Total energy expenditure and physical activity as assessed by the doubly labeled water method in Swedish adolescents in whom energy intake was underestimated by 7-d diet records

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ABSTRACT Swedish children and adolescents may be adopting a sedentary lifestyle with low energy expenditures and intakes, but no quantitative data are available. The purpose of the present study in 50 adolescents aged 15 y was to investigate whether assessment of total energy expenditure (TEE) and physical activity level (PAL) by the doubly labeled water method and indirect calorimetry and estimation of energy intake by a 7-d diet record would indicate physical inactivity. The boys’ (n = 25) mean weight was 112% and the girls’ (n = 25) 109% of Swedish reference values from 1976; the mean height of both boys and girls was 102% of those reference values. Mean TEE in the boys and girls, 13.82 ± 1.90 and 10.70 ± 1.59 MJ/d, and mean PAL (TEE/basal metabolic rate), 1.89 ± 0.16 and 1.79 ± 0.22, respectively, were nonsignificantly higher than corresponding figures from other published studies. Mean energy intake as a percentage of TEE was 81.9 ± 17.9% in the boys and 78.3 ± 16.4% in the girls. Significant negative correlations were found both between energy intake as a percentage of TEE and percentage body fat and between energy intake as a percentage of TEE and body mass index. These results add to the evidence that 7-d diet records underestimate energy intake in adolescents, particularly those with a tendency for overweight and increased body fat. The results support indications of a trend of increasing body weight and height in Swedish adolescents, but conflict with the presumptions of low physical activity, low energy expenditure, and low energy intake. These results support the view that current recommendations for energy intake during adolescence are too low. Am J Clin Nutr 1998;67:905–11.

KEY WORDS Total energy expenditure, physical activity, doubly labeled water method, energy intake, body composition, basal metabolic rate, adolescents, diet record, Sweden

INTRODUCTION

Studies undertaken over the past few decades have indicated changing patterns of diet and activity in Swedish children and adolescents. A gradual decline in assessed energy intake has been observed, while at the same time body weight, height, and estimated fat content have been found to be increasing (1–5). It has been suggested that these conflicting findings are explained by reduced physical activity of these children (3, 4). Epidemiologic studies have indicated that most Swedish adolescents participate in organized sports but that their involvement in spontaneous physical activities has decreased over the past few decades (6).

Until recently, no methods were available to quantitatively measure habitual physical activity or energy expenditure without the risk of interfering with activity habits. The doubly labeled water (DLW) method now makes it possible to take valid measurements of total energy expenditure (TEE) in free-living subjects without influencing their daily life. When the results of such measurements are combined with estimates of the basal metabolic rate (BMR) and TEE is expressed as a multiple of BMR, a measure of the physical activity level (PAL) that is not affected by body size or sex is obtained.

No such quantitative measurements of physical activity and daily energy expenditure have been made previously in Swedish children or adolescents. Consequently, the assumption of low energy expenditure resulting from low physical activity has not been verified. Furthermore, the earlier findings of low energy intakes in children and adolescents have to be reexamined because the validity of the methods used for measuring energy intake has been seriously questioned (7–12). Hitherto, such methods were rarely fully validated because no relevant gold standard was available. The DLW method is now acknowledged as such a reference, and in several validation studies a bias toward underestimation of energy intake was found on comparison with TEE assessed by the DLW method (11, 12).

Assessment of energy intake in normal adolescents has been validated by the DLW method in only two studies, comprising a total of 62 subjects (8, 9). In both of these studies energy intake assessed by diet records—previously regarded as the most accurate method for such measurements—was underestimated compared with TEE. However, in a recent review Torun et al (10) stated that there have been too few studies in children and adolescents in which both energy intake and TEE were investigated to allow the nature and extent of the bias involved in these measurements to be ascertained. The purpose of the present study was to determine whether assessment of TEE and PAL with the DLW...
method and indirect calorimetry would indicate physical inactivity in 15-y-old adolescents and to evaluate the accuracy of energy intake as estimated by a 7-d diet record.

