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Sources of saturated fatty acids in Belgian adolescents' diet: implications for the development of food-based dietary guidelines

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The objectives of the present study are to describe the dietary sources of total fat and of saturated fatty acids (SFA) and to formulate food-based dietary guidelines for SFA in Belgian adolescents. A random sample of 13–18-year-old adolescents was drawn from secondary schools in the region of Ghent. A 7 d estimated food record method was used to quantify nutrient and food intake. The average daily SFA intake is 4 % above the recommended 10 % of the total energy contribution. The most important contributors of SFA on food group level were 'fats, oils and savoury sauces', 'meat and meat products', 'sugar, confectionery, sweet fillings and sauces', 'cheese', 'milk and milk products' and 'bread, rusk and breakfast rolls'. On food subgroup level 'fresh meat', 'high-fat margarine' and 'high-fat cheese' had the highest contribution to SFA intake in all adolescents. Adolescents with a low SFA intake (lowest tertile) were compared with adolescents with a high intake (highest tertile). In the lowest tertile the intake of total fat and MUFA was significantly lower than in the highest tertile, while the intake of total carbohydrates, mono- and disaccharides and complex carbohydrates was significantly higher. Overall, the high-fat cheese intake is significantly lower in the lowest tertile, while the fruit intake is higher. The present analysis shows that the nutritional profile of Belgian adolescents could be potentially improved by decreasing the portion sizes of fresh meat (in boys), high-fat margarine, high-fat cheese and reducing intake of commercially prepared baked goods and processed foods, including fast foods.

Dietary sources: Food-based dietary guidelines: Saturated fatty acids: Adolescents

The FAO/WHO report on guidelines for the preparation of food-based dietary guidelines indicated that such guidelines should be based on an existing public health problem and that they should be derived from existing patterns of food intake in the target population rather than from a theoretical basis. Different options were proposed to identify foods that should be included in the guidelines to modify the intake of a specified nutrient. A first option is identifying the foods with high content of the target nutrient. A second option is identifying the major dietary sources of a nutrient. A third option is comparing the food consumption patterns of different population subgroups that achieve a particular nutritional goal (Food and Agriculture Organization/World Health Organization, 1998).

The global strategy on diet, physical activity and health highlights diet and physical activity as the two main risk factors for non-communicable diseases. The same report indicates that recommendations for populations and individuals should include a shift in fat consumption away from saturated fatty acids (SFA) to unsaturated fatty acids (World Health Organization, 2004). It is well documented that SFA intake raises LDL-cholesterol and is associated with the incidence of CVD, whereas unsaturated fatty acids have the opposite effect (Kinsell *et al.* 1954; Hegsted *et al.* 1965; Keys & Parlin, 1966; Grundy & Denke, 1990). Different classes of SFA can have different effects on plasma lipid and lipoprotein concentrations (Kris-Etherton & Yu, 1997) and, according to some authors, the available evidence on how specific SFA contribute to coronary artery disease is not sufficient to make global recommendations for reducing saturated fats in the diet (German & Dillard, 2004).

However, this issue has been debated in the literature and it does not appear to be important nor feasible to make a distinction between individual SFA in dietary advice to reduce CVD risk, because of the high correlation between the different SFA (Hu *et al.* 1999).

In a previous paper, it has been elucidated that the population distribution of SFA intake is substantially above recommended values (Matthys *et al.* 2003). From a life-course perspective aimed at preventing and controlling non-communicable diseases (World Health Organization, 2004), it seems desirable to tackle this dietary unbalance early on during childhood and adolescence.

The present study explored existing data on habitual diets of adolescents – the only available Belgian consumption database in young individuals – to formulate food-based dietary guidelines aimed at reducing SFA intake. To the knowledge of the authors, this is the first time that such an attempt has been undertaken in Belgium.

Abbreviation: SFA, saturated fatty acid.

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Material and methods

The study was carried out in Ghent, a city in the Dutch-speaking part of Belgium, between March and May 1997. The study sample consisted of 656 adolescents (age 13–18 years) randomly selected on the basis of a multistage cluster sampling technique. The design and methodology have been described in more detail elsewhere (Matthys *et al.* 2003). In brief, local private and public secondary schools (*n* 5) were randomly selected. All contacted schools agreed to participate. Different educational options – classical education and vocational training – were represented in the sample. Within each school, classes were selected in such a way that a uniform distribution over the age range 13–18 years was obtained. Of the 656 adolescents, 565 were considered eligible. Non-eligible students (*n* 91) were on sickness leave or had moved to other schools. Of these 565 eligible students, 411 (72·7 %) actually participated. Because of missing data, the food diaries of seventy students were rejected. Hence, results are reported for 341 of the 565 eligible students (60·3 %). Results are given separately for boys (*n* 129) and girls (*n* 212). A detailed description of the characteristics of the study population is published elsewhere (Matthys *et al.* 2003).

A 7 d estimated food record method (semi-structured diary) was used to quantify food and nutrient intake. Information on the type (including brand names) and amount of food consumed was collected through an open-entry format. Instructions for the completion of the diary and regular checks for quality and completeness of the diaries were carried out by experienced dietitians. The storage of data on intake of individual food items was detailed and contained altogether 745 different food items. From these 745 food entries, 527 were identified as fat containing and were further used in the present study. Dishes were broken down into their constituent ingredients under the condition that all the ingredients were known and described. Sometimes dishes were not broken down into their ingredients, because the composition was not known. Decisions regarding the grouping of foods and the disaggregating of dishes were based on the judgement of the investigators. The dishes were mostly disaggregated to a level at which foods would easily be classified into food groups of the Flemish version of the food pyramid (Flemish Institute for Health Promotion, 2003).

