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Dietary intake and physical activity of normal weight and overweight 6- to 14-year-old Swiss children

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Summary

Principles and questions under study: The prevalence of overweight is increasing in Swiss children, and they are at increased risk for hypertension and insulin resistance. Better understanding of how food intakes and activity patterns differ between overweight and normal weight children is needed to develop intervention strategies to control childhood adiposity. The aim of the study was therefore to compare nutrient intake, dietary patterns and physical activity in overweight and normal weight children in Switzerland.

Methods: The subjects were healthy 6 to 14-year-old normal weight and overweight children (n = 74 and n = 68 respectively). Dietary intakes were assessed during three home visits with two 24-hour recalls and one 1-day food record. Questionnaires on physical activity and social background were completed.

Results: The carbohydrate and fat contents of the diet as a percent of energy did not differ comparing normal and overweight children, but the percentage of protein was significantly higher in overweight children. Intakes of energy, carbohydrates and fat were not significantly correlated with body mass index (BMI) standard deviation scores (SDS) after controlling for age, gender and total energy (for carbohydrates and fat). However, protein intake significantly predicted BMI-SDS after controlling for age, gender and total energy. Similarly, meat intake predicted BMI-SDS after controlling for age, gender and total energy, but none of the other analysed food groups were predictors. Time spent watching television and time spent in organised sports activity were significantly correlated with BMI-SDS. The educational level of mothers of overweight children was significantly lower than of mothers of normal weight children.

Conclusion: Intakes of fat and saturated fat in Swiss children are 20% and 50% higher, respectively than recommended intakes. Higher protein intake, higher intake of meat and more hours spent watching TV and playing computer games are associated with overweight in primary school-aged Swiss children.

Key words: dietary intake; overweight, children, physical activity

Introduction

The prevalence of childhood obesity is increasing rapidly worldwide [1–3]. In Switzerland, a study in Lausanne in 5 to 16-year-old children (n = 1200) found that 14% of girls, and 13–18% of boys were overweight, while the prevalence of obesity was 2.7% for girls and 1.7–2.3% for boys [4]. In a recent representative national study in Swiss children aged 6–12 years (n = 2600), the prevalence of overweight (above the 85th body mass index (BMI) percentile for age) and obesity (above the 95th BMI percentile for age) was 18.9 and 19.9% and 5.7 and 7.4%, in girls and boys, respectively. BMI and body fat percentages have increased sharply in school-aged children in Switzerland over the past 2 decades [5].

We have recently shown that elevated fasting insulin concentrations and high blood pressure, as well as subclinical inflammation – increased C-reactive protein (CRP), interleukin 6 (IL-6) and leptin concentrations – are common in overweight Swiss children at primary school age. In addition, independent of BMI, high intakes of fat and saturated fat are predictors of subclinical inflammation, fasting insulin concentrations and systolic blood pressure in this age group [6, 7]. Previous studies from the U.S. have shown that subclinical inflammation, elevated fasting insulin concentrations and high systolic blood pressure are common in overweight children with the metabolic syndrome [8, 9].

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Clearly, there is a need for effective intervention strategies to control childhood obesity in Switzerland, including better understanding of how food intakes and activity patterns of overweight children differ from those of normal weight children. The question whether paediatric overweight is associated with overeating or under-activity, or a combination of the two, remains unclear. Diet studies in children are difficult because of the methodological difficulties of assessing food intake in children. Passive overconsumption of an increasingly varied, energy-dense and palatable diet may play a role [10], along with the macronutrient composition of the diet. Obese children may have higher intakes of fat and lower intakes of carbohydrates compared to normal weight children [11, 12]. Consumption of sugary soft drinks is high in overweight children [13–15]. Increased risk of childhood overweight has also been associated with inactive leisure time pursuits, such as increased television viewing and video and computer games [13, 16, 17]. However, data suggesting that lower levels of physical activity promote childhood overweight are equivocal [10].