SUBJECTS AND METHODS

Subjects

Two cohorts of a total of 600 adolescents aged 15 y living in the university city of Uppsala and the industrial town of Trollhättan were selected by a randomization computer program (SAS version 5.18; SAS Institute Inc, Cary, NC) from a database containing the official population register of 15-y-old adolescents in the two regions. The selected subjects were mailed an invitation to participate in an extensive investigation of dietary habits, physical activity, energy expenditure, and bone density (13, 14). The inclusion criteria were that subjects lived in the central areas of the two cities and were healthy according to school health records and a clinical examination performed during the study and that their parents were of Swedish origin. Four hundred eleven adolescents from Trollhättan and Uppsala agreed to enter the study. Those invited adolescents who refused to participate were mailed the same questionnaire given to the participants concerning their family, social situation, activity habits, and attitudes toward physical activity and sports. These questionnaires were answered by all participants and 72% of the dropouts. Information was also obtained about the participants’ and nonparticipants’ weights and lengths or heights at birth from the official Swedish Birth Register and at 15 y of age from School Health Services. The study was approved by the Ethics Research Committee of the Medical Faculty of Uppsala University.

No significant differences in mean weights and heights at birth and at 15 y were found between the study group and the dropouts. The participants also did not differ from the nonparticipants in their socioeconomic background, except regarding their mother’s education, which was slightly higher in the study group dropouts. The participants also did not differ from the nonparticipants in their socioeconomic background and no significant differences in activity habits or in mean weights and heights at birth or at age 15 y were found.

Protocol

The measurements were spread evenly over the four seasons. Three to five days before the start of each study the subjects collected predose urine samples. After fasting overnight, the subjects were taken to the hospital from home by car. Body weight of the subjects in light underwear was measured to the nearest 0.1 kg after the subjects emptied their bladders, and height was measured to the nearest 0.5 cm. At 0800 the subjects were given an oral dose of DLW. Immediately afterward, they were allowed to rest for 15–30 min. BMR was then measured, after which a light breakfast was served. Instructions for assessing dietary intake were given by a nutritionist and a clinical examination was performed by a pediatrician. The adolescents were informed about the importance of not changing their usual activity or food habits during the study.

The doubly labeled water method

TEE and total body water (TBW) were measured by the DLW method (15). An oral dose of 0.15 g 2 H 2 O and 0.3 g H 18 O/kg estimated TBW was given. The dosing bottle was weighed before and after dosing. Postdose urine samples were collected at ≈1500, 1900, and 2200 on the day of dosing and at ≈2000 thereafter for 14 d.

Isotope enrichments of the urine samples were analyzed in duplicate relative to laboratory references, standardized against Vienna standard mean ocean water and standard light Arctic precipitation, by using an isotope-ratio mass spectrometer (SIRA, Series II; VG Isogas Ltd, Middlewich, United Kingdom). Ratios of 2 H to 1 H were analyzed after reduction of water to hydrogen gas at 500 °C with use of 200 mg zinc reagent (The Biochemical Lab; Indiana University, Bloomington, IN). Ratios of 18 O to 16 O were analyzed after 5 h of carbon dioxide equilibration at 25 °C by using Isoprep18 (VG Isogas). The analytic precision, including that of the preparation of the analytic gases, was 0.58 ppm (mole fraction) for 2 H and 0.49 ppm (mole fraction) for 18 O.

Because Ritz et al (16) showed that 1 H enrichment in urine is underestimated by the zinc reduction method, which affects the calculated distribution volume but not the slope of isotope disappearance, TBW was calculated as the 18 O distribution space (N 18 O) divided by 1.007 (17) after extrapolation to dosing time by using points between 8 h and 1 wk after dosing. This variable is referred to as TBW O. The carbon dioxide production rate (rCO 2 ) was calculated from results obtained at time points between 8 h and 2 wk (8 h and 1 wk in the validation of energy intake) after dosing. In these calculations we used the ratio of N 18 O (the deu-
where EE is energy expenditure in kJ/d, carbon dioxide production according to the formula of Weir (20):

\[ r_{CO_2} = \left(\frac{N}{2.078} \times (1.007 \times k_d - 1.041 \times k_d - 0.0246 \times 1.057 \times (1.007 \times k_d - 1.041 \times k_d)) \right) \]

where \( k_d \) is the rate constant for \(^{18}\)O and \( k_0 \) is the rate constant for deuterium and \( N \) (distribution space) was calculated as \( TBW_0 \times (1.007 + 1.041)/2 \).

During the first 7 d of the DLW measurement, the food intake of each subject was estimated by a combined weighed and estimated diet record as described below. The nutrient content and food quotient were calculated (18). TEE was estimated as proposed by Elia (19) from carbon dioxide production (ICO2) and with the mean food quotient representing the respiratory quotient:

\[ TEE (MJ/d) = V \times CO_2 \times 22.4 \times EeqCO_2 \times 0.001 \]

where EeqCO\(_2\) (MJ/mol), the energy equivalence of CO\(_2\), is 15.48/food quotient + 5.55.