Nutrient composition data used in the present study are those from the Belgian and the Dutch food composition tables (NEVO Foundation, 1993; NUBEL, 1992, 1995). Average nutrient and food intakes were calculated as the mean of the 7 d intake period.

Under-reporting was studied using the cut-offs provided by Goldberg *et al.* (1991). On the basis of the Goldberg formula, an average study-specific energy intake:BMR ratio of 1·1 was calculated as the minimal acceptable value at the individual level.

In the present study, three main objectives could be distinguished. A first objective of the study was to describe the food sources of total fat and SFA. The mean proportion of a nutrient from a food item is determined by calculating the proportion of that nutrient from that food item for each individual and then by taking an arithmetic mean of all the proportions. This mean proportion methodology is described by Krebs-Smith *et al.* (1989). Food items were classified in different food groups (*n* 22) according to the Dutch food composition table (NEVO Foundation, 2001). A total of ten groups had a very low contribution to the total fat intake and were aggregated in one group, namely 'other'. The groups classified under 'other' were 'potatoes', 'alcoholic and other beverages', 'cereal products (for example, pasta, rice) and binding agents (for example, bread crumbs)', 'savoury sandwich fillings (for example, peanut butter)', 'herbs and spices', 'vegetables', 'fruit', 'legumes', 'soya products and meat substitutes' and 'soup'. On the other hand, a few groups (*n* 5) were disaggregated in subgroups. The group 'fats, oils and savoury sauces' was divided into 'high-fat margarine' (≥60 g fat per 100 g margarine), 'butter', 'oil' and 'low-fat margarine' (<60 g fat per 100 g margarine). The groups 'meat' and 'fish' were divided into a subgroup 'fresh' and a subgroup 'processed'. In the group of 'cheese', 'high-fat cheeses' (>30 g fat per 100 g cheese) were distinguished. The group 'sugar, confectionery, sweet fillings and sauces' was divided into 'confectionery' (for example, candy bars) and 'sweet fillings and sauces' (for example, chocolate). The food group 'bread, rusk and breakfast rolls' was divided into 'bread', 'rusk' and 'breakfast rolls' (for example, croissants).

The second objective of the present study was the identification of dietary habits adopted by groups who have high and low intakes of SFA (Food and Agriculture Organization/World Health Organization, 1998). Therefore subjects were classified into tertiles. The average population intake of energy and nutrients and the average consumption of different foods were calculated in all tertiles. Also, for the various foods, the percentage of consumers was calculated.

In a third phase of the present paper, simulation scenarios were conducted to explore the effect of changes in food consumption in order to decrease the SFA intake. Three kinds of scenarios were distinguished. In a first scenario, all high-fat cheese was substituted by low-fat cheese in all adolescents. In the second scenario, high-fat margarines were substituted by low-fat margarines. The third scenario was a combination of the first and second scenarios.

Statistical analysis was done with the SPSS software version 12 (SPSS Inc., Chicago, IL, USA). A Kolmogorov–Smirnov test was used to test for normality. Non-parametric tests (Mann–Whitney *U* test) were used to determine differences between the lowest and highest tertile of the population in nutrient and food intake. To identify the food groups' contribution to the variability in SFA intake (g/d) a stepwise multiple regression, where the SFA intake is the dependent variable and intakes of food groups are the independent variables, was used. These analyses were completed by correlation analyses (Spearman) to identify key food groups for food-based dietary guidelines (Leclercq & Arcella, 2001). Given the multitude of statistical tests, a *P* value of <0·01 was taken in order to reduce the probability of false-positive findings.

The present study was approved by the ethical committee of the Ghent University Hospital.

Results

Energy intake, energy from total fat and from the fat sub-fractions is given by sex in Table 1. Mean energy intake was respectively 11 108 kJ for boys and 8248 kJ for girls. The overall picture of energy contribution from the different fat fractions is very similar in boys and girls. Both boys and girls have a total fat intake that is above the recommended intake of 30 % energy as fat. The mean SFA intake, 14·5 % energy, is above the upper limit of 10 % energy. The mean intake of MUFA and total PUFA fell within the range of the recommended intake.

Table 1. Distribution parameters of energy intake (kJ), intake of total fat and different sub-fractions (energy %) in adolescents according to sex and Belgian nutritional recommendations

(Medians and 25th and 75th percentiles)

	Boys (*n* 129)		Girls (*n* 212)		
	Median	25th and 75th percentiles	Median	25th and 75th percentiles	Dietary guidelines for Belgium
Energy	10 911	9480, 12 658	8226	6918, 9383	Age-dependent
Total fat	36·5	32·9, 39·2	35·7	31·9, 38·8	< 30
SFA	14·7	13·0, 16·3	14·27	12·8, 16·0	< 10; intake not necessary
MUFA	13·6	12·2, 15·0	13·1	11·7, 15·2	> 10
PUFA	5·6	4·5, 7·1	5·5	4·6, 6·4	5·3–10

SFA, saturated fatty acids.

In Tables 2 and 3 the proportional contribution of different food groups to total fat and SFA is shown. The major contributors to total fat intake are 'fats, oils and savoury sauces', 'meat and meat products', 'sugar, confectionery, sweet fillings and sauces', 'bread, rusk and breakfast rolls' and 'cheese', although the rank order was slightly different between boys and girls. 'Fresh meat' and 'high-fat margarine' together, account for about 20 % of the total fat intake.