Few studies in Switzerland have examined food intakes and eating patterns in children. Suter and Benz [18] found that children who regularly ate breakfast had a significantly lower BMI than those who did not. Frequent snacking also was a risk factor for overweight, and children who consumed high fat snacks had a significant higher BMI compared to those consuming low fat snacks. Decarli et al. [19] reported that 11- to 16-year-old Swiss children consumed a diet rich in refined foods and low in plant-derived foods, and daily energy intakes were below recommendations, especially for girls. Other studies have also reported low consumption of fruits and vegetables in adolescents [20, 21]. Additional information is needed on food intake and physical activity in normal and overweight children in Switzerland, particularly in younger children. The aim of this study was therefore to compare dietary intakes, physical activity and socioeconomic background in normal weight and overweight primary school-aged children in Switzerland.

Subjects and methods

Subjects

The subjects for this study were 6 to 14-year-old children (n = 156) living in the German part of Switzerland. The children were a convenience sample recruited in two steps. The first group of children was recruited in 2003 through letters to randomly selected primary schools in the cantons of Zurich, Berne and Basel (n = 77, 43 overweight, 34 normal weight). The second group was recruited in 2004/2005 again through letters to primary schools in the canton of Zurich (n = 64, 33 normal weight, 31 overweight), and through a paediatric clinic (Ostschweizer Kinderspital, St. Gallen) offering adiposity counselling (n = 15, all overweight). The children recruited through the clinic were otherwise healthy overweight and obese children, presenting at the clinic for the first time for weight counselling.

Informed written consent was obtained from the parents and informed oral assent from the children. The study protocol was approved by the ethical committee of the Swiss Federal Institute of Technology in Zurich.

Dietary assessment

Dietary assessment was done using two 24-hour recalls and one 1-day food record. This combination has been previously validated in children as young as 8 years [22] and provides a good overview of a child's habitual diet. The fieldwork was done by trained female interviewers in the family home. Each child was visited three times by the same interviewer. Height was measured to the nearest 0.5 cm and weight to the nearest 100 g on a digital scale (Breuer BF 18, Ulm Germany) in light summer clothes. The first visit included a 24-hour recall and questions concerning physical activity of the children. During the second visit, the second 24-hour recall was completed, instructions for the 1-day weighed food record, which was to be completed by the child assisted by the parents, were given. Moreover, a questionnaire on social background was distributed. At the third visit, the 1-day food record was carefully reviewed. Volumes and portion sizes for the 24-hour recalls were estimated using measuring cups and spoons, photographs of food portions, and graduated food samples of cheese and bread. For the 1-day-food record individual digital kitchen scales were used.

The extent of underreporting was assessed using the criteria defined by Goldberg et al. [23]. Resting metabolic rate (RMR) for each child was calculated using the equations by Maffeis et al. (RMR [kJ/day] for boys = 1287 + 28.6 * weight [kg] + 23.6 * height [cm] – 69.1 * age [y]; RMR [KJ/day] for girls = 1552 + 35.8 * weight [kg] + 15.6 * height [cm] – 36.3 * age [y]) [24]. A minimal physical activity level (PAL) was set at 1.2. Data of children for whom energy intake was below RMR*1.2 were excluded for underreporting.

Macronutrients analysed were fat, saturated, monounsaturated and polyunsaturated fatty acids, protein, carbohydrate and fibre. Micronutrients analysed were vitamin C, vitamin E, vitamin D, calcium, magnesium and iron. The following food groups were chosen for analysis: bread and cereals, bakery products, eggs, pasta, fruit, vegetables, potatoes, dairy products, beverages, fat and oil, sweets, fish and meat products.

Physical activity and socioeconomic assessment

The physical activity questionnaire aimed at recording the usual physical activity pattern of the children. Questions included the way to school, activity during school breaks, frequency, activity and effort of physical education at school, the amount of regular exercise performed in a week, the habitual use of leisure time, as well as the time per day spent watching TV and playing computer games. The questionnaire regarding the socioeconomic background of the children included queries about the parent's education (scores form 0 = no professional education to 5 = university degree), whether they were working at the moment, about the household size and whether siblings of the interviewed child were overweight.

