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Dietary intake among under-, normal- and overweight 9- and 15-year-old Estonian and Swedish schoolchildren

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Abstract

Objectives: To determine the differences in macronutrient and food group contribution to total food and energy intakes between Estonian and Swedish under-, normal- and overweight schoolchildren, and to estimate the association between diet and body mass index (BMI).
Design: Cross-sectional comparison between Estonian and Swedish children and adolescents of different BMI groups.
Setting: Twenty-five schools from one region in Estonia and 42 in two regions of central Sweden.
Subjects: In total 2308 participants (1176 from Estonia and 1132 from Sweden), including 1141 children with a mean age of 9.6 ± 0.5 years and 1167 adolescents with a mean age of 15.5 ± 0.6 years.
Results: Overweight was more prevalent among younger girls in Sweden (17.0 vs. 8.9%) and underweight among girls of both age groups in Estonia (7.9 vs. 3.5% in younger and 10.5 vs. 5.1% in older age group of girls). Compared with that of normal- and underweight peers, the diet of overweight Estonian children contained more energy as fat (36.8 vs. 31.7%) but less as carbohydrates, and they consumed more milk and meat products. Absolute BMI of Estonian participants was associated positively with energy consumption from eggs and negatively with energy consumption from sweets and sugar. Swedish overweight adolescents tended to consume more energy from protein and milk products. Risk of being overweight was positively associated with total energy intake and energy from fish or meat products. In both countries the association of overweight and biological factors (pubertal maturation, parental BMI) was stronger than with diet.
Conclusion: The finding that differences in dietary intake between under-, normal- and overweight schoolchildren are country-specific suggests that local dietary habits should be considered in intervention projects addressing overweight.

Keywords
Children
Adolescents
Overweight
Dietary intake
Sweden
Estonia

Overweight and obesity in children and adolescents is multifactorial, with excessive energy intake from foods and low level of energy expenditure being important determinants[1–6]. Salbe *et al.* suggest that food intake may be the most important determinant of excess weight gain in young children, whereas physical activity may have a greater effect in older children and adolescents[7]. Nevertheless, some studies have shown no difference in food consumption between obese and non-obese children[8]. The macronutrient intake must also be considered, as the percentage of energy from fat in the diet and the total intake of fat appear to be relevant modulators of body fat deposition and it has been proposed that dietary protein intake may modulate body fat content[3].

Estonia and Sweden are two countries which are similar climatically but different in socio-economic terms. While Sweden is a developed and socio-economically stable country, great changes have taken place during the last 14 years in Estonia, an Eastern European country, a recent member of the European Union and previously part of the Soviet Union.

The food in Estonia has traditionally been rich in fat. During the years of socio-economic transition, the availability of different foods increased enormously and dietary habits have changed a lot towards healthier choices[9]. Eating habits in Sweden can be considered relatively stable, even though in adults the intake of fat (as a percentage of energy intake) has decreased, and fruit

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and vegetable intake has increased somewhat, according to national surveys from 1989 and 1997/8[10–12]. At the same time the intake of sugary products, snacks and alcoholic beverages has also increased from the first to the second survey in Sweden. An increase of the number of meals eaten outside the home has taken place in Sweden.

Much concern is given to the emerging problem of childhood overweight all over the world[13]. When focusing on the problem in Europe, we can see that the prevalence of overweight and obesity is increasing steadily, with the highest prevalence in the Southern European countries. Lobstein and Frelut report an overweight prevalence of 18% in Swedish 9–11-year-olds[14]. According to a study of 6–13-year-old children from the north of Sweden, the prevalence of obesity doubled from 1986 to 2001[15]. In Estonia the prevalence of overweight and obesity decreased during the socio-economic transition period in the 1990s. The average weight and body mass index (BMI) of children, and especially adolescents, have declined during the last decade compared with data from the 1980s. In 1989 the mean BMI of 15-year-olds was 20.5 $kg\,m^{-2}$ for boys and 21.3 $kg\,m^{-2}$ for girls; in 1996 the values were 19.5 and 20.3 $kg\,m^{-2}$, respectively[9,16]. The prevalence of obesity among Estonian children and adolescents has declined from 19% at the beginning of the 1980s[17] to 2–8% at the end of the 1980s[18], to 3–5% in the middle of the 1990s[19] and even less at the end of the 1990s.

Thus the trends in overweight and obesity in Estonia and Sweden have been in the opposite directions, making it important to understand the eating patterns in both countries and how these are related to weight development, with overweight and obesity pointed out as emerging public health problems with urgent needs for action.

The objectives of the present study were to determine the differences in macronutrient and food group contribution to total food and energy intakes between Estonian and Swedish under-, normal- and overweight schoolchildren and to estimate the association between diet and BMI.

