. There was also no difference in values for the boys of social group 4 although the ten girls of social group 4 who ate school lunch had a higher total food intake than those who did not. However, two of these girls had very high intakes (more than 12·55 MJ (3000 kcal)/d) which resulted in a disproportionate effect on the mean value of the small group.

It is impossible to know whether the mean intake of those who ate school meals

would have been different if no school lunches had been eaten but the influence of school meals seems to have been small in the children of these two surveys.

Nutritional intake from different foods

The contribution of the different foods to the total nutritional intake of the diet is shown in Table 6. For the boys in the 1964 and in the 1971 studies there are similarities and differences.

Protein. Meat provided the same quantity of protein in 1971 as in 1964, although the proportion of protein derived from meat increased in the later study because the total protein intake had become reduced. Milk was still a very important source of protein in 1971 but the intake was less than in 1964. Bread continued to provide considerable quantities of protein but the intakes from fish, eggs and cheese were surprisingly small.

Energy. The principal sources of energy were: (*a*) meat; (*b*) sugar, sweets and beverages; (*c*) bread; (*d*) potatoes; (*e*) milk; (*f*) cakes and biscuits; (*g*) fats. Milk, bread, cakes and biscuits were relatively less important energy sources in the later survey.

Ca and Fe. Milk was obviously a very important source of Ca in both surveys, contributing almost 60 % of the total Ca intake in 1964 and almost 50 % in 1971. Eggs and cheese again were much smaller sources than might have been expected. Apart from meat, the only foods eaten which contained appreciable amounts of Fe were bread and potatoes.

The pattern of eating of the girls was, proportionately, almost identical to that of the boys, both in relation to the foods consumed and to the rather small changes which occurred after the 7-year interval between the studies. The contribution of sugar, sweets and beverages to the total energy of the diet (on average about 14 % in each of the separate studies) was perhaps smaller than might have been expected in this age group.

Differences between social groups were small for both the boys and the girls. The boys of social class 1 (the professional and managerial group) ate slightly more fish and slightly more cheese than the poorest group (4); but, perhaps surprisingly, there were almost no differences between the groups of girls.

Effects of weekdays and weekends on food intake

The mean protein and energy intakes for the 5 weekdays were analysed to see if they were significantly different from the intakes on Saturday and from the intakes on Sunday using the combined values for the four groups of boys and for the four groups of girls and also values for each of the four social groups of each sex for the 1971 survey. There was no significant difference between any of the compared values.

Comparison of food intake on first and last days of survey

The protein and energy intakes on the 1st day of the 1971 survey and on the last (7th) day were compared for all the boys and all the girls and for each of the four social groups. This statistical analysis was carried out to determine whether the

survey had interfered with the normal routine of the individual subject and, if so, whether the intake on day 1 might be higher or lower than normal and, with the passage of some days, whether this difference became less marked. Therefore values for the last day might be more similar to the normal intake and might be significantly different from those for day 1.

For the boys one significant difference ($P < 0.05$) was found; the energy intake of the sixty boys in social class 1 was about 0·84 MJ (200 kcal) higher on day 1 than on day 7.

There were other differences between the various intake values of the girls. In the eighty-eight girls of social class 3, the intake of protein was 6 g higher ($P < 0.05$) and the energy intake was 1·42 MJ (340 kcal) higher ($P < 0.001$) on day 1 than on day 7. The thirty-three girls of social class 4 consumed 1·26 MJ (300 kcal) more energy on day 1 than on day 7 ($P < 0.05$).

These results show the possibility that the results of some individuals might not always represent the 'normal'. However, the over-all influence on the mean values was probably small and would not affect the implications of the results.

DISCUSSION

There are one or two aspects of the anthropometric results which require explanation. All the boys and all the girls in the 1964 and in the 1971 studies were of similar age, height and body-weight. For the girls, the percentage contribution of fat to the body-weight was similar, although there was a consistent (in all social groups) increase in body fat of the boys in the 1971 study compared to that of the earlier study. There were small discrepancies in the heights and weights between some of the social groups, probably because of the small numbers of subjects in some of these groups. However, if the combined values for the four groups are accepted as reasonably representative, the relationship between the total daily energy intake in the food and the body-fat content indicates some remarkable changes in the relatively short time between 1964 and 1971. Both boys and girls show a reduction in mean energy intake of about 0·8–1·0 MJ (200–250 kcal)/d during this period and, for the boys, this is accompanied by an increase in body fat. The most plausible explanation seems to be that there was a marked diminution in physical activity, and it is unfortunate that the estimates of physical activity made in the 1971 study were not sufficiently comparable to the 1964 values for this suggestion to be confirmed by direct observation. If this explanation is true and applicable to other populations, it has considerable nutritional importance. That the results of the 1971 study were not unusual is suggested by the findings of Cook *et al.* (1973). The protein and energy intakes of 191 boys and 191 girls aged 13 to 15 years, living in Kent, England, were almost identical to our values. Similar results were reported (Department of Health & Social Security, unpublished results) in a study of ninety-three boys and eighty-five girls, aged 14–15 years, living in Newcastle upon Tyne.

