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ORIGINAL COMMUNICATION

Estimated energy intake, macronutrient intake and meal pattern of Flemish adolescents

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Objective: To describe the energy and macronutrient intake and the meal patterns of Flemish adolescents, aged 13–18 y.
Methods: A 7 day estimated food record was administered to the whole sample.
Setting: Secondary schools in the city of Ghent, Belgium.
Subjects: A total of 341 adolescents (13–18 y) selected by a multistage clustered sampling (participation: 72.7%).
Main results: A significant increase with age was observed in total energy intake in adolescent boys ($P < 0.01$), but not in girls. The energy distribution over the macronutrients showed no significant difference between boys and girls. On average, 35.7% (s.d. 4.81%) of energy came from total fat and 15.4% (s.d. 2.46%) from saturated fatty acids; 49.0% (s.d. 5.28%) from total carbohydrates with 25.1% (s.d. 4.49%) from complex carbohydrates and 23.9% (s.d. 5.86%) from free sugars. The energy contribution of alcohol in the 16–18 y-old-group was significantly higher as compared with the 13–15 y-old-group, for both boys and girls. Snacks between meals accounted for almost 20% of the total energy intake. Lunch and dinner were characterized by high total fat content.
Conclusion: These students consumed a diet high in total fat and in saturated fatty acids and also high in mono- and disaccharides. Observed mean intakes deviate considerably from the Belgian dietary guidelines. A low energy intake at breakfast was observed, while a higher proportion of energy was derived from snacks.
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Keywords: adolescents; dietary survey; energy; macronutrients; meals

Introduction

Adolescence is a particularly unique period in life as it is characterized by intense physical, psychosocial and cognitive development. From nutritional point of view, this transition period from childhood to adulthood deserves special attention in view of the dramatic physical changes of the body. Increased nutritional needs relate predominantly to the fact that adolescents gain up to 50% of their adult weight, more than 20% of their adult height and 50% of their adult skeletal mass during this period (World Health Organization, 1995).

Moreover, there is evidence that an unfavourable nutritional profile—in terms of foods, meals, macronutrients, micronutrients, non-nutrients, etc—during adolescence, is related to adverse health outcomes in later adult life.

The EURODIET project (a European effort to enable a coordinated EU and member state health promotion programme on nutrition, diet and healthy lifestyles; Kafatos & Codrington, 1999) has recently summarized the potentials of healthy lifestyles, particularly diet, weight control, physical activity and non-smoking, in the prevention of chronic diseases. Diet-related lifestyles are considered to be responsible for about 10% of the so-called disability adjusted life years lost (DALYs) and therefore they also have a considerable impact on public health costs.

On the basis of this knowledge, it is clear that monitoring dietary habits in different subgroups of the general population is of great interest for public health. Until now, there has

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been almost no epidemiological data on nutrient intake of adolescents available in Belgium. The latest Flemish survey, based on a one day food record, dates from 1978 (Verdonk *et al*, 1982) and the latest Walloon survey, based on a food frequency questionnaire, dates from 1995 (Paulus *et al*, 2001).

The aim of the present study, therefore, was to estimate food consumption and nutrient intake in a random sample of Flemish adolescents aged 13–18 y. In this paper results are presented on the daily energy and macronutrient intake of teenagers and on their meal patterns; a comparison is made with other European studies and with the recommendations from the National Nutrition Council.

Materials and methods

The present study was part of an international project, including Ireland, Finland, Germany, Italy and Belgium, looking at methodological aspects of dietary assessment in the context of food safety monitoring (Lambe *et al*, 2000). For Belgium, the data were analysed in more depth in order to allow for a cross-sectional description of the dietary habits in this subgroup of the population (boys and girls aged 13–18 y).

The study was carried out between March and May 1997. Subjects were residents in the region of Ghent, a medium sized ($n = \pm 225\,000$) city in Flanders, the northern Dutch-speaking part of Belgium.

A random sample of 13–18-y-old adolescents was drawn on the basis of a multistage cluster sampling technique. In a first step, local schools from both the private and public school-network were randomly selected. All contacted schools ($n = 5$) agreed to participate. In a second step, a stratification according to the learning option ascertained that all social backgrounds were represented. In Belgium, students can essentially choose between a 'classical' education (mainly theoretical courses) or vocational training (in which 25–75% of the time is focussed on practical skills). These different educational options were proportionally represented in the sample.

Finally, classes were randomly selected as final cluster units. Selection of classes was aimed at establishing a uniform distribution of teenagers over the age range 13–18 y in both sexes. All students from the selected classes were considered eligible for the study.

Information letters were sent to directors, parents and the adolescents, who were all asked to give their written consent. The recruitment and the fieldwork were carried out in collaboration with the local Medical School Services. These medical services have medical records of all registered students on the basis of repeated obligatory medical examinations in the schools.

The described sampling procedure yielded a sample of 656 students, who were officially registered in the 48 sampled classes. Non-eligible students ($n = 91$) were either on sickness leave or had moved to other schools, so eventually only 565 students were considered eligible. Of these, 411 individuals (72.7%) actually participated.