Methods

Subjects

The subjects in this study were apparently healthy children and adolescents who participated in the European Youth Heart Study (EYHS) in Estonia and in Sweden. Data were collected in both countries from the beginning of September 1998 to the end of June 1999. In total 2308 participants, including children of the 3rd grade with a mean age of 9.6 ± 0.5 years and adolescents of the 9th grade with a mean age of 15.5 ± 0.6 years, were studied. Of all children participating in the study, 2182 had a full set of data and were included in further analyses. In Estonia, the city of Tartu and its surrounding rural areas was the geographical sampling area. In Sweden, two areas in central Sweden were chosen for data collection (Södertörn and Örebro). The main sampling unit was a school. Schools (25 from Estonia and 42 from Sweden) were sampled using probability proportional to school size[20]. From each school, all 3rd and 9th graders were invited to participate in the study. The local research ethics committees approved the study (Örebro City Council no. 690/98, Huddinge University Hospital no. 474/98, and University of Tartu no. 49/30-1997). A notice was sent to the parents and teachers explaining the survey and stating that participation was voluntary and data collected remained completely confidential. In the 9-year-old participants, one parent or legal guardian, and in the 15-year-olds both one parent and the participant, provided written informed consent.

The participation rate was 76% in Estonia and 50% in Sweden. Non-participants were absent from the school during the recruitment period or testing day, or had parents who had refused, or the students themselves were unwilling to participate. The main reason for not participating was the fear of venous blood sampling, one procedure in the EYHS. A dropout analysis of the Swedish part of the EYHS has been performed and is published[21]. This analysis showed that despite the low participation rate no differences were found between participants and non-participants in basic background variables that could influence interpretation of the outcomes of the study.

Dietary intake

Dietary 24-hour recall of food intake was used. Children completed a food record at home during the day before the study, for the younger children with support from their parents if necessary. A face-to-face interactive interview was performed on the next day. The interview data were compared with the record data and differences were discussed with the participant. Portion size, which was not indicated on the food record, was estimated using pictures of portion sizes[22]. A quality ranking of the interview was also recorded, with 1 = very good to 5 = very poor. Diet interviews with a quality ranking score 3 or above were excluded from further analysis.

Nutrient intake data were analysed in Sweden using the Swedish food composition database PC-kost (maintained by the Swedish National Food Administration) and in Estonia with the Finnish food composition database Micro-Nutrica 2.0 (modified and translated into the Estonian language at Tallinn University of Technology, Department of Food Processing)[23]. Hakala *et al.* have indicated that, for a dominant part of the nutrients, the estimated intakes calculated by means of standardised procedures using the PC-kost and Micro-Nutrica databases are comparable[24].

Body composition

Height and weight were measured in light clothing by standardised procedures. BMI was calculated as weight (kg)/[height (m)]^2. Based on BMI all children were grouped into underweight, normal-weight and overweight groups. The cut-off points for underweight were taken as the age-adjusted 10th percentile according to population reference standards in Estonia by Grünberg *et al.*[16] and in Sweden by Lindgren *et al.*[25]. Criteria for overweight and obesity are based on data by Cole *et al.*, per closest half year of age[26]. Male and female investigators, using the 5-stage scale according to Tanner[27], assessed pubertal maturation of participants. Tanner score was calculated by summing pubic hair stage with breast development stage in girls and with testis development stage in boys.

The height and weight of parents were self-reported.

Statistical analysis

Crude differences in average values of the studied factors between BMI groups were calculated using one-way analysis of variance. Given the considerable differences between the number of subjects in the groups, Hochberg's GT2 tests and Games–Howell tests were used for *post hoc* comparisons for situations with equal and unequal variances respectively[28]. In addition, tests for linear trends were performed. Kruskal–Wallis tests and Mann–Whitney tests with Bonferroni correction were used for non-normally distributed data. Nominal data were compared using chi-square tests and Fisher's exact tests. Individual effects of the studied factors on the risk of being overweight or obese were studied by multiple logistic regression analyses. Odds ratios with 95% confidence intervals were calculated. Multiple linear regression analyses were performed to study independent influences of the studied characteristics on the whole BMI distribution. Due to the relatively low number of participants in each age group and a large number of variables, forward stepwise procedures were performed[29]. Analyses were conducted in SPSS, version 11.0 (SPSS Inc.).

Results

Overweight was more prevalent among younger Swedish girls and underweight among Estonian girls of both age groups (Figs 1 and 2). Obesity was more prevalent in younger Swedish boys compared with Estonian boys (3.7 vs. 0.4%, $P = 0.003$). Overweight without obesity was more prevalent in younger Swedish girls than their Estonian peers (15.6 vs. 7.9%, $P = 0.002$). Overweight 9-year-old children from both countries were significantly taller than their under- and normal-weight peers (Table 1). In adolescents the same result was found only as a trend (Table 2). Overweight children of both countries and adolescents in Sweden had also significantly higher pubertal maturation score compared with peers with lower BMI.

Parental BMI was significantly higher in overweight children of both countries compared with participants with lower BMI (Tables 1 and 2).