In boys, the five most important contributors of SFA are 'fats, oils and savoury sauces', 'meat and meat products', 'sugar, confectionery, sweet fillings and sauces', 'cheese' and 'milk and milk products'. In girls, the major contributors for SFA are 'fats, oils and savoury sauces', 'meat and meat products', 'cheese', 'milk and milk products' and 'bread, rusk and breakfast rolls'. 'Fresh meat', 'high-fat margarine' and 'high-fat cheese' are the subgroups with the highest contribution to SFA intake in both boys and girls. 'High-fat cheese' is the most important source of SFA in girls.

The individual proportional contributions varied greatly in all food (sub)groups. In boys, the proportional contribution of 'cheese' to SFA intake of subjects of the highest tertile is higher than of subjects in the lowest tertile, although not significantly ($P=0{\cdot}025$). In girls, the proportional contribution of 'meat and meat products' and 'high-fat cheese' is higher in the highest tertile and borderline significant (meat $P=0{\cdot}029$; high-fat cheese $P=0{\cdot}012$) (data not shown).

In Tables 4 and 5 daily intake of some selected nutrients and food groups in adolescents according to tertiles of SFA (in energy %) are given. Energy intake and the overall EI:BMR ratio did not differ significantly between tertiles in boys and girls. The percentage of subjects with a ratio below the individual

Table 2. Median intake (g/d), percentage consumers of different food groups and proportional contribution of food groups to total fat and saturated fatty acids (SFA) for adolescent boys (*n* 129)

			Food sources (%)			
			Total fat		SFA	
	Median intake	Percentage consumers	Median	25th and 75th percentiles	Median	25th and 75th percentiles
Fats, oils and savoury sauces	45·7	100	28·5	20·2, 34·8	20·9	15·2, 29·4
High-fat margarine	10·3	99	8·2	3·9, 14·2	889	4·6, 14·5
Oils	3·4	76	2·6	0·2, 5·8	1·0	0·1, 2·8
Butter	0·0	32	0·0	0·0, 1·4	0·0	0·0, 2·2
Low-fat margarine	0·0	33	0·0	0·0, 2·5	0·0	0·00, 1·78
Meat and meat products	140·6	100	18·7	12·9, 25·3	19·8	13·4, 25·5
Meat (fresh)	93·6	99	11·3	7·0, 14·8	11·6	7·4, 15·9
Processed meat	45·7	95	7·3	3·2, 11·5	7·3	3·1, 12·4
Sugar, confectionery, sweet fillings and sweet sauces	26·1	95	7·6	3·9, 14·1	8·0	3·8, 14·5
Sweet fillings and sauces	18·9	92	5·8	2·4, 10·3	6·1	2·6, 11·0
Confectionery	2·9	56	0·5	0·0, 2·8	0·6	0·0, 3·8
Bread, rusk and breakfast rolls	188·6	100	7·3	5·3, 10·1	6·7	4·2, 10·1
Cheese	18·4	92	5·7	2·1, 11·6	7·9	3·3, 17·0
High-fat cheese	16·0	88	5·0	1·6, 10·8	6·9	2·2, 14·3
Milk and milk products	234·3	98	5·9	2·5, 9·4	9·6	4·2, 14·3
Cakes and biscuits	31·4	90	5·8	2·1, 9·5	7·5	2·4, 11·5
Nuts, seeds and snacks	11·4	75	2·6	0·2, 6·9	1·8	0·1, 4·5
Composite dishes	17·1	52	1·0	0·0, 4·9	0·8	0·0, 4·1
Poultry	21·4	77	1·1	0·2, 2·5	0·8	0·1, 1·9
Fish and fish products	14·3	64	0·3	0·0, 1·3	0·2	0·0, 1·0
Fish (fresh)	2·1	50	0·0	0·0, 0·6	0·0	0·0, 0·4
Processed fish	0·0	33	0·0	0·0, 0·4	0·0	0·0, 0·3
Eggs	6·3	62	0·7	0·0, 1·6	0·4	0·0, 1·1
Other	111·8	100	1·2	0·5, 2·6	0·7	0·3, 1·4

Table 3. Median intake (g/d), percentage consumers of different food groups and proportional contribution of food groups to total fat and saturated fatty acids (SFA) for adolescent girls (*n* 212)