Dietary assessment was done on the basis of a 7 day estimated food record method, using a semi-structured diary. Students were informed about the aim of the study and were given necessary instructions for accurate completion of the food diary. Special attention was thereby given to the issue of estimation of portion sizes of food items and this was demonstrated with a number of standardized examples.

In the diaries, days were truncated into six eating occasions, namely breakfast, lunch, dinner and snacks (divided in morning, afternoon and late-evening snacks). Information on the type (including brand names) and amount of food consumed was collected through an open entry format. For each eating occasion, the time of the day was recorded.

For each day, specific information on the type of fat used for cooking and frying was collected on a separate sheet, along with recipes for home-made dishes. Every 2 days, the diaries were checked for quality and completeness by experienced dieticians. After completion, the diaries were processed into food quantities and codes by experienced dieticians on the basis of a standard protocol, including a standard manual on food portions and household measures (Vakgroep Humane Voeding en TNO Voeding, 1997). Food codes from the Dutch Food Composition Tables (NEVO, 1993) and from the Belgian Food Composition Table from 1992 and 1995 (NUBEL, 1992; NUBEL, 1995) were used. Calculation of nutrients was done by means of a nutritional software package developed by the Unilever company in the Netherlands (Unilever, 1992).

It was decided beforehand that only good quality food diaries with a full 7 days record would be considered. Therefore, the food diaries of 70 students had to be excluded from analysis. Most of the rejected food diaries were excluded on the basis of incompletely recorded days. Others had very unrealistic data which could not be corrected in a reliable way. The standardization of the exclusion procedure was guaranteed by the fact that the evaluation of the food diaries was done by the same dietician, who has a long-standing experience in nutritional epidemiologic fieldwork. Hence, results are reported for 341 students. Considering the number of students that were originally invited, the number of full 7 day records represents 60.3% participation.

Average energy intake and nutrient intakes were calculated as the mean of the 7 day intake period; the same procedure was followed for the estimation of the meal specific energy and macronutrient intake. Breakfast can be defined as the first meal in the morning. Lunch and dinner can either be cold or hot meals; lunch is a meal in the middle of the day before 3 pm and dinner is served after 3 pm. The snacks refer to a summation of the morning, afternoon and late-evening snacks.

Statistical analysis was done with the SPSS software (SPSS, 1999). Descriptive statistics used means and standard deviations for continuous data. Tests for normality were performed, using a Kolmogorov–Smirnov test. Student's t-tests were used to compare the means of the different groups. Chi-square test was used to compare proportions. A P-value of <0.05 was taken as threshold for significance.

In this paper, a distinction is made between 'included individuals' and 'non-included individuals', referring to, respectively, full participants and subjects who either refused or who have been excluded on the basis of quality control procedures.

Members of the research-unit measured heights and weights of all 'included' subjects. The measurements were carried out according to the standardized method as described in WHO, Technical Report Series 854 (World Health Organization, 1995). Data on measured heights and weights were completed in the same period (within 1 week) as the dietary diary. For a random sub-sample of the 'non-included' subjects — respectively 48 boys and 64 girls — heights and weights were obtained from medical records from the local School Medical Services. The body mass index (BMI) was computed as weight (kg) divided by the square of height (m^2). No standard definitions of overweight or obesity in adolescents are defined in Belgium. Instead, the internationally accepted age- and sex-specific cut-off points for body mass index related to overweight and obesity in children (using dataset specific centiles linked to adult cut-off points, developed by Cole *et al*, 2000) were used. The reference population in this method is based on six large nationally representative cross-sectional surveys on growth from Brazil, the UK, Hong Kong, the Netherlands, Singapore and the United States. Estimates of basal metabolic rate (BMR) have been derived from standard equations based on weight, age and sex (Schofield *et al*, 1985). The formulas used in this study are shown for males and females aged 10–18 y:

$$\text{male BMR (MJ)} = 0.0732 \times (\text{weight (kg)}) + 2.72$$
$$\text{female BMR (MJ)} = 0.0510 \times (\text{weight (kg)}) + 3.12$$

A comparison of energy intake with estimated BMR can be used to estimate the number of respondents in a dietary survey who might be under-reporting their energy intake. For individuals in a non-dieting population, it is suggested that a ratio between energy intake and BMR of less than 1.35 (cut-off 1) is unlikely to reflect habitual intake. To detect if the reported energy intake is a plausible measure of the actual diet during the measurement period, a second cut-off value (cut-off 2) was introduced. The derivation of the cut-off 2 is based on the assumption of energy balance and takes into account several parameters (Goldberg *et al*, 1991). The calculation of cut-off 2 in this study was done under the following conditions: data on an individual level; 7 days per subject; estimated values for BMR taken from Schofield equations and the lower limit of the 95% confidence interval. On the basis of these calculations, the value of the second cut-off value was 1.1.

On the other hand an instrument to detect the over-reporters in a dietary survey does not exist.

The study was approved by the Ethical Committee of the Faculty of Medicine and Health Sciences of the Ghent University.