Fat-free mass was calculated as TBW/0.732, total body fat as body weight – fat-free mass, and percentage body fat as total body fat/body weight × 100.

**Basal metabolic rate**

At 0800, immediately after the dosing for the DLW study, the subjects were asked to lie in a recumbent position in a quiet room at 22°C for 15–30 min. BMR was then measured for 30 min by open-circuit indirect calorimetry with a ventilated hood (Oxycon Sigma; Mijnhardt, Bunnik, Holland). The metabolic rate was calculated automatically from oxygen consumption and carbon dioxide production according to the formula of Weir (20):

\[ EE = 3.94 \times V \times O_2 + 1.11 \times V \times CO_2 - 2.17 \times UN \]

where EE is energy expenditure in kJ/d, \( V \times O_2 \) is oxygen consumption in mL/min, \( V \times CO_2 \) is carbon dioxide production in mL/min, and UN is urea nitrogen production in g/L, assuming a urea nitrogen production rate of 13 g/d. In the calculation of BMR, the first 5 min of the BMR measurement were omitted.

**Diet record**

The adolescents kept records of all foods and fluids consumed over 7 consecutive days after instruction by a specially trained nutritionist. The subjects were issued a logbook for the recordings, dietary scales (article no. 8021; Soehnle, Mohardt, Germany) for weighing all foods and fluids consumed at home, and the Meal Model (21), a booklet with illustrations of foods and photographs of portion sizes that helped subjects in estimating amounts of food eaten outside the home. Subjects were given detailed instructions for and demonstrations of the cumulative weighing technique, the use of food pictures, and recording in the logbook. Subjects were encouraged to contact the investigators by telephone at any time during the following days in case of doubt about recording. After 7 d the nutritionist and each subject scrutinized the record, discussed the recorded intake, and supplemented the recording if necessary.

The estimated intake of foods and fluids was converted to weights by use of a standardized system (22). Food items were coded and processed in a computer. A data bank of the energy and nutrient contents of 1100 different foods and 500 dishes from the Swedish National Food Administration (23) was used in the computer program.

**Statistical analysis**

Statistical probability was assessed by use of Student’s unpaired \( t \) test. Correlations between variables were examined by using linear regression analysis. Values were considered significant at \( P < 0.05 \).

**RESULTS**

The subjects were studied around their 15th birthdays (range: 1 mo before to 3 mo after). They were all in good health as assessed in the clinical examination. Advanced puberty (Tanner stages 4–5) had been reached by 64% of the boys and 92% of the girls. The mean Tanner stage was 4.00 ± 1.15 in the boys and 4.56 ± 0.65 in the girls. Some of the subjects’ physical characteristics are presented in Table 1. The mean weight of the boys was 112% and that of the girls 109% of the currently used Swedish reference values (24), which are for 15-y-old adolescents born 20 y earlier than the subjects of the present study. The mean height of both boys and girls was 102% of the reference value. The mean weights of the boys and girls in the present study were 5% and 3% greater, respectively, and the mean height 1% greater than those of Swedish adolescents born only 5 y earlier (B Werner, personal communication, 1995). There were no significant differences in mean weight and body mass index between boys and girls in the present study. Mean height, estimated fat-free mass, and TBW, however, were significantly greater in boys and estimated percentage body fat significantly lower than in girls.

The results of the energy expenditure measurements and energy intake assessments are presented in Table 2. The mean BMR, TEE, and activity energy expenditure (TEE – BMR) were significantly higher in boys than in girls; there was no significant sex difference in the PAL. The measured BMR values (7.3 MJ/d in boys and 6.0 MJ/d in girls) did not differ significantly from the corresponding predicted values obtained as described by Schofield (25). To validate the PAL, the relation between this index and BMR was analyzed; as expected, no significant correlation was found (boys: \( r = 0.060 \); girls: \( r = 0.007 \); boys + girls: \( r = 0.204 \)).

In only eight subjects was recorded energy intake higher than TEE (Figure 1). Mean energy intake as a percentage of TEE in

<table>
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<tr>
<th>TABLE 1</th>
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<tr>
<td><strong>Physical characteristics of the subjects</strong></td>
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<tr>
<td><strong>Boys (n = 25)</strong></td>
</tr>
<tr>
<td>Age (y)</td>
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<tr>
<td>Tanner stage (1–5)</td>
</tr>
<tr>
<td>Weight (kg)</td>
</tr>
<tr>
<td>Height (m)</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
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<tr>
<td>Fat-free mass (kg)</td>
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<tr>
<td>Percentage body fat (%)</td>
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<tr>
<td>Total body water (kg)</td>
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<td>(%)</td>
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\(^1\) \( \bar{x} \) ± SD.