			Food sources (%)			
			Total fat		SFA	
	Median Intake	Percentage consumers	Median	25th and 75th percentiles	Median	25th and 75th percentiles
Fats, oils and savoury sauces	31·1	100	26·8	18·8, 33·6	19·1	13·7, 26·1
High-fat margarine	6·6	99	7·6	4·7, 13·3	7·9	4·4, 13·9
Oils	2·1	75	2·4	0·0, 5·1	0·9	0·0, 2·3
Low-fat margarine	0·0	43	0·0	0·0, 3·0	0·0	0·0, 1·5
Butter	0·0	23	0·0	0·0, 0·0	0·0	0·0, 0·0
Meat and meat products	87·1	99	15·0	10·0, 21·5	14·6	9·0, 21·8
Meat (fresh)	60·0	95	8·9	5·5, 14·3	8·8	5·3, 14·4
Processed meat	25·0	90	5·4	2·2, 9·4	5·1	2·1, 8·2
Cheese	21·7	93	8·6	4·2, 16·1	12·3	5·8, 22·3
High-fat cheese	15·6	91	7·2	2·4, 14·9	10·2	3·6, 19·8
Bread, rusk and breakfast rolls	140·3	99	8·2	6·0, 11·2	7·8	5·0, 11·2
Sugar, confectionery, sweet fillings and sweet sauces	19·4	95	8·0	4·3, 12·2	8·6	4·1, 13·5
Sweet fillings and sauces	12·1	91	5·3	2·1, 9·4	5·5	2·4, 9·3
Confectionery	5·0	62	1·3	0·0, 3·5	1·6	0·0, 4·6
Cakes and biscuits	24·5	91	5·9	2·9, 10·8	7·8	3·2, 13·1
Milk and milk products	165·9	96	6·0	2·8, 11·5	9·3	4·5, 17·8
Nuts, seeds and snacks	8·0	70	2·8	0·0, 5·7	2·0	0·0, 4·6
Composite dishes	0·0	44	0·0	0·0, 3·0	0·0	0·0, 2·0
Poultry	17·9	68	1·1	0·0, 2·7	0·8	0·0, 1·8
Eggs	5·6	72	0·8	0·0, 1·9	0·5	0·0, 1·4
Fish and fish products	8·6	65	0·3	0·0, 1·0	0·2	0·0, 0·7
Fish (fresh)	0·0	46	0·0	0·0, 0·6	0·0	0·0, 0·3
Processed fish	0·0	36	0·0	0·0, 0·2	0·0	0·0, 0·2
Other	90·6	98	1·4	0·5, 3·5	0·7	0·3, 1·9

cut-off point of 1·1 was not significantly different between tertiles. Nevertheless, the percentage was low in boys but about 20 % in girls.

In both boys and girls in the lowest tertile the intakes of total fat, SFA, MUFA and the food group ‘cheese’ are significantly lower than in the highest tertile, while the intakes of total carbohydrates, mono- and disaccharides and complex carbohydrates are significantly higher. The percentage of consumers of ‘cheese’ is lower in the lowest tertile in both boys and girls.

In boys, the Ca intake in the lowest tertile is significantly lower than in the highest tertile. Female subjects of the highest tertile have a statistically significant higher intake of ‘meat and meat products’ and a statistically significant lower intake of ‘fruit’.

Although the differences were not statistically significant the consumption of ‘fresh meat’ in boys of the lowest tertile (84·8 g) was lower than the intake of boys of the opposite tertile (106·8 g) ($P=0{\cdot}014$). In girls, both the intakes of ‘fresh meat’ and ‘processed meat’ were statistically significant lower in the lowest tertile.

A similar intake pattern was found for ‘high-fat margarine’. Boys of the lowest tertile (12·0 g) had a lower intake than boys of the highest tertile (15·4 g) ($P=0{\cdot}102$). Girls of the lowest tertile (6·9 g) had a significantly lower intake than their counterparts (11·4 g) ($P<0{\cdot}000$).

Girls from the lowest tertile have a higher intake of ‘bread’ (131·4 g *v.* 114·9 g; $P=0{\cdot}041$) and a lower intake of ‘breakfast rolls’ (17·0 g *v.* 28·3 g; $P=0{\cdot}027$) than their upper tertile counterparts. Analyses based on consumers only did not differ from the overall analyses (data not shown).

Stepwise multiple regression analyses (data not shown) were used in boys and girls separately to identify the food groups that determine SFA intake. In boys, the food groups (in order of importance) ‘cheese’, ‘fats, oils and savoury sauces’, ‘cakes and biscuits’, ‘milk and milk products’, ‘sugar, confectionery, sweet fillings and sauces’ and ‘meat and meat products’ were found to be responsible for 64 % of the variability in the SFA intake. In girls, the food groups (in order of importance) ‘sugar, confectionery, sweet fillings and sauces’, ‘meat and meat products’, ‘cheese’, ‘cakes and biscuits’, ‘fats, oils and savoury sauces’ and ‘milk and milk products’ were found to be responsible for 73 % of the variability in the SFA intake. In both boys and girls the highest correlation with SFA, which varied between 0·23 and 0·49 in boys and between 0·35 and 0·44 in girls, was found for the food groups ‘sugar, confectionery, sweet fillings and sauces’, ‘meat and meat products’, ‘cheese’, ‘cakes and biscuits’ and ‘fats, oils and savoury sauces’. Non-significant, weak positive correlations were found for intakes of ‘fruit’ (r 0·08 for boys; r 0·04 for girls) and ‘vegetables’ (r 0·03 for boys; r 0·14 for girls) and a weak negative correlation of ‘fish’ (r −0·08 for boys; r −0·03 for girls) with SFA intake was found.