Data and statistical analysis

Body mass index (BMI) of each child was calculated as weight in kilograms divided by height in meters squared (kg/m^2). BMI standard deviation scores (BMI-SDS: individ-

ual BMI value – reference mean BMI value divided by the standard deviation of the mean of the reference population to scale the data for comparison across ages and gender) were calculated and used in the analysis. The population of the CDC 2000 growth charts was used as reference population (www.cdc.gov.growthcharts). Age and gender specific criteria from the U.S. Centres for Disease Control and Prevention (CDC) [25] were used to classify children as normal weight or overweight (above the 85th percentile). These criteria have been previously validated in Swiss children at this age [5].

Dietary data obtained from the three records were checked carefully and entered by the lead interviewers (I.A and M.K.) into a nutrition software system (EBISpro for Windows 4.0, Dr. J. Erhardt, University of Hohenheim, Germany). This system translates the amount of food eaten into individual nutrients (macro- and micronutrients) and assigns consumed foods into 22 food groups. The program is based on the German Food and Nutrition Data Base BLS 2.3 (Federal Health Department, Berlin, Germany), and for foods specific to Switzerland, it incorporates values from the Swiss Food Composition Database [26]. Energy and nutrient data were averaged over the three days to obtain a mean daily energy and nutrient intake for each child. The reference values for nutrient intake for Germany, Austria and Switzerland (D-A-CH references [27]) were used for comparison of the actual intake to the recommendations for the respective age groups.

Statistical analysis was performed using the statistical package SPSS 13.0 for Windows (SPSS Chicago, Illinois, USA). Non-normally distributed variables were log transformed for data analysis. The subjects were divided into four groups: normal weight girls, normal weight boys, overweight girls and overweight boys. Analysis of variance was used to detect differences in the intake of nutrients and food groups between boys and girls or overweight and normal weight children. For the gender differences, age and group (normal weight or overweight) were introduced as covariates, for the group differences the covariates were age and gender. All models were further controlled for interactions between group and gender.

Results

The data of 14 (2 normal weight boys, 6 overweight boys and 6 overweight girls) of the 156 children were excluded from the analysis due to underreporting. The anthropometric data together with data on physical activity and educational status of the parents of the 142 remaining children is shown in table 1. Table 2 shows energy, as well as macro- and micronutrient intakes of normal weight and overweight boys and girls. The median (interquartile range) energy intake was 1687.7 (230.4) kcal and 1951 (194.1) kcal for normal weight girls and boys, respectively and 1897.5 (223.2) kcal and 1909.4 (237.1) kcal for overweight girls and boys, respectively. The macronutrient composition of the diet was 51.0% and 52.0% carbohydrates, 37.0% and 36.0% fat and 12.0% and 12.0% protein in normal weight girls and boys respectively, and 51.0% and 51.0% carbohydrates, 36.5% and 35.0% fat and 14.0% and 13.0% protein in overweight girls and boys respectively. Comparing the macronutrient and energy intake of normal weight and overweight children by analysis of variance (age and gender as covariates), there was a significant difference only in the intake of protein in gram as well as in % of total energy. On average, overweight children consumed 7.7 g more protein or 1.2% more energy as protein than normal weight children (see table 4). A gender difference could be detected for energy, protein and carbohydrate intake (analysis of variance with age and group as covariates). The intake of boys was generally higher: 128.7 kcal more, 5.2 g more protein and 17.3 g more carbohydrates as shown in table 4. Figure 1 shows a scatterplot of energy intake against BMI-SDS for boys and girls. As shown by the regression, a significant correlation between energy intake and BMI-SDS exists for girls ($r^2 = 0.14$, $p = 0.002$) but not for boys ($r^2 < 0.001$, $p = 0.965$). No significant difference could be detected between normal weight and overweight children or between boys and girls regarding the intake of different groups of fatty acids. The median intake of saturated fat in all children contributed with 14.8% to the total energy intake. The intake of micronutrients (vitamin C, vitamin D, vitamin E,

Table 1

Anthropometric data of all children divided by gender and weight status.