Results

The characteristics of the study population are shown in Table 1. In both boys and girls, the loss of subjects (due to non-participation or incomplete diary) was significantly higher in students from vocational education as compared with students from theoretical education. A similar phenomenon was observed for age with higher proportional drop-out in older age groups as compared with younger age-groups (this could however not be tested in a formal way because of missing values, cf. Table 1).

In Table 2, anthropometrical data from the study population are compared with the data from a random sub-sample of the 'non-included' subjects. In both boys and girls, weight was not significantly different between participants and non-included individuals, whereas height was significantly higher in non-included boys as compared with participating boys. The proportion of boys who suffer from overweight does not differ between the included and the non-included subjects. In girls, the difference between overweight and non-overweight subjects is almost 6%, although not significant. In Figure 1 the distribution of the ratio of the reported

Table 1 Characteristics of included and non-included subjects by sex: effects of education level and age group

	Boys		*Girls*		
	Included	*Non-included*	*Included*	*Non-included*	*Total invited*
n	129	104	212	120	565
Education type					
Theoretical (*n* (%))	112 (62%)	68 (38%)	101 (78%)	28 (22%)	309
Vocational (*n* (%))	17 (32%)	36 (68%)	111 (55%)	92 (45%)	256
Age groups					
13–15 y (*n*)	74	13[a]	89	28[a]	204[a]
16–18 y (*n*)	55	67[a]	123	63[a]	308[a]

[a]Birthday data of 24 boys and 29 girls are missing.

Table 2 Height, weight and overweight of the study population

	Boys		Girls	
	Included	Non-included	Included	Non-included
Height (in cm) (s.d.)	174.2 (8.9)	177.6 (7.9)[a]	165.8 (6.1)	165.6 (6.5)[a]
Weight (in kg) (s.d.)	60.7 (10.7)	63.6 (10.1)[a]	59.1 (10.9)	60.7 (10.1)[a]
Overweight (%)	6.2	6.3	14.4	20.3

[a]Measurements of 48 boys and 64 girls were included in the non-included sub-sample.

energy intake (EI) and estimated BMR and the percentage of respondents with energy intake/BMR values less than 1.35 and 1.1, respectively, are shown. The average EI/BMR ratio in boys and girls is, respectively, 1.56 and 1.36. The proportion of adolescents below cut-off 1 is 19.4% for boys and 46.7% for girls. The percentage of respondents with a EI/BMR ratio below cut-off 2 is 7.8% for male subjects and 20.3% for female subjects.

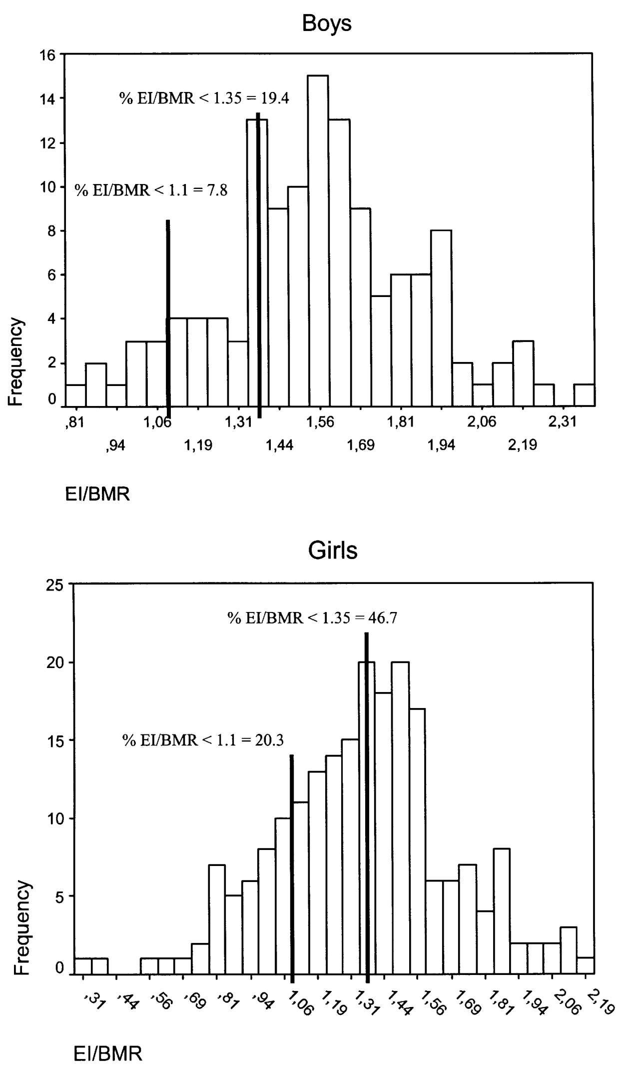

Figure 1 Comparison of energy intakes (EI) with estimates of basal metabolic rate (BMR) in adolescent boys and girls. (Based on estimates by Schofield *et al* (1985)).