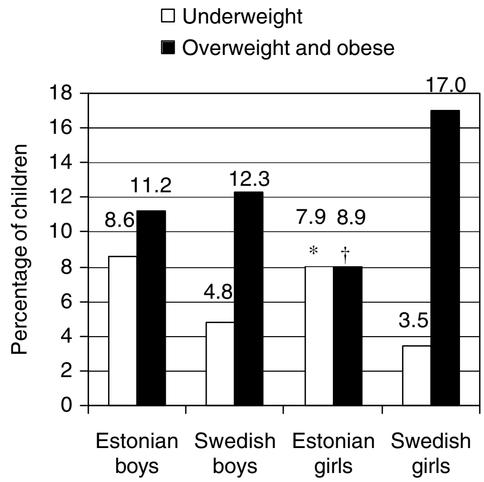

Fig. 1 Distribution (%) of 9-year-old Estonian and Swedish children into groups according to body mass index (data for normal-weight children not shown). *Significant difference from underweight Swedish girls ($P = 0.002$); †significant difference from overweight/obese Swedish girls ($P = 0.002$)

Significant differences in nutrient intake between BMI groups were found only in younger Estonians. In overweight Estonian children the energy contribution was higher from total fat, saturated fatty acids and monounsaturated fatty acids, and less from carbohydrate, compared with underweight peers (Table 1). A trend towards higher energy contribution from protein was noticed in overweight Swedish adolescents (Table 2). Overweight Estonian 9-year-olds consumed more milk than normal- or underweight participants (318.4 ± 228.9 vs. 250.5 ± 227.5 vs. 229.2 ± 250.5 g day^{-1}; $P < 0.05$), tended to consume more meat products, and their energy contribution from cereal products was lower, compared with their peers with lower BMI. Overweight Swedish adolescents tended to consume more milk products, but

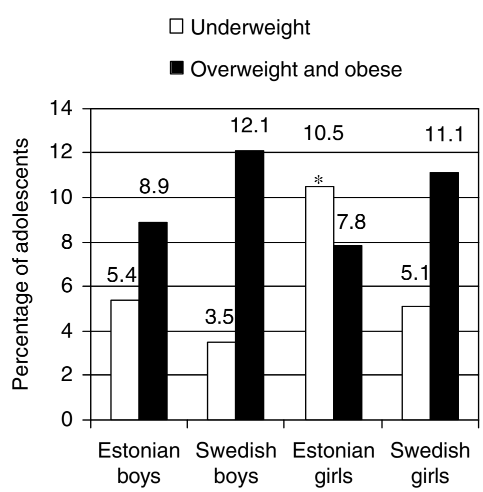

Fig. 2 Distribution (%) of 15-year-old Estonian and Swedish adolescents into groups according to body mass index (data for normal-weight adolescents not shown). *Significant difference from underweight Swedish girls ($P = 0.018$)

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Table 1 Mean ± standard deviation of anthropometric measurements, pubertal score, energy and macronutrients intake for 9-year-old male (M) and female (F) Estonian and Swedish children (*P*-values above 0.10 are not presented)

		9-year-old Estonian boys and girls				9-year-old Swedish boys and girls			
	RDA*	Underweight ($n=44$: 23 M, 21 F)	Normal-weight ($n=444$: 206 M, 238 F)	Overweight ($n=54$: 29 M, 25 F)	*P*-value	Underweight ($n=23$: 13 M, 10 F)	Normal-weight ($n=441$: 214 M, 227 F)	Overweight ($n=80$: 32 M, 48 F)	*P*-value
Height (cm)		135.2 ± 5.7	136.9 ± 6.3	141.8 ± 6.6	b ($P<0.001$)	136.7 ± 4.6	138.6 ± 6.0	142.2 ± 6.7	b, c ($P<0.001$)
Weight (kg)		25.4 ± 2.4	30.6 ± 4.3	42.5 ± 5.8	a, b, c ($P<0.001$)	25.8 ± 2.0	32.1 ± 4.3	44.2 ± 6.2	a, b, c ($P<0.001$)
BMI ($kg\,m^{-2}$)		13.9 ± 0.6	16.3 ± 1.3	21.0 ± 1.7	a, b, c ($P<0.001$)	13.8 ± 0.5	16.6 ± 1.3	21.8 ± 1.9	a, b, c ($P<0.001$)
Mother's BMI ($kg\,m^{-2}$)		23.5 ± 4.9	23.4 ± 4.0	25.0 ± 5.1	c ($P<0.01$)	22.3 ± 3.2	23.3 ± 3.6	25.6 ± 4.7	b, c ($P<0.001$)
Father's BMI ($kg\,m^{-2}$)		24.2 ± 3.3	25.9 ± 3.5	27.3 ± 4.1	a, b, c ($P<0.01$)	24.0 ± 2.1	25.5 ± 3.2	26.6 ± 3.6	a, b, c ($P<0.001$)
Tanner score		2.2 ± 0.4	2.3 ± 0.7	2.8 ± 0.9	b, c ($P<0.001$)	2.1 ± 0.3	2.2 ± 0.5	2.6 ± 0.7	b, c ($P<0.001$)
Energy intake ($MJ\,day^{-1}$)	7.6 (F), 8.8 (M)	7.5 ± 2.8	8.1 ± 2.7	8.5 ± 2.6		8.9 ± 2.6	8.6 ± 2.1	9.1 ± 1.9	
Protein (%)	10–20	12.2 ± 2.9	12.4 ± 2.9	12.8 ± 2.8		15.0 ± 3.3	15.6 ± 3.2	15.6 ± 3.4	
Carbohydrate (%)	50–60	56.1 ± 8.0	53.1 ± 8.9	50.3 ± 9.7	b, c ($P<0.01$)	52.7 ± 7.5	52.1 ± 7.0	51.0 ± 8.1	
Fat (%)	25–35	31.7 ± 7.4	34.5 ± 8.2	36.8 ± 9.4	b ($P<0.01$)	32.5 ± 5.6	32.4 ± 6.2	33.3 ± 6.9	
SFA (%)	10	12.2 ± 3.6	13.0 ± 3.9	14.1 ± 3.7	b ($P<0.05$)	15.5 ± 3.9	15.1 ± 3.3	15.4 ± 3.6	
MUFA (%)	10–15	10.2 ± 2.9	11.4 ± 3.5	12.4 ± 34.3	b ($P<0.01$)	11.7 ± 2.0	11.8 ± 2.7	12.1 ± 2.9	
PUFA (%)	5–10	6.9 ± 3.0	7.4 ± 3.4	7.8 ± 4.4		3.6 ± 1.2	3.7 ± 1.5	3.9 ± 2.4	
Fibre ($g\,day^{-1}$)	14†	17.1 ± 9.0	18.0 ± 9.5	16.9 ± 6.7		14.3 ± 5.9	14.8 ± 5.8	15.2 ± 5.2	