\(^2\) Significantly different from boys, \( P < 0.001 \).
girls, 78.3% (range: 51.5–110.7%), was not significantly lower than that in boys (81.9%; range: 30.0–108.4%). When the boys and girls were divided into three equal groups on the basis of their TEE and PAL values, no significant difference in energy intake as a percentage of TEE was found in either boys or girls.

**DISCUSSION**

The subjects included in this study were randomly selected from the population register. As described earlier, we calculated the mean TEE and PAL for both the participants and nonparticipants (i.e., for the entire randomly selected sample of 600 adolescents). No significant differences in TEE or PAL were found between the participants and the whole sample. Thus, we concluded that for TEE and PAL these adolescents were representative of the population from which they were randomly selected. The adolescents were studied around their 15th birthdays to define the sample as accurately as possible, and the investigations were spread evenly over the seasons to avoid effects of any seasonal variations in TEE or PAL.

The question of whether children and adolescents, like adults, have adopted a sedentary lifestyle has been discussed in recent decades not only in Sweden but also in several other industrialized countries (26–29). If the assumption of a low activity level in children were true, the future public health of these societies would be significantly affected. Surprisingly, habitual levels of physical activity and TEE have been measured with use of accurate methods in only a small number of healthy children and it is uncertain whether any of the few studies published to date were based on samples representative of the population from which they were drawn.

The present anthropometric results fit closely with those of earlier studies (1–5) showing a trend over three decades of increasing weight, height, and body mass index in Swedish children and adolescents. The values for percentage body fat in the adolescents of the present study, which were estimated from TBW measurements, are similar to those reported for 15-y-old boys and girls from Boston and Belfast, Northern Ireland, by Bandini et al (30) and Livingstone et al (31), respectively, using the same technique as in the present study, and also agree with the results of Forbes (32). In previous investigations (4) we found a gradual increase in body fat content, based on skinfold-thickness measurements over the decades, in children aged <14 y, but no such data are available for adolescents. Hence, we do not know whether body fat content has increased in Swedish 15-y-old adolescents over the past few decades. If so, this need not indicate that adolescents have reduced their physical activity over these years. An increase in body fat can be expected as a result of the earlier sexual maturation in Swedish children that has taken place during this period and the increase in body fat content during puberty that normally occurs not only in girls but also in boys (32).

In the present study the DLW method was used because it is considered to provide the most accurate measurements of TEE and PAL in free-living children and adolescents (10). Three investigations of TEE and PAL measured by the DLW method in 15-y-old adolescents have been published. The results from two of these are summarized in Table 3 and Table 4 together with those of the present study. The results obtained in the study by Livingstone et al (31), which comprised only three boys and three girls aged 15 y, the same subjects who also seem to have been included in the study by Davies et al (33), are not presented separately in this table. Note that the age variation was much larger (SD for boys: 1.5 y; SD for girls: 1.0 y) and the mean age and Tanner stages were lower in the study by Bandini et al (30) than in the present study.

The TEEs of the Swedish adolescents in this study, 13.82 MJ/d in the boys and 10.70 MJ/d in the girls, are not significantly greater than the mean TEE values reported by Bandini et al (30) or Davies et al (33). The adolescents in the present study, however, were taller and heavier than those studied by Bandini et al (30). When TEE was calculated per kilogram body weight and per kilogram fat-free mass, the results of the present study and