In Table 3, the mean energy intake is shown by sex and age-group. The mean energy intake in the 13–15-y-old group was 10.6±2.12 (s.d.) MJ for boys and 8.0±1.92 MJ for girls, while in the 16–18-y-old group, it was respectively 11.7±2.1 MJ for boys and 8.4±2.01 MJ for girls. In both age groups, the energy intake in boys was significantly higher as compared with girls ($P<0.001$). A significant increase in total energy intake over the age groups was observed in boys ($P<0.01$), while in girls no significant differences were found between the age groups.

Table 3 also shows the mean overall energy contribution from proteins, carbohydrates, fats and their sub-fractions, and alcohol. The overall picture of energy contribution from macronutrients is very similar in boys and girls from both age groups. Protein contributed on average 14.5% to the energy intake, fat 36% and carbohydrates 49%. Saturated fatty acids represented the largest fraction of the total ingested fat. The energy contribution of alcohol in 16–18-y-old group was significantly higher as compared to the 13–15-y-old group, although the contribution of alcohol to the total energy intake was limited. Except from alcohol, there were no statistical differences between the two sexes and the two age-groups, in relative energy contribution from any of the other macronutrients. Fibre intake is also included in Table 3; in absolute figures boys had a significant higher intake than girls in both age groups and the youngest boys had a significant lower fibre intake than the older ones. In relative figures (expressed as g/10 MJ), female adolescents had a higher intake than their counterparts. There was only a significant difference between boys and girls of the youngest age group.

In Figure 2 the energy contribution of macronutrients is compared to the Belgian dietary recommendations (Nationale Raad voor de Voeding, 1996). The National Nutrition Council advises a mean population protein intake of about 10% of the total energy intake. Almost all boys and girls had a higher intake than 10%. As for total carbohydrates (derived by the 'difference' method), the National Nutrition Council advises a lower limit of 55% to cover the carbohydrate requirement of adolescents. Around 20% of the adolescents had a total carbohydrate intake lower than 45% of the total energy intake. Only 10.1% of the boys and 11.8% of the girls

Table 3 Mean energy intake (s.d.) (kJ), mean intakes (s.d.) of macronutrients (as energy percentage) and fibre (in g/day and g/10 MJ per day) by sex and age group

	13–15 y			*16–18 y*				
	Boys	*Girls*	*P-value*	*Boys*	*Girls*	*P-value*	*P-value, boys*[a]	*P-value, girls*[b]
Energy	10 625 (2120.2)	8030 (1973.8)	**	11 744 (2062.4)	8400 (1813.7)	**	**	NS
Protein	14.7 (2.05)	15.3 (2.52)	NS	14.0 (1.97)	14.6 (2.66)	NS	NS	NS
Carbohydrates, total	49.1 (4.62)	49.1 (5.37)	NS	48.3 (5.45)	49.3 (5.54)	NS	NS	NS
Free sugars	24.3 (4.90)	24.3 (4.95)	NS	23.3 (6.48)	23.8 (6.69)	NS	NS	NS
Complex CH	24.8 (4.37)	24.8 (4.56)	NS	25.0 (4.11)	25.5 (4.69)	NS	NS	NS
Fat, total	36.1 (4.54)	35.5 (5.01)	NS	36.3 (4.57)	35.4 (4.95)	NS	NS	NS
SFA	15.7 (2.46)	15.4 (2.67)	NS	15.3 (2.53)	15.3 (2.29)	NS	NS	NS
MUFA	14.4 (2.25)	14.1 (2.44)	NS	14.8 (2.12)	14.2 (2.57)	NS	NS	NS
PUFA	6.1 (1.59)	5.9 (1.29)	NS	6.2 (1.59)	5.9 (1.57)	NS	NS	NS
Alcohol	0.2 (0.40)	0.2 (0.57)	NS	1.5 (2.52)	0.7 (1.39)	NS	**	**
Fibre (in g)	19.0 (5.89)	15.8 (5.22)	**	21.3 (5.73)	15.9 (5.46)	**	*	NS
Fibre (in g/10 MJ)	18.0 (4.83)	20.2 (6.24)	*	18.4 (5.14)	19.1 (5.43)	NS	NS	NS

SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.
[a]Difference between 13–15- and 16–18-y-old boys.
[b]Difference between 13–15- and 16–18-y-old girls.
*Significant at the 0.05 level. **Significant at the 0.001 level.
NS, not significant.