In Fig. 1, simulation scenarios that explored the effect of food changes in respect to decreasing the SFA intake are shown. In a first simulation scenario, substitution of all high-fat cheese by low-fat cheese, the energy contribution of total fat decreased with 1 energy % in boys and with 1·5 energy % in girls. The decrease in the contribution of SFA was respectively 0·7 energy % in boys and 1 energy % in girls. The decrease in MUFA intake was 0·4 energy % in boys and 0·6 energy % in girls. No

Table 4. Daily intake of nutrients and food groups in male adolescents (*n* 129) according to tertiles of energy intake (EI) from saturated fatty acids (SFA)* (Medians and percentage consumers)

	Tertile 1 (*n* 43)		Tertile 2 (*n* 43)		Tertile 3 (*n* 43)		
	Median	Percentage consumers	Median	Percentage consumers	Median	Percentage consumers	*P*
Age (years)	15·0		15·0		15·0		0·775
Energy (kJ)	10 915		10 634		11 166		0·150
EI:BMR	1·5		1·6		1·6		0·098
EI:BMR < 1·1 (%)	7·0		9·3		7·0		0·905
Total fat	32·0		36·8		39·6		0·000
SFA	12·2		14·7		17·1		0·000
MUFA	12·3		14·3		14·4		0·000
PUFA	5·3		5·6		5·6		0·935
Protein	14·3		14·2		14·3		0·726
Total carbohydrates	52·7		49·2		45·4		0·000
Mono- and disaccharides	25·1		23·2		20·1		0·000
Complex carbohydrates	24·7		22·8		21·5		0·004
Ca	718·3		869·4		997·6		0·009
Fe	13·7		12·8		13·3		0·422
Vitamin C	82·0		71·9		62·4		0·098
Potatoes	150·0	100	117·9	100	136·7	100	0·969
Bread, rusk and breakfast rolls	210·9	100	191·4	100	172·9	100	0·427
Eggs	6·3	67	4·2	56	7·1	67	0·951
Fruit	74·9	91	51·1	91	73·9	95	0·969
Cakes and biscuits	27·9	86	27·1	93	45·6	91	0·150
Poultry	21·4	65	22·9	79	22·9	86	0·105
Cereal products and binding agents	53·6	98	39·6	95	58·6	98	0·941
Vegetables	116·1	100	109·0	100	119·2	100	0·955
Savoury sandwich fillings	0·0	23	0·0	26	0·0	14	0·242
Cheese	12·1	84	17·0	93	36·4	98	0·000
Milk and milk products	207·7	100	268·9	98	226·7	98	0·390
Nuts, seeds and snacks	11·4	74	15·7	81	6·4	70	0·285
Sugar, confectionery, sweet fillings and sweet sauces	39·0	98	33·9	100	35·7	100	0·829
Fats, oils and savoury sauces	39·2	100	56·7	100	47·5	100	0·072
Fish and fish products	17·9	74	12·5	63	7·1	54	0·033
Meat and meat products	135·7	100	138·9	100	159·3	100	0·070

* Macronutrient intake is given in energy %, micronutrient intake is given in mg/d and food intake is given in g/d.

differences were observed in PUFA intake. When the different tertiles were compared, we found that the decrease of SFA in the highest tertile was bigger than in the lowest tertile in both boys and girls. Ca intake remained similar.

In a second simulation scenario, with substitution of all high-fat margarines by low-fat margarine, the energy contribution of total fat decreased with 1·3 energy % in boys and with 1·1 energy % in girls. The decrease in the contribution of SFA was respectively 0·9 energy % in boys and 0·8 energy % in girls. The decrease in MUFA intake was 0·1 energy % in both boys and girls. A decrease of 0·3 energy % of PUFA was observed in all adolescents.

In the third simulation scenario, combination of the first and the second scenario, the energy contribution of total fat decreased with 2·3 energy % in boys and with 2·6 energy % in girls. The decrease in the contribution of SFA was respectively 1·6 energy % in boys and 1·7 energy % in girls. The decrease in MUFA intake was 0·5 energy % in boys and 0·7 energy % in girls. A decrease in PUFA intake of 0·3 energy % was found.

In all three scenarios, we found that the decrease of SFA in the highest tertile was greater than in the lowest tertile, in both boys and girls. However, the decreases were rather small (in absolute figures) between the simulation scenarios; they were all significantly different ($P < 0·001$).

Discussion

SFA have the capacity to raise serum cholesterol (Keys & Parlin, 1966). Investigations have shown that lauric, myristic and palmitic acid raise both LDL- and HDL-cholesterol; thus the LDL:HDL ratio increases (Katan *et al.* 1994). Epidemiological studies have found a positive correlation between SFA consumption and the incidence of CVD (Kromhout *et al.* 1995). Epidemiological research has estimated that a 1 % decrease in serum cholesterol leads to a 2 % reduction in coronary events (Anonymous, 1984). In a previous publication, the intake of SFA in Flemish adolescents was identified as one of the major nutritional concerns and an important factor to tackle from a public health point of view. The mean SFA intake was found to be 14·6 % in boys and 14·4 % in girls of the total energy intake. There are only 3·9 % of the boys and 2·6 % of the girls who have an average SFA intake below the recommended value of 10 %. The high intake of SFA in adolescents forms the rationale to develop new food-based dietary guidelines to modify the current intake. The FAO/WHO report on guidelines for the preparation of food-based dietary guidelines mentioned different options to identify foods to be included in these guidelines (Food and Agriculture Organization/World Health Organization, 1998). The first option as described (p. 546) was not performed. In the present study, the first objective was to determine the main dietary