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**TABLE 2**

<table>
<thead>
<tr>
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<th>Boys (n = 25)</th>
<th>Girls (n = 25)</th>
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<tbody>
<tr>
<td>BMR (MJ/d)</td>
<td>7.31 ± 0.75</td>
<td>5.97 ± 0.57</td>
</tr>
<tr>
<td>TEE (MJ/d)</td>
<td>13.82 ± 1.90</td>
<td>10.70 ± 1.59</td>
</tr>
<tr>
<td>AEE (MJ/d)</td>
<td>6.50 ± 1.38</td>
<td>4.74 ± 1.32</td>
</tr>
<tr>
<td>PAL</td>
<td>1.89 ± 0.16</td>
<td>1.79 ± 0.22</td>
</tr>
<tr>
<td>TEE/BW (kJ · d⁻¹ · kg⁻¹)</td>
<td>227 ± 30</td>
<td>184 ± 25</td>
</tr>
<tr>
<td>TEE/FFM (kJ · d⁻¹ · kg⁻¹)</td>
<td>270 ± 29</td>
<td>255 ± 23</td>
</tr>
<tr>
<td>BMR/BW (kJ · d⁻¹ · kg⁻¹)</td>
<td>121 ± 16</td>
<td>103 ± 13</td>
</tr>
<tr>
<td>BMR/FFM (kJ · d⁻¹ · kg⁻¹)</td>
<td>143 ± 14</td>
<td>143 ± 11</td>
</tr>
<tr>
<td>AEE/BW (kJ · d⁻¹ · kg⁻¹)</td>
<td>107 ± 20</td>
<td>81 ± 21</td>
</tr>
<tr>
<td>AEE/FFM (kJ · d⁻¹ · kg⁻¹)</td>
<td>127 ± 23</td>
<td>112 ± 26</td>
</tr>
<tr>
<td>EI (MJ/d)</td>
<td>11.40 ± 2.71</td>
<td>8.28 ± 1.88</td>
</tr>
<tr>
<td>100 × EI/TEE (%)</td>
<td>81.9 ± 17.9</td>
<td>78.3 ± 16.4</td>
</tr>
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1 P < 0.001; 2 P < 0.05.

TEE calculated for 14 d after dosing.

TEE calculated for the 7-d period of the EI assessment.

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**FIGURE 1.** Comparison of total energy expenditure (TEE) measured by the doubly labeled water method and energy intake (EI) assessed by diet record. Boys, open symbols; girls, filled symbols. The identity line is shown.
those of the study by Bandini et al (30) were almost identical (Tables 3 and 4). However, the estimates of TEE in 15-y-old adolescents in all three studies are high compared with current national and international recommendations for energy intake (34). These recommendations, which seem too low (10), are based on factorial calculations of energy requirements. The FAO/WHO/UNU report states, however, that estimates of energy requirements should be based on measurements of energy expenditure (34). Work aimed at establishing new recommendations is now in progress.

The mean PAL estimates of the present study were not significantly higher than those made by Bandini et al (30); for the boys the figure was close to that reported by Davies et al (33). The mean PAL values of the 15-y-old girls in the studies of Davies et al (33) and Bandini et al (30) were almost identical. It is impossible, however, to test the mean PAL values reported by Davies et al (33) against those of other studies for any significant differences because Davies et al did not publish the corresponding SDs. All of the mean PAL estimates in boys and girls in the present study and in the investigations by Davies et al (33) and Bandini et al (30) are high compared with the corresponding FAO/WHO/UNU (34) factorial estimates for 15-y-old boys (1.65) and girls (1.55).

In a recent review of PALs of children and adolescents, Torun et al (10) suggested mean PAL values for estimation of TEE and energy requirements for children and adolescents with different levels of habitual physical activity. The proposed mean PAL values for boys aged 14–18 y with light, moderate, and high habitual activity are 1.60, 1.80, and 2.05, and the corresponding values for girls are 1.45, 1.65, and 1.85, respectively. With use of these values as references, the mean PAL values of boys and girls in the present study, 1.89 and 1.79, respectively, are high, but not uniquely so. The mean PAL values of 12- and 18-y-old girls in the study by Davies et al (33) were 1.75 and 1.88, respectively, and the value in 18-y-old boys was 2.01. The findings of a high level of daily energy expenditure and physical activity in the adolescents in the present study are supported by the fact that on the questionnaire most of the subjects expressed a positive attitude toward physical activity and sports: 80% walked or bicycled to and from school, almost all took part in school physical education, and 62% trained regularly during their leisure time.

Although the 15-y-old adolescents in this study were selected randomly and this is the largest DLW study in this age group published hitherto with as many subjects as have been investigated in total by this method previously, a sample of 50 subjects is too small to allow general conclusions to be drawn about TEE and PAL in Swedish adolescents. This question is addressed further in a separate publication in which daily energy expenditure and physical activity were assessed through use of an activity diary in 374 randomly selected adolescents (including the sample in the present investigation) (14).