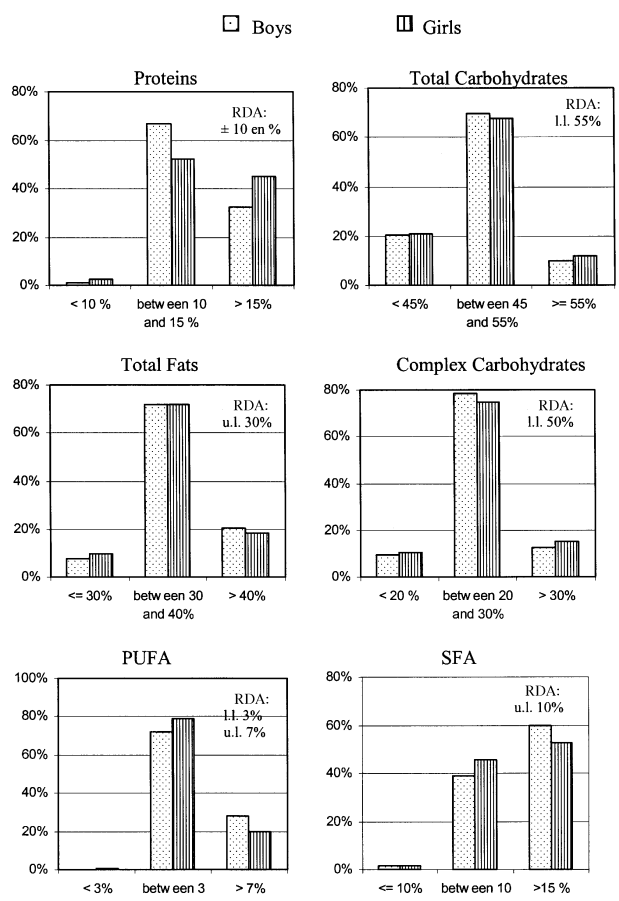

Figure 2 Energy contribution of some macronutrients compared with the lower and upper limits of the Belgian dietary recommendations. PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids; l.l., lower limit; u.l., upper limit.

Table 4 Mean overall energy contribution (as energy percentage) from macronutrients: recommended values as compared with the results of this study and a Belgian study of 25 y ago

Reference	*This study*	*Verdonk* et al	*Belgian nutritional recommendations*
Period	1997	1978–1979	
Survey method	7 day EDR	1 day EDR	
Age (y)	13–18	13–19	
Boys			
n	129	235	
Energy (kcal)	2653 ± 516.2	3029 ± 1000	Age-dependent
Energy (%)			
Protein	14.4 ± 2.03	12.7	10
CH, total	48.8 ± 4.98	49.0	55–75
Free sugars	23.9 ± 5.63	21.9	
Complex CH	24.9 ± 4.24	27.1	l.l. 50
Fat, total	36.2 ± 4.54	36.7	u.l. 30
SFA	15.5 ± 2.48	21.4	u.l. 10
MUFA	14.6 ± 2.20	10.3	
PUFA	6.1 ± 1.58	5.0	3–7
Girls			
n	212	363	
Energy (kcal)	1970 ± 450.9	2292 ± 849	Age-dependent
Energy (%)			
Protein	14.9 ± 2.62	12.0	10
CH, total	49.2 ± 5.46	49.0	55–75
Free sugars	24.0 ± 6.01	22.9	
Complex CH	25.2 ± 4.64	26.1	l.l. 50
Fat, total	35.5 ± 4.96	38.1	u.l. 30
SFA	15.4 ± 2.45	21.6	u.l. 10
MUFA	14.2 ± 2.51	11.0	
PUFA	5.9 ± 1.46	5.6	3–7

EDR, estimated dietary record; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; l.l., lower limit; u.l., upper limit.

had a relative carbohydrate contribution higher than 55%. In more detail, the recommended relative contribution of complex carbohydrates (combination of all polysaccharides) amounts at least 50%. Only 12.4% of the boys and 15.1% of the girls had a relative contribution higher than 30%. Concerning total fat intake, a maximum limit of 30% is recommended. More than 90% of the participants had a relative fat intake higher than 30%. About 20% of both sexes even had an intake of more than 40% of the total energy. About 79% of the boys and 72% of the girls fell within the recommended range for polyunsaturated fatty acids (PUFA) intake (3–7%). The saturated fatty acid (SFA) intake is recommended to be less than 10% of the total energy intake. Only 1.5% of the boys and girls met this advice. More than 50% of the boys and the girls had an SFA intake higher than 15% of the total energy intake.

In Table 4 data from this study are compared with results from a similar survey in Flemish adolescents (Verdonk *et al*, 1982), carried out almost 25 y ago in a region close to Ghent and with the Belgian dietary recommendations (Nationale Raad voor de Voeding, 1996). The major differences can be summarized as follows: the mean energy intake is lower today than 25 y ago; the mean relative contribution of carbohydrates has remained constant, although the mean