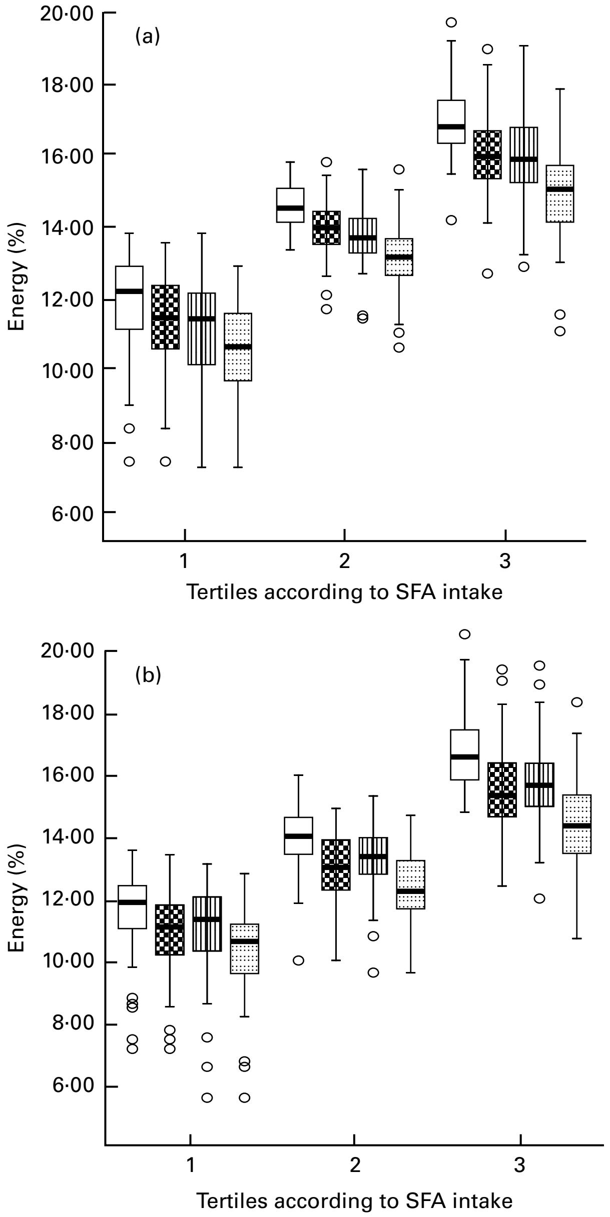

Fig. 1. Box and whisker plot of the saturated fatty acid (SFA) intake (energy %) in different scenarios according to SFA intake tertiles in (a) boys and (b) girls. Each box represents the interquartile range, which contains 50 % of values. The whiskers (vertical lines) extend from the boxes to the highest and lowest values that are not outliers. Every point more than 3/2 times the interquartile range from the end of a box are the unfilled circles. Medians are indicated by horizontal lines across the boxes. (□), Original data; (▩), cheese scenario; (▥), margarine scenario; (▦), cheese and margarine scenario. For details of scenarios, see p. 547.

sources. The major contributors – on food-group level – for SFA in all adolescents are ‘fats, oils and savoury sauces’, ‘meat and meat products’, ‘sugar, confectionery, sweet fillings and sauces’, ‘cheese’, ‘milk and milk products’ and ‘bread, rusk and breakfast rolls’. On food-subgroup level, ‘fresh meat’, ‘high-fat margarine’ and ‘high-fat cheese’ are the items with the highest contribution to SFA intake in both boys and girls. The total population intakes and the consumers-only intakes of the latter food items were higher in the highest tertile. Those tertiles have a significantly higher proportional contribution of ‘high-fat cheese’. ‘Fruit’ intake was significantly lower among high SFA consumers, only for girls. The stepwise multiple regression analyses confirmed these findings in boys. ‘Cheese’ explained the highest proportion of inter-individual variability in SFA intake in boys. In girls, the food group ‘sugar, confectionery, sweet fillings and sauces’ (including candy bars) was the most important contributor of the variability in SFA intake and had the highest correlation with SFA intake.

In using this food consumption database to examine patterns of food and nutrient intake among adolescents for the purpose of developing food-based dietary guidelines, it is important to consider some methodological issues. The database for this analysis dated from 1997. This may not be the most accurate reflection of the current pattern of nutrient and food intakes among adolescents but is the most representative survey. This may be particularly true of certain food items which have changed in availability or in composition in the last few years (for example, high-fat margarine, yoghurts) (Flynn & Kearney, 1999). In addition, the study was conducted during spring; therefore it is not possible to take into account seasonal effects. Under-reporting can influence the usefulness of dietary data as a basis of food-based dietary guidelines (Becker & Welten, 2001). However, in the present study there were no significant differences in the percentage of under-reporters between tertiles, nor significant differences in the mean EI:BMR ratio of each tertile. Thus, it can be assumed that in the present study the effect of under-reporting is negligible, although a selective way of under-reporting food items between tertiles cannot be fully excluded (Becker *et al.* 1999). The issue of food composition tables in the development of food-based dietary guidelines cannot be neglected. The choice of food composition database may introduce a major source of error due to incompleteness, seasonal variation and may have a great contribution towards the lack of agreement between different assessment tools. In the present study, the food composition databases were locally developed (Belgium and the Netherlands); therefore comparisons with other European countries could introduce errors (Leclercq *et al.* 2001). The issue of survey duration should be considered in the development of food-based dietary guidelines (Lambe & Kearney, 1999). The present survey duration was 7 d, which is in general accepted as a representation of the current ‘usual’ intake (Nelson & Bingham, 1996). Nelson *et al.* (1989) have pointed out that to classify subjects in their true thirds, fourths, fifths, etc, of the SFA distribution intake respectively 7 d (male adults) and 6 d (female adults) are needed. To estimate true average SFA intake for an individual, longer periods are necessary, with estimates in the literature from 30 to 156 d for adult men and from 32 to 114 d for adult women (Basiotis *et al.* 1987). However, for the purpose of estimating group means a substantially smaller number of days is required. In order to estimate true average SFA intake accurately for a group of male adults (*n* 13), a number of 8 d and for a group of female adults (*n* 16) a number of 7 d has been reported in the past (Basiotis *et al.* 1987). However, to the authors’ knowledge, no specific figures on this topic are available for adolescents, nor are specific data available on the number of days necessary to estimate intake of food items or food groups. On the basis of the above, the authors conclude that the instrument used in the present study allows valid comparisons between groups of individuals (tertiles) and tackles the issue of survey duration proposed by Lambe & Kearney (1999). However, due to the lack of comparable, validated food composition database and the unavailability