BMI – body mass index; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids.
P-values for *post hoc* tests: a – difference between under- and normal-weight; b – difference between under- and overweight; c – difference between normal- and overweight. In all other cases presented *P*-values are *P*-values for omnibus tests.
* Recommended Dietary Allowance[30].
† Age plus 5 g as a reasonable minimum recommendation for dietary fibre intake was used[31,32].

Table 2 Mean ± standard deviation of anthropometric measurements, pubertal score, energy and macronutrients intake for 15-year-old male (M) and female (F) Estonian and Swedish adolescents (*P*-values above 0.10 are not presented)

		15-year-old Estonian boys and girls				15-year-old Swedish boys and girls			
	RDA*	Underweight ($n = 48$: 13 M, 35 F)	Normal-weight ($n = 467$: 215 M, 252 F)	Overweight ($n = 41$: 21 M, 20 F)	*P*-value	Underweight ($n = 25$: 9 M, 16 F)	Normal-weight ($n = 460$: 211 M, 249 F)	Overweight ($n = 55$: 28 M, 27 F)	*P*-value
Height (cm)		166.8 ± 9.5	169.3 ± 7.9	170.5 ± 8.4	$P = 0.057$	168.2 ± 9.7	170.0 ± 8.4	171.9 ± 8.9	$P = 0.076$
Weight (kg)		45.9 ± 5.4	57.7 ± 7.5	77.0 ± 11.8	a, b, c ($P < 0.001$)	47.2 ± 5.3	59.1 ± 7.2	77.9 ± 10.2	a, b, c ($P < 0.001$)
BMI ($kg\,m^{-2}$)		16.4 ± 0.7	20.1 ± 1.7	26.5 ± 3.4	a, b, c ($P < 0.001$)	16.6 ± 0.7	20.4 ± 1.7	26.3 ± 1.9	a, b, c ($P < 0.001$)
Mother's BMI ($kg\,m^{-2}$)		23.0 ± 3.0	24.6 ± 4.1	27.6 ± 5.7	a, b, c ($P < 0.001$)	23.1 ± 2.7	24.1 ± 3.8	26.9 ± 5.4	b, c ($P < 0.001$)
Father's BMI ($kg\,m^{-2}$)		24.8 ± 3.7	25.8 ± 3.7	27.4 ± 3.8	b, c ($P < 0.05$)	24.7 ± 3.6	25.8 ± 3.1	27.0 ± 3.1	b, c ($P < 0.01$)
Tanner score		7.8 ± 1.7	8.6 ± 1.3	8.8 ± 1.3	a, b ($P < 0.001$)	7.8 ± 2.1	9.2 ± 1.1	9.6 ± 0.9	a, b, c ($P < 0.001$)
Energy intake ($MJ\,day^{-1}$)	9.6 (F), 11.3 (M)	9.5 ± 3.2	10.1 ± 3.6	10.3 ± 4.7		9.3 ± 2.5	10.7 ± 3.6	10.3 ± 2.8	
Protein (%)	10–20	13.1 ± 3.0	12.7 ± 3.1	13.1 ± 3.4		14.4 ± 3.9	15.1 ± 3.5	16.1 ± 3.2	$P = 0.053$
Carbohydrate (%)	50–60	51.4 ± 8.2	51.0 ± 9.4	50.3 ± 9.9		55.9 ± 7.2	53.7 ± 7.7	52.8 ± 7.7	
Fat (%)	25–35	35.5 ± 7.6	36.3 ± 8.7	36.6 ± 8.6		29.7 ± 6.7	31.2 ± 6.7	31.2 ± 7.1	
SFA (%)	10	12.6 ± 3.4	13.2 ± 4.1	13.7 ± 3.9		13.4 ± 3.1	14.3 ± 3.8	13.9 ± 2.9	
MUFA (%)	10–15	12.2 ± 3.6	12.3 ± 3.6	12.6 ± 3.6		10.9 ± 2.5	11.5 ± 3.1	11.1 ± 3.1	
PUFA (%)	5–10	7.2 ± 3.2	7.7 ± 3.5	7.5 ± 3.4		3.7 ± 2.5	3.9 ± 2.0	4.2 ± 3.7	
Fibre ($g\,day^{-1}$)	20†	21.8 ± 10.3	23.9 ± 13.6	23.5 ± 13.4		16.2 ± 6.1	18.9 ± 8.8	15.9 ± 6.6	c ($P < 0.05$)