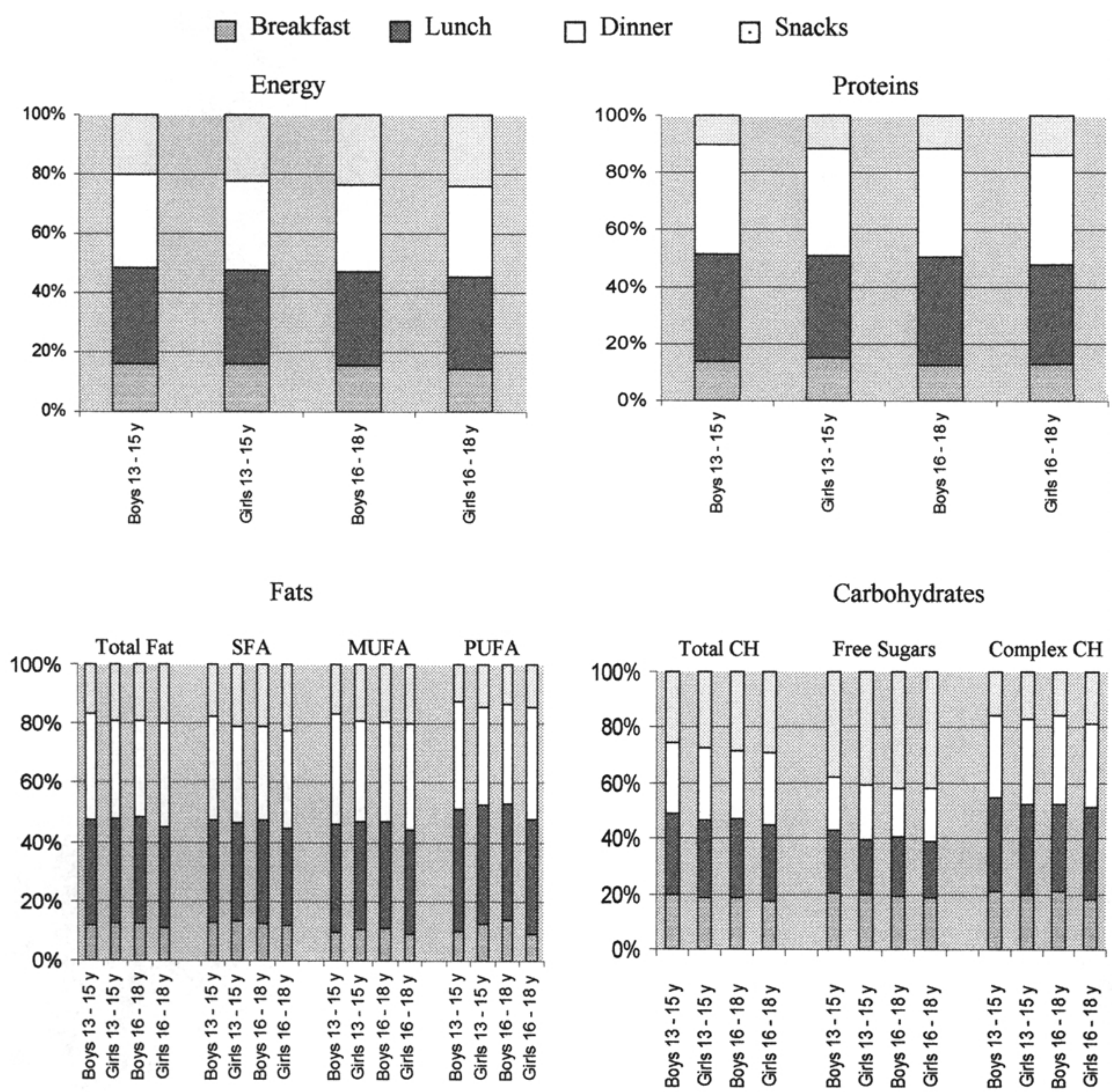

Figure 3 Mean proportional contribution from individual meals to the total intake of selected nutrients and to total energy intake by sex and age group.

relative intake of free sugars has increased; the mean relative contribution of proteins has increased. The decrease in mean relative saturated fatty acids intake between 1978 and 1997 was apparently compensated for by an increase in the mean relative unsaturated fatty acid intake, resulting in a steady-state situation in the total fat intake. On the whole, the energy intake and the macronutrient profile in the present study are more in accordance with the Belgian dietary guidelines.

Figure 3 shows the mean proportional contribution from individual meals to the total intake of selected nutrients and to total energy intake. On average between 15 and 16% of the total energy intake comes from breakfast and about 32% comes from lunch; dinner represents on average 30.5%. The contribution of snacks varies between 20 and 24%. For most nutrients shown in these figures, the contribution from the different meals shows roughly the same pattern as the proportional energy contribution from these respective meals. An outlying observation concerns the very high supply of total carbohydrates and especially of free sugars from snacks (on average 42% of the total intake of free sugars *vs* about 22% energy from snacks), resulting in a relatively lower supply of fat and protein from snacks. Compared with the boys, girls obtain proportionally more energy from snacks; this pattern is representative for all nutrients. Figure 3 also indicates an increasing contribution of free sugars from snacks with age, at least among boys, but there were no significant differences. The contribution of breakfast to the total intake of nutrients and to the total intake of energy decreases with age (13–15 *vs* 16–18-y-old).

Discussion

On the basis of the random sampling procedure and the reasonably high participation rate, the results in the present study can be considered representative for 13–18-y-old adolescents living in the region of Ghent. In both boys and girls, the participation rate among the vocational students was significantly lower than the participation rate of theoretical students (Table 1). It is not clear in what way this may have affected the results of the study. However, the anthropometrical data suggest a very small difference, if any, between the included and non-included subjects in overall nutritional status (Table 2).