The use of TEE as assessed by the DLW method has now generally been accepted as a reference in the validation of dietary intake methods (11, 12). The measurement of TEE to validate methods used to estimate energy intake assumes that the subjects being investigated are in energy balance. In this study, the mean weight change in the boys was 0.12 kg and in the girls was −0.09 kg during the study week; mean changes in body weight from 3–4 d before the start of the study and 7 d after the end of the diet recording were on the same order of magnitude. Thus, changes in body energy stores in these subjects were less than a few percentages of their TEEs, indicating further that the mean energy intake during the study represented the subjects’ habitual intakes. Thus, their TEE can be considered equivalent to their true energy intake during this period and their low recorded energy intake in relation to TEE may be regarded as a result of underreporting rather than undereating.

In only two previous studies was energy intake validated by the DLW method in healthy adolescents. In 28 lean adolescents with a mean age of 14.5 y studied by Bandini et al (8), energy intake was 80.2% of TEE. In 12 adolescents aged 15 y studied by Livingstone et al (35), energy intake in the boys (n = 6) was 88.0% of TEE and in the girls (n = 6) was 68.0%. The results of these two investiga-
tions in adolescents are similar to those of the present study, in which energy intake in the 15-y-old boys was 81.9\% of TEE and in the girls was 78.3\%. In these three studies energy intake was assessed by diet records. The study by Bandini et al (8) was conducted over a period of 14 d and portion sizes were estimated with the aid of food models and household measures such as cups and spoons. In the study by Livingstone et al (35), diet records were kept for 7 consecutive days and the food eaten at home was weighed, but the portion sizes of food eaten outside the home were estimated, a method similar to that used in the present study. The age variation was much larger (SD for boys: 1.5 y; SD for girls: 1.0 y) and the mean Tanner stages lower (boys: 3.50; girls: 2.86) in the study by Bandini et al (8) than in the present study.

Irrespective of these differences in methodology and in the age and maturity of the subjects, the concordant results among the three studies indicate that the energy intake of adolescents is underestimated by ≈20\% by the diet record method. Livingstone et al (35) validated energy intake not only by diet records but also by diet history and studied other age groups in addition to 15-y-olds. In all age groups, estimation of energy intake by diet history lacked precision. In the adolescents, no significant bias of energy intake as assessed by diet history was found, but in younger children significant overestimation of energy intake was observed.

What are the reasons for the frequently observed bias in self-report dietary intake methods? In earlier studies obese subjects showed the poorest correspondence between reported intake and energy expenditure (8, 36). The subjects of the present study were a random sample of healthy teenagers. Still, significant inverse correlations were found both between percentage body fat and energy intake as a percentage of TEE and between body mass index and energy intake as a percentage of TEE. These correlations were found both when all adolescents were analyzed together and when the boys and girls were analyzed separately (Figure 2 and Figure 3), indicating that in a normal adolescent population there is an association between underreporting of energy intake and a tendency toward increased body fat content and overweight.

When, after the 7-d diet recording, the adolescents were asked about their eating habits during the study and their view of the recording procedure, some said they had appreciated the recording and found it interesting, whereas most found it inconvenient. Almost all claimed that they had kept to their ordinary eating habits during the study and thought they had recorded almost all of their intakes. The diet recording procedure is regarded as a burden by many adolescents, which probably promotes underreporting of dietary intake in a large number of subjects. Regardless of the reasons for the underreporting—many of them are unknown—the implications for dietary studies are serious. Not only is the measurement of energy intake biased, but assessment of nutrient intake also is uncertain.

Until recently, 7-d diet records were considered to be more accurate and precise than the diet history and recall methods and more appropriate for individual estimates, whereas diet history and recall methods were chosen in investigations aiming at group estimates. Considering the results of several validation studies, however, it is obvious that no method in which dietary intake is measured by self-report can be considered a priori as valid (10–12). The use of the 7-d diet record as the method of choice for assessing total energy and nutrient intake has to be reconsidered in food intake studies in adolescents and the results of previous dietary intake investigations reexamined, including those studies referred to earlier suggesting low energy intakes in children and adolescents. In the present study the results of TEE assessments, but not those of energy intake, indicate actual energy intake.

In conclusion, the findings in the present study agree with earlier results indicating a secular trend of increasing body weight and height in Swedish adolescents, but are in conflict with the presumptions of low physical activity, low energy expenditure, and low energy intake in these young people. The present study has provided further evidence of underestimation of energy intake in adolescents by the 7-d diet record, particularly in those with a tendency toward overweight and an increased body fat content. The results also support a growing view that current national and international recommendations for dietary energy intake during adolescence are too low (10).

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