	Normal weight		overweight	
	Girls	**Boys**	**Girls**	**boys**
n	**31**	**43**	**34**	**34**
Age (y)	9.4 (1.6)[1]	9.6 (2.1)	9.5 (1.5)	9.8 (1.9)
Height (m)	1.36 (0.11)	1.38 (0.13)	1.42 (0.11)	1.43 (0.11)
Weight (kg)	30.5 (6.7)	31.3 (9.0)	46.1 (11.7)	47.2 (12.4)
BMI	16.2 (1.6)	16.1 (1.8)	22.2 (2.8)	22.6 (2.8)
RMR	1058.3 (84.4)	1141.2 (103.8)	1213.5 (129.0)	1273.4 (120.1)
TV watching (min/week)	299.5 (168.8)	410.0 (271.4)	449.6 (305.0)	470.4 (337.3)
Sport (organised) (min/week)	108.9 (101.4)	146.9 (141.6)	108.0 (106.3)	112.1 (83.0)
Education mother	3.2 (1.3)	3.3 (1.3)	2.4 (1.2)	2.9 (1.0)
Education father	3.9 (0.8)	3.9 (1.1)	3.3 (1.1)	4.0 (0.8)

1 mean (SD)

2 levels of education range from 0 = no professional education to 5 = university degree

calcium, magnesium, iron) did not significantly differ between boys and girls or between normal weight and overweight children in the analysis of variance.

Intakes of the different food groups (in grams per day), is shown in table 3. The intake of meat products differed significantly between normal and overweight children as well as between boys and girls. Overweight children consumed 27.9 g more meat products than normal weight children and boys consumed 21.8 g more than girls (compare table 4). Furthermore a difference was shown between boys and girls for the intake of fruits. All other food groups did not differ between normal weight and overweight children or between boys and girls in the analysis of variance.

Time spent in organised sports activities (median (interquartile range)) was 108.9 (101.4) and 146.9 (141.6) min/week for normal weight girls and boys respectively and 108.0 (106.3) and 112.1 (83.0) min/week for overweight girls and boys respectively (compare table 1). The amount of time spent watching TV or playing computer games was reported to be 299.5 (168.8) and 410.0 (271.4) min/week for

Table 2

Dietary intakes of normal weight and overweight children grouped by gender.