In the present study a 7 day estimated dietary record was chosen because of the high respondent burden and time-consuming characteristic of weighed dietary food records. Estimated records are less accurate than weighed records of individuals' diets, but they have the same order of accuracy when ranking subjects into thirds or fifths (Bingham *et al*, 1988). On the other hand some validation studies express doubts about the use of a 7 day diet record as the method of choice for assessing total energy and nutrient intake in adolescents. The results of three studies (Bandini *et al*, 1990; Bratteby *et al*, 1998; Livingstone *et al*, 1992) indicate that the energy intake of adolescents is underestimated by ~20% by the diet record method. The most common reason for the observed bias in self-reported dietary intake methods is that the procedure is regarded as a burden, which probably promotes under-reporting of dietary intake (Bratteby *et al*, 1998). To avoid the issue of under-reporting, Goldberg, Black and colleagues (Black *et al*, 1991; Goldberg *et al*, 1991) developed a tool to detect the under-reporters. They calculated cut-off values based on the ratio of mean reported energy intake and basal metabolic rate, as estimated from weight and height using equations (Schofield *et al*, 1985), with the WHO recommended physical activity level for light activity (World Health Organization, 1985). Following the most specific method (cut-off 2) 15.5% of the study population, 7.8% of the boys and 20.3% of the girls, could be classified as probable under-reporters. Nevertheless the authors did not reject those subjects for the following reasons. Firstly, in the assumption that over-reporting is also present in the results, exclusion of the presumed under-reporters can bias the results as well (Black *et al*, 1991). An upper cut-off value exists but was derived rather arbitrarily (Livingstone *et al*, 1992) and was not used in this survey. Secondly, the calculation of the specific cut-off value requires specific information about the physical activity level of children or adolescents, which is not available in this study. In a recent study Black (2000) reports that, to identify diet reports of poor validity using the Goldberg cut-off, it is desirable to measure energy expenditure by doubly labelled water, heart rate monitoring or activity diary, and to make a direct comparison of energy intake and energy expenditure, thus avoiding the limitations of the cut-off value. Thirdly, it has been suggested that low energy reporting may be just as common amongst those with plausible energy intakes as amongst those classically defined as under-reporters (Macdiarmid & Blundell, 1997), so that selectively excluding only those with implausible energy intakes could bias the results. Fourthly, the cut-off values are only appropriate for individuals who are in energy balance. Horwath (1991) reported that 13% of the investigated population, young female students, followed a weight-reduction diet at the time they were recording the diets. It is likely that at any time a proportion of the subjects will be dieting, and may therefore provide diet records, which reflect their under-eating.

The sampling period was limited to 3 months, therefore it is not possible to describe seasonal effects.

The research team used the same method to recruit the study population as in a previous study (de Henauw *et al*, 1997), namely a multistage cluster sampling. A random sampling at the individual level would have been methodologically better, although the authors do not have arguments to assume that the procedure used in this study would introduce any measurable selection bias. The used dietary assessment method allows to characterize the study population reliable in terms of group means (which are used in all the tables).

Comparisons in dietary patterns of adolescents with other European countries have to be interpreted with caution as survey methods and populations can vary. Apparently, substantial variability in mean total energy intake can be observed across Europe. Swedish boys seem to have the lowest energy intakes (mean 10.2 MJ; Samuelson *et al*, 1996). Average intakes reported in some other Western European countries are as follows: Belgium 11.1 MJ (this study), France 12.1 MJ (Hercberg *et al*, 1991), Germany 10.9 MJ (Kersting *et al*, 1998) and England 11.4 MJ (Crawley, 1993). Differences in energy intake also seem to be accompanied by differences in the proportional distribution of the macronutrients. Swedish adolescents have a relatively low fat intake (Samuelson *et al*, 1996). Bergström *et al* (1993) reports that the decrease in fat intake among Swedish teenagers is mainly due to a shift to low energy spreads on bread and a lower intake of fat from dairy products, at the same time as cereal consumption is increasing.

Differences are also observed in the qualitative fat intake. In Spanish adolescents (Cruz, 2000) a dietary pattern rich in total fat (around 40% of the energy intake) is observed with a majority of monounsaturated fatty acids (around 18% of the energy intake). Meanwhile, the total fat contribution of Swedish adolescents (Bergström *et al*, 1993) accounts on average for 33% of the energy intake with a majority of saturated fatty acids (around 15% of the energy intake). The mean percentage of energy provided by total fat by Spanish adolescents is higher than in Belgium and Sweden, but the proportion of saturated fat is below the Flemish and Swedish value.

The energy contribution of proteins of German (Kersting *et al*, 1998) and British (Crawley, 1993) boys and girls is lower than their Belgian counterparts, on average 12.5 *vs* 14.6%, while the contribution of fat is higher than in the Belgian population, around 40 *vs* 36%.