BMI – body mass index; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids.
P-values for *post hoc* tests: a – difference between under- and normal-weight; b – difference between under- and overweight; c – difference between normal- and overweight. In all other cases presented *P*-values are *P*-values for omnibus tests.
* Recommended Dietary Allowance[30].
† Age plus 5 g as a reasonable minimum recommendation for dietary fibre intake was used[31,32].

less energy from vegetables, than peers with lower BMI in the same country (Tables 3 and 4).

Stepwise multiple linear regression analysis showed that absolute BMI values were positively associated with parental BMI and the Tanner score of children and adolescents in both countries (Tables 5 and 6). In Swedish children, increase in daily energy intake by 1 MJ was associated with an increase in BMI of $0.1\,kg\,m^{-2}$. BMI in Estonian participants was negatively associated with energy contribution from sweets, sugar and soft drinks but positively associated with that from eggs. Increased energy percentage from eggs by 1% was associated with an increase in BMI of $0.1\,kg\,m^{-2}$.

When the dietary data were analysed in a logistic regression analysis together with age, gender, Tanner score and parental BMI, the risk of being overweight was associated with parental BMI in both countries. Increase in total energy intake by 1 MJ was associated with 16% increased odds of being overweight in Swedish children. Higher energy contribution from fish in Swedish children was also associated with a higher probability of being overweight. In Swedish adolescents the only dietary component correlated with the risk of being overweight was energy contribution from meat: an increase of 1% was associated with increasing odds of being overweight by 3%. Lower energy contribution from carbohydrates in Estonian children was negatively associated with the risk of being overweight.

Discussion

The main result of the current study is that the association between diet and BMI in schoolchildren was country-specific. We also found that the association between BMI and biological factors such as pubertal maturation (Tanner score) and parental BMI was stronger than the association with food or macronutrient intake.

Estonian overweight children consumed more energy as fat and less as carbohydrates, and Swedish overweight adolescents tended to consume more energy as protein, compared with their peers with lower BMI. Risk of being overweight was positively associated with total energy intake in Swedish children.

According to some authors, the macronutrient composition of children's diets, particularly higher dietary fat and lower carbohydrate intakes, may play a role in adiposity, independent of the influence of total energy intake, gender, physical fitness and parental BMI[4,33–35]. Similar results have been shown in animal studies; macronutrient intake, particularly elevated dietary fat consumption, causes obesity, even without excessive energy intake[36,37]. Other authors have proposed that dietary protein intake may modulate body fat content. Kim *et al.* found that the percentage of body fat in rats increased if they consumed an increasing proportion of protein[38]. Hauner *et al.* suggested that high protein intake in excess of metabolic requirements may enhance the secretion of insulin and insulin-like growth factor-I, which can stimulate adipogenic activity[39]. Findings of our population-based study are consistent with these preclinical and clinical data. Country-specific differences in our study can be explained by the difference in consumption of larger amounts of certain foods or food groups, by the preference for more energy-dense foods inside the same food groups by overweight participants, or by the difference in fat and energy content of the same foods in Estonia and Sweden.

Although in their study of 11- to 16-year-old Canadian adolescents Janssen *et al.* found no clear association between dietary habits (food frequency) and overweight[40], we found an association between the amount of food and BMI. Estonian overweight children consumed more milk ($g\,day^{-1}$) and tended to consume more meat, and Swedish overweight adolescents tended to consume more milk products. It was surprising to find that in Estonian children and adolescents the amount of milk and milk products consumed was almost two times smaller than that of their Swedish peers. Nevertheless, the milk consumed by Estonian children yielded higher energy consumption as fats or fatty acids, but in Swedish adolescents yielded higher energy intake as proteins. Such a finding can be explained by the fact that the types of milk preferred in Estonia contain 2.5% fat and above (full milk). In Sweden low-fat milk, containing 0.5 or 1.5% fat, is most prevalent. Higher intake of energy as protein in overweight Swedish adolescents can also be explained by their higher intake of energy as meat.

In Swedish children overweight was associated with higher energy consumption from fish. As their total energy intake was associated with higher BMI, it can be suggested that overweight Swedish children preferred more energy-dense fish.

The food in Estonia and other Baltic countries has traditionally been high in fat content, as also shown in a comparative analysis by the World Health Organization[41,42]. Although dietary habits have changed during the last decade, it seems that fatty foods such as meat products and high-fat milk are still preferred, and especially by overweight children. This suggestion is supported by another result of our study showing that even in Estonian under- and normal-weight adolescents the energy contribution from total fat was higher than in overweight Swedish peers.

In Sweden, the introduction of low-fat alternatives and educating people about healthy diets started decades ago, much earlier than in Estonia. Also the availability of low-fat alternatives, in Sweden labelled with the keyhole symbol, is lower in Estonia. In Estonia milk with high fat content is believed to be a healthy choice for children.