Table 5. Daily intake of nutrients and food groups in female adolescents (*n* 212) according to tertiles of energy intake (EI) from saturated fatty acids (SFA)*

	Tertile 1 (*n* 70)		Tertile 2 (*n* 71)		Tertile 3 (*n* 71)		
	Median	Percentage consumers	Median	Percentage consumers	Median	Percentage consumers	*P*
Age (years)	16·0		16·0		16·0		0·319
Energy (kJ)	8047		8152		8528		0·064
EI:BMR	1·3		1·4		1·4		0·051
EI:BMR < 1·1 (%)	22·9		19·7		18·3		0·850
Total fat	31·3		35·3		39·3		0·000
SFA	12·3		14·2		16·8		0·000
MUFA	11·9		13·1		14·9		0·000
PUFA	5·3		5·6		5·7		0·193
Protein	14·7		14·9		14·8		0·088
Total carbohydrates	53·7		49·3		45·6		0·000
Mono- and disaccharides	25·1		23·3		20·1		0·000
Complex carbohydrates	25·6		22·6		21·7		0·000
Ca	695·3		764·3		773·9		0·042
Fe	9·7		9·9		10·2		0·625
Vitamin C	80·3		67·4		59·8		0·016
Potatoes	93·0	99	91·1	99	96·4	100	0·366
Bread, rusk and breakfast rolls	156·5	99	137·1	100	135·7	100	0·194
Eggs	6·9	79	2·9	63	6·4	75	0·540
Fruit	111·8	96	81·4	93	75·0	96	0·009
Cakes and biscuits	27·9	87	23·3	92	22·9	94	0·924
Poultry	17·86	67	17·4	61	23·2	72	0·498
Cereal products and binding agents	48·8	99	34·3	89	33·6	94	0·086
Vegetables	98·6	100	89·3	100	100·4	100	0·343
Savoury sandwich fillings	0·0	26	0·0	31	0·0	18	0·348
Cheese	12·9	91	22·2	94	30·5	94	0·000
Milk and milk products	169·6	94	165·7	96	160·0	97	0·853
Nuts, seeds and snacks	7·9	73	8·6	69	8·6	68	0·580
Sugar, confectionery, sweet fillings and sweet sauces	24·4	100	27·7	99	27·9	100	0·215
Fats, oils and savoury sauces	31·3	100	29·4	100	37·6	100	0·116
Fish and fish products	6·8	61	13·6	69	7·1	63	0·924
Meat and meat products	63·4	97	90·0	99	108·4	100	0·000

* Macronutrient intake is given in energy %, micronutrient intake is given in mg/d and food intake is given in g/d.

of a valid indicator to detect adolescent under-reporters (Black, 2000), it remains difficult to predict the total impact of all these factors on the development of food-based dietary guidelines.

One of the limitations of the methodology used in the present study is the way of classifying the dishes. The standard procedure was to break down a dish into different ingredients; however, this method was not always possible. Practically this means that the same food items were classified in different ways. For example, ‘spaghetti bolognaise’ was broken down into spaghetti, tomatoes, etc when the composition was known. In other circumstances the composition was not known (for example, eaten at a restaurant) and was not broken down into its different components. The storage of the data does not allow us to see what the effect is of classifying in different ways. On one hand the current methodology does not allow us to ascertain the importance of dishes as a source of nutrients but on the other hand it has been reported that the disaggregation of dishes gave a more precise picture of the dietary contributions of various food groups (Krebs-Smith *et al.* 1990).

The major dietary sources of saturated fat have a different ranking order in boys compared with girls. These differences in the ranking order could be explained by the differences in the amount consumed of a certain food group in relation to the SFA content. A comparison of the present results with other studies is difficult to make and needs to be interpreted carefully, mainly because of potential differences in methodology (ways of grouping foods, mean proportion *v.* population proportion, disaggregating dishes) and study population. In an older Belgian study among adults (*n* 10 694; aged 25–74 years; between 1980 and 1985), the mean SFA intake was 17·5 energy % and the main dietary sources of SFA were butter (23·9 %), meat and meat products (25 %), all margarines (12 %), cheese (10 %) and whole milk (5·1 %) (Staessen *et al.* 1998). A similar pattern is shown in the present study; however, the contribution of butter is decreased in favour of margarines. In an American study in adolescents (*n* 100; average age 15 years; in 1984), saturated fat accounted for more than 12 % of energy. Dairy; meat, fish, poultry and eggs, and bakery products were the primary sources of SFA intake in American adolescents (Witschi *et al.* 1990). In another US adolescent setting (*n* 1426; aged 12–18 years; between 1989 and 1991), milk (17·5 %), cheese (13·8 %), beef (11·7 %) and cake and biscuits (5·3 %) were the main dietary SFA sources (Subar *et al.* 1998). In Spanish children (*n* 1112; aged 6–7 years; in 1998–9) the SFA contribution to the total energy was on average 16·7 %. The principal source of SFA was whole milk (14·9 %), followed by ham (8·2 %), olive oil (6·7 %), dried fruits and nuts (6·4 %) and red meat (5·7 %) (Royo-Bordonada *et al.* 2003). The current SFA intake in adolescents is lower than previously found in Belgian adults and in Spanish children but higher than in American adolescents. The current food sources of SFA were comparable with other studies although milk contributed to a lesser extent than in other countries.