In Belgium, regional differences between a Walloon survey (Paulus *et al*, 2001) and the present study (Flanders) can be identified. Their comparison suggests that the energy intake is higher in the Walloon part than in the Flemish part of Belgium, respectively ± 14.65 *vs* ± 10.88 MJ for boys and ± 10.46 *vs* ± 8.37 MJ for girls. A lower relative contribution of proteins (about 2 E%) was observed in Wallonia, while the relative contribution of total carbohydrates is comparable. The proportional total fat intake was higher (on average 2 E%) in Wallonia than in Flanders, in both male and female adolescents. Comparing the fatty acids, a higher saturated fatty acid intake and a lower intake of unsaturated fatty acids could be noticed in Wallonia. Although the dissimilar methodologies in each survey (FFQ *vs* 7 day food record), the differences are in line with results from a nationwide nutritional survey at the beginning of the eighties (Kornitzer & Bara, 1989), in which differences were observed between the north (Flanders) and the south (Wallonia): saturated fatty acids intake as well as nutritional cholesterol intake was higher in the south, whereas polyunsaturated fatty acids intake was higher in the north.

Comparing the results of this study with the current Belgian nutrient recommendations (Nationale Raad voor de Voeding, 1996) some important differences could be noted, although the overall energy intake seems to be adequate for both boys and girls. In both male and female adolescents, energy supply from proteins is on average 4 E% higher than the population recommended intake, while the relative contribution of carbohydrates is low, especially the intake of complex carbohydrates. In contrast, the mean intake of free sugars is proportionally very high and the relative fat intake is above the recommended intake, especially the saturated fatty acids.

The free sugars enter the diet through food items mostly of poor nutritional value, like sweets, sugar-sweetened drinks and cakes. These food items represent 50% of the intake of free sugars (data not shown). These poor nutritional food items (low nutrient density) are a source of concern. First, they have a high energy content, through free sugars, without providing essential nutrients and, according to a recent study (Ludwig *et al*, 2001), these kind of food items, especially sugar-sweetened drinks, are associated with obesity in children. A second source of concern is that adolescents have a more and more sedentary lifestyle (Deheeger *et al*, 1997), so less energy intake is necessary. A combination of high intake of these poor nutritional foods and lower energy requirements could lead to a low intake of essential micronutrients and increased risk of obesity.

Due to a lack of specific Belgian recommendations on fibre intake, an American recommendation is used, the 'age plus 5 – plus 10' rule (Williams, 1995). This rule reports that the actual total fibre intake should be between the age of the child plus 5 and the age plus 10, expressed in grams per day. Almost 50% of the boys had an intake lower than the recommended amount, while about 75% of the girls were below the lowest threshold. This is in line with the low intake of fruits and vegetables by adolescents (data not shown).

On the basis of the current Belgian dietary guidelines, total fat intake is considered too high, especially the intake of saturated fatty acids. Whether a further decrease in total fat intake is really necessary or could alternatively be replaced by a shift towards unsaturated fatty acids, is still under debate in scientific literature (Astrup *et al*, 2000; Bray & Popkin, 1998; Willett, 2000).

Some important changes occurred between 1978 (Verdonk study) and 1997 (this study); in both girls and boys the energy intake seems to have decreased in time and a shift in the proportional contribution of the macronutrients is observed. A more sedentary lifestyle is probably one of the reasons for the lower energy intake. On the other hand different types of methodologies and food composition databases could induce observed differences between the two surveys. A higher relative contribution of protein (about 2 E%) was noticed in the 1990s, while the relative contribution of total carbohydrates remained constant, although a higher contribution of free sugars could be identified for both boys and girls. The increase of availability of some specific food items like sweets and sugar-sweetened drinks could explain the higher intake of simple sugars. The increase in protein intake could be explained by a rise in available protein sources. The proportional total fat intake was higher in the 1970s in female adolescents and remained constant in male adolescents. On the other hand a strong decrease between the 1970s, and the 1990s, of saturated fatty acids could be detected, while mean MUFA and PUFA intake increased.

Currently there are no Belgian recommendations concerning the distribution of energy intake over the day. Even in scientific literature it is difficult to find clearly described definitions of the energy contribution of each meal. In Sweden recommendations have been developed: breakfast 20–25% of daily energy intake, lunch and dinner 25–35% and the rest as two to three snacks between meals (Bergström *et al*, 1993). The meal pattern in the present study was quite different. A lower energy intake at breakfast was found while a higher proportion of energy was derived from snacks. Snacks are often considered to be of lower nutritional quality than the other meals. This consideration was reflected in the high free sugar content, but the fat content was lower compared with lunch and dinner. The same pattern was established in a Flemish primary schoolchildren study (de Henauw *et al*, 1997). Lunch and dinner are very rich in fat; this indicates that nutritional campaigns aiming at altering the fat intake should focus on these meal occasions.

In conclusion, this study shows clearly that the pattern of macronutrient intake of Flemish adolescents differs from the current Belgian dietary recommendations. In particular, the mean intake of fat and free sugars is higher than recommended. Snacks were found to be an important source of free sugars and saturated fatty acids, while energy intake from breakfast was on average very low. It can be concluded that further efforts are needed in order to improve the dietary habits in young Flemish adolescents.

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