Together with higher consumption of energy as fats, Estonian overweight children consumed less energy as carbohydrates, and there was also an inverse relationship between total BMI and energy intake as carbohydrates.

Table 3 Intake (g day^{-1}, mean ± standard deviation) of food groups and percentage of energy (%E) from food groups for 9-year-old male (M) and female (F) Estonian and Swedish children (*P*-values above 0.10 are not presented)

	9-year-old Estonian boys and girls				9-year-old Swedish boys and girls			
	Underweight ($n = 44$: 23 M, 21 F)	Normal-weight ($n = 444$: 206 M, 238 F)	Overweight ($n = 54$: 29 M, 25 F)	*P*-value	Underweight ($n = 23$: 13 M, 10 F)	Normal-weight ($n = 441$: 214 M, 227 F)	Overweight ($n = 80$: 32 M, 48 F)	*P*-value
Cereal products	228.4 ± 148.7	206.5 ± 126.5	198.1 ± 103.8		256.1 ± 156.2	305.5 ± 167.9	311.4 ± 172.3	
%E	30.9 ± 14.5	26.6 ± 12.9	24.9 ± 11.6	a, b ($P < 0.05$)	26.8 ± 12.8	31.5 ± 13.5	30.0 ± 13.6	
Vegetables & potatoes	250.1 ± 236.7	311.5 ± 235.5	300.6 ± 252.3		254.1 ± 164.5	227.7 ± 192.8	222.2 ± 186.4	
%E	10.8 ± 10.4	13.6 ± 11.1	12.8 ± 11.1		10.4 ± 7.6	9.2 ± 8.6	7.9 ± 7.3	
Fruits & jams & juices	190.7 ± 241.6	176.1 ± 234.3	192.5 ± 202.6		197.1 ± 190.3	233.5 ± 240.3	245.4 ± 216.9	
%E	6.2 ± 6.4	5.1 ± 5.7	5.6 ± 5.0		6.5 ± 5.3	7.8 ± 6.9	7.8 ± 6.0	
Fats & oils	29.6 ± 22.9	32.7 ± 29.0	32.8 ± 33.6		21.9 ± 16.3	19.8 ± 18.8	21.9 ± 23.7	
%E	11.7 ± 6.4	11.6 ± 7.9	11.8 ± 9.2		5.9 ± 4.5	5.1 ± 4.7	4.8 ± 5.2	
Milk products	322.5 ± 260.3	340.9 ± 246.8	388.1 ± 237.3		675.6 ± 387.5	619.9 ± 361.2	651.7 ± 347.9	
%E	15.4 ± 9.9	15.1 ± 9.9	17.0 ± 10.0		21.3 ± 10.8	21.5 ± 11.0	21.1 ± 11.2	
Meat products	82.9 ± 68.2	108.3 ± 89.6	122.6 ± 91.2	$P = 0.087$	123.0 ± 97.4	145.3 ± 119.5	153.6 ± 127.7	
%E	9.4 ± 8.1	11.8 ± 9.8	12.5 ± 9.2		11.4 ± 9.9	12.9 ± 10.1	13.8 ± 10.4	
Fish	6.3 ± 18.6	7.3 ± 23.5	2.9 ± 16.6		28.6 ± 55.6	24.9 ± 57.7	32.6 ± 59.8	
%E	0.5 ± 1.4	0.5 ± 1.7	0.4 ± 2.3		2.2 ± 4.8	1.8 ± 4.1	2.7 ± 5.0	
Eggs	12.3 ± 24.9	19.5 ± 38.1	21.8 ± 49.9		7.2 ± 19.1	5.6 ± 25.4	3.7 ± 13.6	
%E	0.8 ± 1.6	1.5 ± 3.2	1.3 ± 2.4		0.5 ± 1.3	0.4 ± 1.7	0.3 ± 1.1	
Drinks (tea, coffee, soft drinks)	570.9 ± 384.3	520.1 ± 306.4	521.3 ± 300.8		405.5 ± 369.2	409.4 ± 362.0	508.6 ± 449.2	
Sugar & sweets	46.2 ± 29.2	50.3 ± 38.3	46.9 ± 40.6		28.2 ± 35.7	22.0 ± 32.4	28.7 ± 40.5	
%E (sugar & sweets & drinks combined)	14.2 ± 7.5	14.0 ± 9.6	13.4 ± 9.6		11.4 ± 10.4	8.0 ± 8.3	9.7 ± 10.9	

P-values for *post hoc* tests: a – difference between under- and normal-weight; b – difference between under- and overweight. Presented *P*-value is *P*-value for omnibus tests.