It may be, therefore, that at least in the UK the daily energy intake of adolescents is steadily falling. There has been an obvious alteration since the surveys of Widdowson

Table 7. *Relationship of daily energy intake (MJ, kcal in parentheses) and 'fatness' or 'thinness' of 14-year-old Glasgow children* in 1971*

	Combined groups†	Social class†			
		1	2	3	4
Boys					
Thinnest	10·84 (2590)	11·28 (2696)	9·16 (2189)	12·86 (3073)	7·81 (1867)
Fattest	10·64 (2543)	9·60 (2295)	12·55 (2999)	12·53 (2995)	10·64 (2543)
Girls					
Thinnest	9·23 (2207)	9·95 (2378)	8·82 (2109)	8·45 (2019)	10·15 (2427)
Fattest	7·07 (1690)	6·45 (1542)	8·19 (1958)	6·96 (1664)	7·62 (1821)

* Groups composed of the 'fattest' and 'thinnest' 10% of the respective populations, based on body fat derived from skinfold thickness (Durnin & Rahaman, 1967).

† Subdivided on the basis of occupation of wage-earning parent, see p. 170.

(1947) which were done in the middle and late 1930s. In her study, the energy intake of 14-year-old boys was 12·8 MJ (3065 kcal)/d and of 14-year-old girls 11·0 MJ (2637 kcal)/d. The body-weights of these children were not significantly different from those in our study.

The fall in energy intake found in our studies was also accompanied, in some groups, by an increasing proportion of fat in the body. There is little reason to suppose that this trend is restricted to adolescents – indeed adolescents might form a group who would demonstrate the trend to a lesser degree than adults. More information on other groups is urgently needed which might indicate that energy and nutrient recommendations for populations must be reassessed.

Body fat and energy intake. There are few reports of studies of the relationship between 'fatness' or 'thinness' and food intake. In the 1971 study, the 'fattest' and the 'thinnest' 10% of the boys and of the girls were compared for their energy intake. Table 7 shows these results for the combined groups and for each socio-economic group. The results for the boys are somewhat confusing, but those for the girls show a consistently higher energy intake for the thinnest girls. Similar results were reported by Johnson, Burke & Mayer (1956) and by Hampton, Huenemann, Shapiro & Mitchell (1967). This finding might be the result of a conscious effort on the part of the fattest girls to restrict their food intake during the investigation, although we think this is unlikely. We tried frequently to persuade each individual not to alter their normal routine in any way, particularly their eating habits. Although it is impossible to be certain of the success of this persuasion, the impression we obtained from almost daily contacts with the subjects was that these eating habits were not unusually disturbed and that the fattest girls did not behave in any different way, in this respect, from the thinnest girls. Also, as is medically well known, it is notoriously difficult to influence obese adolescents to reduce their food intake.

We suggest therefore that the fattest girls in this study were considerably less physically active than the thinnest girls and thus needed less food.

We are grateful to the Director and the Deputy Director of Education of the City

of Glasgow, and the headmasters, headmistresses, teachers and pupils of the various schools who participated in these studies. We are indebted to Mrs A. Parker, Computing Department, University of Glasgow for much help in the calculation and analysis of the data. The earlier study was financed by a grant from the Medical Research Council, and the 1971 study by a grant from the Scottish Home and Health Department, and we are grateful to these bodies for this financial help.

REFERENCES

British Medical Association (1950). *Report of the Committee on Nutrition.* London: British Medical Association.
Cook, J., Altman, D. G., Moore, D. M. C., Topp, S. G. & Holland, W. W. (1973). *Br. J. prev. soc. Med.* **27**, 91.
Department of Health and Social Security. (1969). *Rep. publ. Hlth med. Subj., Lond.* no. 120.
Durnin, J. V. G. A. (1971). *Acta paediat., Stockh.* **217**, Suppl. 133.
Durnin, J. V. G. A. & Brockway, J. M. (1959). *Br. J. Nutr.* **13**, 41.
Durnin, J. V. G. A., Blake, E. C., Brockway, J. M. & Drury, E. A. (1961). *Br. J. Nutr.* **15**, 499.
Durnin, J. V. G. A. & Rahaman, M. M. (1967). *Br. J. Nutr.* **21**, 681.
FAO (1950). *F.A.O. nutr. Stud.* no. 5.
FAO (1957). *F.A.O. nutr. Stud.* no. 15.
FAO/WHO (1973). *F.A.O. nutr. Mtg Rep. Ser.* no. 52.
Garry, R. C., Passmore, R., Warnock, G. M. & Durnin, J. V. G. A. (1955). *Spec. Rep. Ser. med. Res. Coun.* no. 289.
Hampton, M. C., Huenemann, R. L., Shapiro, L. R. & Mitchell, B. W. (1967). *J. Am. diet. Ass.* **50**, 385.
Huenemann, R. L., Shapiro, L. R., Hampton, M. C. & Mitchell, B. W. (1967). *J. Am. diet. Ass.* **51**, 433.
Hodges, R. E. & Krehl, W. A. (1965). *Am. J. clin. Nutr.* **17**, 200.
Johnson, M. L., Burke, B. S. & Mayer, J. (1956). *Am. J. clin. Nutr.* **4**, 37.
Lonergan, M. E. (1967). The food intake and energy expenditure of adolescent schoolchildren. MSc Thesis, University of Glasgow.
Marr, J. W. (1971). *Wld Rev. Nutr. Diet.* **13**, 105.
McCance, R. A. & Widdowson, E. M. (1960). *Spec. Rep. Ser. med. Res. Coun.* no. 297.
Widdowson, E. M. (1947). *Spec. Rep. Ser. med. Res. Coun.* no. 257.

Printed in Great Britain