The significant higher intake of fruit in the lowest tertile of female adolescents, combined with the negative association of fish consumption and SFA intake, could suggest that an increase of the intake of fish and fruit could lower the intake of SFA. However, the weak correlation of fruit and vegetables with SFA intake indicates that the assumption that lowering saturated fat intake will change other relevant dietary intake variables in a favourable way is not necessarily legitimate. Therefore, when one develops food-based dietary guidelines, it is recommended to restrict the number of dietary goals, preferably just one (Lowik *et al.* 1999).

Overall, the consumption of ‘sugar, confectionery, sweet fillings and sauces’ (recommendation as low as possible) and ‘meat and meat products’ (recommendation 100 g/d) (boys) is high and the consumption of ‘fruit’ (recommendation 250 g/d) and ‘vegetables’ (recommendation at least 300 g/d) is too low in all tertiles (Flemish Institute for Health Promotion, 2003). In boys and girls, the intake of ‘fruit’ is lower in the highest tertile and the intake of ‘meat and meat products’ and ‘cheese’ is higher. The consumption of ‘breakfast rolls’ (rich in SFA) was higher in highest tertiles. The proportional contribution of SFA to the total fat intake is in subjects of the highest tertile higher than in subjects of the lowest tertile. The intake of Ca is higher in the former while the intake of vitamin C is higher in the latter. Analogous results were found in adults in the UK (Wearne & Day, 1999).

Different options to change the intake of a specific nutrient have been suggested (Gibney, 1999*a*). In the current context, the used strategy explores whether, within a given food category, nutrient intake can be changed by switching to a comparable alternative. The authors would like to underline the importance of the other options mentioned by Gibney (1999*a,b*), but explore the effects of changing high-fat margarine to low-fat margarine and high-fat cheese to low-fat cheese. The rationale to choose high-fat margarine and high-fat cheese was based on their high proportional contribution to the total SFA intake. The current simulation had several limitations and was based on highly conservative assumptions. It was suggested that all adolescents will change to the proposed alternative. No changes in percentage consumers, portion size and frequency were taken into account. The effect of introducing an alternative on taste or food preference or cooking processes was ignored. The so-called hidden SFA (for example, biscuits) were not taken into account. The energy intake did not remain the same, which is in conflict with the general staring point of preparing food-based dietary guidelines, namely energy balance. However, the simulation showed that the intake of SFA decreased significantly by introducing alternative foods. The effect was bigger in the highest tertiles; this is due to the higher consumed amounts of the replaced foods. However, the proportional contribution of all macronutrients to total energy intake changed. The current simulation shows that it is not possible – on a population level – to decrease SFA intake below the upper limit only by switching to an alternative food. However, a combination of different strategies such as decreasing the portion sizes of high-fat cheese and meat and meat products, lowering the proportion of specific food categories and changing the frequency of food groups will be needed.

Based on the present findings one could suggest that efforts to decrease the level of consumption of fresh meat (in boys), high-fat margarine and high-fat cheese should be a priority to lower the SFA intake. Another alternative would be to choose lean alternatives. In girls, attention has to be paid on food items belonging to the sugar, confectionery, sweet fillings and sauces food group. At the same time an increase of the consumption of fruit and vegetables could be introduced. Before these issues could be used as a basis for food-based dietary guidelines to decrease the intake of SFA among adolescents, it is advisable to carry out qualitative research in selected focus groups in order to identify the best strategy (Food and Agriculture Organization/World Health Organization, 1998; Gibney, 1999*a*). There are a number of factors that should also be considered before implementing food-based dietary guidelines; namely, practicality, comprehensibility and cultural acceptability (Food and Agriculture Organization/World Health Organization, 1998).

A possible nutritional consequence of implementing the above-mentioned guidelines is that the total fat content decreases where fat is needed as a vehicle for fat-soluble vitamins. At the same time, a decrease of, for example, the portion size of high-fat cheese could decrease the intake of Ca as it is already low in the present study. Another option would be to choose cheese with reduced fat content (if available), which also contains as much or more Ca. A change in the intake of one nutrient introduces a change in the intake of another (for example, Ca, vitamin A, D).

Individuals who choose to change their dietary pattern in favour of a lower SFA intake probably reduce the intake of all fatty acid categories (Gibney, 1999*b*). The only way this can be prevented is by changing the fatty acid composition of the fats within these food categories. Therefore by developing guidelines, an effective partnership and collaboration among the many sectors (governments, food industry and health professionals) that influence food supply and food selection is recommended (Anderson & Zlotkin, 2000).

To the knowledge of the authors, this is the first comprehensive examination of food sources of SFA in Belgian adolescents. The results show that the nutritional profile of Belgian adolescents could be substantially improved by decreasing the portion sizes of fresh meat (in boys), high-fat margarine and high-fat cheese, by choosing vegetable oils and by reducing intake of commercially prepared baked goods, snack foods, and processed foods, including fast foods. Another option would be to choose lean alternatives, if available.

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