Table 4 Intake (g day^{-1}, mean ± standard deviation) of food groups and percentage of energy (%E) from food groups for 15-year-old male (M) and female (F) Estonian and Swedish adolescents (*P*-values above 0.10 are not presented)

	15-year-old Estonian boys and girls				15-year-old Swedish boys and girls			
	Underweight ($n=48$: 13 M, 35 F)	Normal-weight ($n=467$: 215 M, 252 F)	Overweight ($n=41$: 21 M, 20 F)	*P*-value	Underweight ($n=25$: 9 M, 16 F)	Normal-weight ($n=460$: 211 M, 249 F)	Overweight ($n=55$: 28 M, 27 F)	*P*-value
Cereal products	230.0 ± 146.1	256.3 ± 163.5	257.7 ± 168.8		305.1 ± 164.3	367.1 ± 204.2	338.8 ± 201.1	
%E	27.4 ± 12.8	26.4 ± 11.9	25.6 ± 11.9		30.4 ± 14.5	30.7 ± 12.8	31.1 ± 14.8	
Vegetables & potatoes	313.6 ± 230.6	356.9 ± 297.4	301.2 ± 240.7		282.4 ± 187.3	272.7 ± 221.6	222.9 ± 214.5	
%E	11.5 ± 9.2	12.4 ± 10.5	9.6 ± 9.6		10.1 ± 7.8	9.5 ± 8.7	7.4 ± 8.4	$P=0.064$
Fruits & jams & juices	162.8 ± 169.4	246.5 ± 314.3	253.5 ± 311.7		269.6 ± 271.7	281.8 ± 310.4	197.1 ± 244.9	
%E	4.5 ± 4.1	5.8 ± 6.8	6.3 ± 7.7		8.5 ± 5.7	8.3 ± 7.9	6.1 ± 5.2	
Fats & oils	40.5 ± 26.4	46.6 ± 35.7	44.4 ± 41.1		18.8 ± 23.3	24.1 ± 29.3	21.8 ± 32.5	
%E	13.0 ± 6.8	13.7 ± 8.3	13.0 ± 8.1		3.9 ± 4.3	4.6 ± 4.9	4.2 ± 6.7	
Milk products	317.2 ± 224.4	359.9 ± 318.5	420.1 ± 349.9		496.2 ± 353.9	693.7 ± 475.3	765.8 ± 500.2	$P=0.065$
%E	12.7 ± 7.9	12.9 ± 9.2	14.6 ± 10.1		15.8 ± 9.9	19.4 ± 10.9	20.9 ± 10.1	$P=0.053$
Meat products	129.6 ± 143.9	135.9 ± 104.4	182.1 ± 177.8		140.9 ± 105.9	164.8 ± 156.9	175.3 ± 117.7	
%E	12.2 ± 9.7	12.4 ± 9.4	14.5 ± 10.1		12.0 ± 10.0	11.3 ± 10.0	13.6 ± 10.3	
Fish	22.5 ± 82.5	17.7 ± 66.6	9.7 ± 28.4		28.6 ± 59.6	29.9 ± 72.6	33.5 ± 79.7	
%E	1.1 ± 3.6	1.0 ± 3.4	0.4 ± 1.1		1.6 ± 3.1	2.0 ± 4.6	2.3 ± 4.5	
Eggs	26.2 ± 34.9	33.7 ± 53.3	52.4 ± 70.8		2.4 ± 8.3	4.8 ± 19.0	8.2 ± 31.4	
%E	1.6 ± 2.1	1.8 ± 2.6	2.4 ± 2.8		0.2 ± 0.7	0.3 ± 1.4	0.4 ± 1.6	
Drinks (tea, coffee, soft drinks)	685.9 ± 373.3	699.8 ± 484.3	616.7 ± 478.8		654.8 ± 450.7	908.7 ± 698.1	965.7 ± 730.6	
Sugar & sweets	64.5 ± 73.0	59.5 ± 55.5	60.4 ± 86.6		40.3 ± 52.3	47.6 ± 60.2	44.9 ± 62.1	
%E (sugar & sweets & drinks combined)	15.9 ± 11.3	13.5 ± 10.5	13.5 ± 14.0		15.1 ± 16.2	12.9 ± 11.6	13.2 ± 10.9	

Presented *P*-values are *P*-values for omnibus tests.

Table 5 Results of multiple linear and logistic regression analyses for the younger age group*

	BMI difference (95% CI)		Adjusted OR for overweight/obesity (95% CI)	
	Estonia	Sweden	Estonia	Sweden
Mother's BMI	0.07 (0.03, 0.16)	0.17 (0.12, 0.22)	1.07 (1.01, 1.14)	1.12 (1.05, 1.19)
Father's BMI	0.12 (0.07, 0.17)	0.12 (0.05, 0.18)	1.12 (1.03, 1.22)	1.11 (1.03, 1.20)
Male gender	0.48 (0.10, 0.85)	0.68 (0.23, 1.14)		
Tanner score	0.85 (0.58, 1.13)	1.59 (1.17, 2.00)		2.99 (1.97, 4.54)
Total energy intake, MJ		0.10 (0.01, 0.20)		1.16 (1.01, 1.32)
% Energy from carbohydrates	− 0.04 (− 0.06, − 0.02)		0.94 (0.91, 0.98)	
% Energy from fish				1.06 (1.01, 1.12)

BMI – body mass index; CI – confidence interval; OR – odds ratio.
* Independent variables were entered into the models using a forward stepwise procedure. Presented results are adjusted for the variables in the table. Inclusion of gender and other variables listed in Tables 1–4 did not improve the models.

Similarly, in Estonian overweight adolescents absolute BMI was associated with the consumption of less energy from sweets, sugar and sweet drinks.

Several authors have also described the association between total energy intake and overweight. Rocandio *et al.*[4] have shown that overweight children consume less energy (kJ day^{-1}) than non-overweight children, and suggested that the positive energy balance causing overweight is possibly due to low energy output. Several other authors have obtained similar results when adjusting energy intake per resting metabolic rate[34], per kilogram of body weight[35] or as the ratio of reported energy intake to measured energy expenditure[43]. In our study no difference was found in energy intake between different BMI groups. The differences in BMI could thus be explained by differences in energy output. However, in Swedish children we found a positive association between absolute BMI and energy intake in regression analysis. This suggests that the development of overweight can differ by country regarding the contribution of distinct components in energy balance.

Earlier pubertal onset or menarche has been found to be associated with greater BMI values in several previous studies[44–46]. Pubertal maturation score is strongly associated with age during the maturation, thus older children in a group are usually more mature and their BMI is higher. We also found a positive association between pubertal score and absolute BMI. The risk of being overweight was significantly associated with sexual maturation only in Swedish participants. The lack of an association between pubertal score and the risk of being overweight in Estonian participants can be explained by the low prevalence of overweight in the Estonian sample.

Danielzik *et al.* have shown that the nutritional status of prepubertal children is influenced by parental BMI, and parental overweight and obesity are risk factors for childhood overweight[47]. Vogler *et al.* proposed that most of the familial risk for childhood obesity is likely to be explained by genetic factors[48]. Perusse and Bouchard presumed that in children the maximal heritability of obesity phenotypes ranges from about 30 to 50%[49]. This finding can be interpreted as indicating that besides genetic factors, there is space left for environmental factors, such as for example nutrition. Wardle *et al.* described that children of overweight parents had a higher taste preference for fatty foods, a lower liking for vegetables and a more 'overeating-type' eating style[50]. In our study, the absolute BMI of both the father and the mother was positively associated with participant's absolute BMI and with the risk of being overweight in both countries. The associations found were stronger than between BMI and diet.

Our study has both limitations and strengths. We have studied a large number of young people in two countries with different prevalences of overweight, different dietary

Table 6 Results of multiple linear and logistic regression analyses for the older age group*

	BMI difference (95% CI)		Adjusted OR for overweight/obesity (95% CI)	
	Estonia	Sweden	Estonia	Sweden
Mother's BMI	0.15 (0.09, 0.22)	0.15 (0.10, 0.21)	1.15 (1.08, 1.12)	1.14 (1.07, 1.22)
Father's BMI	0.13 (0.06, 0.20)	0.13 (0.05, 0.21)		
Male gender		− 0.84 (− 1.33, − 0.34)		
Tanner score	0.41 (0.21, 0.60)	0.69 (0.48, 0.91)		1.62 (1.10, 2.38)
% Energy from meat				1.03 (1.00, 1.06)
% Energy from sweets, sugar & soft drinks	− 0.35 (− 0.06, − 0.01)			
% Energy from eggs	0.10 (0.01, 0.21)			

BMI – body mass index; CI – confidence interval; OR – odds ratio.
* Independent variables were entered into the models using a forward stepwise procedure. Presented results are adjusted for the variables in the table. Inclusion of gender and other variables listed in Tables 1–4 did not improve the models.

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patterns and different socio-economic conditions. Data collection in both countries was performed in parallel using the same methodology. The limitation of our study is its cross-sectional design that does not allow us to describe causality. Although the participation rate was high in Estonia, only 50% of young people invited actually participated in Sweden. Nevertheless, dropout analysis of the Swedish sample showed that despite the low participation rate no differences were found between participants and non-participants[21]. Sampling method ensured that the sample is representative, so we can generalise the results at least in the areas where the study was performed.

We used 24-hour recall of food intake, together with a food record-assisted recall method. This is not an appropriate method for reflecting typical dietary patterns on an individual level, but can be reliable on a group level. The method has been developed, validated and successfully used in the CATCH (Child and Adolescent Trial for Cardiovascular Health) study[51].

The variability of the dietary data was large both between subjects and within subjects. Large variability requires large samples to show significant differences. The limitation of the current study is that the groups of underweight and overweight were much smaller than the group of normal-weight participants.

Another limitation for the study, as also of other food consumption surveys, can be underreporting of food consumed. Especially females and overweight persons have been found to underreport their food consumption[8,52]. In the present study quality ranking of the interview was used to identify those persons whose diet reports were of poor validity. Trained interviewers performed dietary interviews, the interview data were compared with data recorded during the day before the study, and differences were discussed with the participant. The parents of younger children were asked to help with diet recording. Nevertheless, altogether 126 participants (78 from Estonia and 48 from Sweden) had to be excluded from further analysis because of poor diet interview. No significant gender or BMI differences were found between the participants who were or who were not excluded from the analysis.

One additional shortcoming of our study can be the self-reported heights and weights of the parents. Wardle *et al.* have shown that the underestimation of BMI is greater for obese parents than for normal-weight subjects[50]. Nevertheless, parental BMI in our study was significantly higher in overweight children of both countries.

The results of our study allow us to conclude that differences in dietary intake between under-, normal- and overweight schoolchildren exist but are country-specific and the association between overweight and diet is rather weak. It can be suggested that other factors than diet still remain important in the development of overweight in children and adolescents.

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