	Normal weight		overweight	
	Girls	**Boys**	**Girls**	**boys**
n	**31**	**43**	**34**	**34**
Energy intake (kcal)	1687.7 (230.4)	1951.3 (194.1)	1897.5 (223.2)	1909.4 (237.1)
Fat intake (g)	68.4 (6.9)	77.8 (14.0)	79.9 (11.8)	77.4 (9.1)
% energy as fat	37.0 (2.0)	36.0 (4.0)	36.5 (3.5)	35.0 (3.3)
Saturated fatty acid (g)	28.1 (3.4)	31.6 (5.2)	31.9 (5.7)	31.3 (4.1)
% energy as SFA	15.1 (2.0)	14.8 (2.3)	15.4 (1.4)	14.2 (1.7)
Monounsaturated fatty acid (g)	24.9 (4.4)	28.5 (5.4)	28.2 (4.7)	28.3 (4.3)
% energy as MUFA	12.8 (1.5)	12.7 (1.8)	13.1 (1.8)	12.4 (1.4)
Polyunsaturated fatty acid (g)	9.9 (2.3)	9.9 (2.0)	9.7 (2.7)	11.7 (2.5)
% energy as PUFA	5.0 (0.7)	4.7 (0.9)	5.0 (1.2)	5.5 (1.2)
Protein intake (g)	53.1 (5.8)	62.2 (9.5)	61.2 (9.3)	66.6 (9.4)
% energy as protein	12.0 (1.5)	12.0 (1.5)	14.0 (1.5)	13.0 (1.0)
Carbohydrate intake (g)[2]	212.8 (32.1)	243.1 (38.4)	235.2 (17.3)	240.5 (40.4)
% energy as carbohydrates	51.0 (3.0)	52.0 (4.5)	51.0 (5.0)	51.0 (3.0)
Fibre (g)	16.8 (2.9)	16.9 (2.5)	16.5 (2.4)	14.8 (4.3)
Vitamin C (mg)	87.2 (26.6)	91.6 (39.9)	80.5 (25.2)	103.5 (33.5)
Vitamin E (mg)	9.9 (1.7)	10.3 (2.1)	9.4 (1.9)	10.4 (3.2)
Vitamin D (µg)	1.0 (0.5)	1.3 (0.4)	1.5 (0.6)	1.1 (0.5)
Calcium (mg)	806.3 (177.1)	938.2 (221.1)	891.3 (183.9)	914.9 (193.4)
Magnesium (mg)	247.9 (37.9)	262.7 (41.9)	273.3 (30.5)	276.7 (59.1)
Iron (mg)	9.0 (1.3)	10.1 (2.0)	9.6 (1.2)	9.6 (1.8)

1 all values are presented as medians (interquartile range)
2 available carbohydrates only

Table 3

Intakes of selected food groups by normal weight and overweight children, grouped by gender.

	Normal weight		overweight	
	girls	**boys**	**Girls**	**boys**
n	**31**	**43**	**34**	**34**
Bread + cereals g/d	102 (21)	124 (27)	127 (30)	120 (32)
Bakery products g/d	31 (30)	42 (26)	25 (25)	33 (24)
Eggs g/d	3 (4)	3 (6)	7 (9)	3 (7)
Pasta g/d	50 (57)	33 (31)	48 (42)	42 (40)
Fruit g/d	215 (118)	214 (104)	199 (106)	264 (103)
Vegetables g/d	117 (66)	103 (38)	92 (57)	90 (36)
Potatoes g/d	30 (28)	53 (31)	35 (38)	45 (32)
Dairy products g/d	241 (84)	302 (128)	315 (80)	274 (160)
Beverages g/d	1041 (399)	973 (371)	930 (141)	906 (311)
Fat and oil g/d	14 (8)	16 (8)	16 (6)	12 (6)
Sweets g/d	48 (16)	46 (15)	47 (19)	36 (22)
Meat products g/d	34 (25)	65 (31)	62 (37)	96 (41)

1 all values are presented as median (interquartile range)

normal weight girls and boys and 449.6 (305.0) and 470.4 (337.3) min/week for overweight girls and boys, respectively. No gender differences were found in the measures of physical activity. However, time spent watching TV or playing computer games was on average 100. 5 minutes higher in the overweight children while no significant difference could be shown for organised sports activities (see table 4). In a multiple regression model controlled for BMI-SDS, neither time spent watching TV or time spent in organised sports activities significantly predicted energy intake.

From data collected in the socioeconomic questionnaire the education of the parents was compared between normal weight and overweight children using independent samples t-test. The mean score for education for the mothers was 3.25 and 2.65 for normal weight and overweight children respectively ($p = 0.008$, 95% confidence interval: 0.156–1.038). For the fathers the mean scores for education were 3.93 and 3.67 for normal weight and overweight children, which is not significantly different.

Discussion

In most industrialised countries, the prevalence of overweight and obesity in childhood is increasing dramatically [1–3, 28]. In our 2002 Swiss national childhood overweight study [28], there was no significant age or gender difference in the prevalence of overweight or obesity in 6 to 12-year olds.

Figure 1

Scatterplot (including regression line) showing the correlation between energy intake and BMI-SDS for girls and boys.

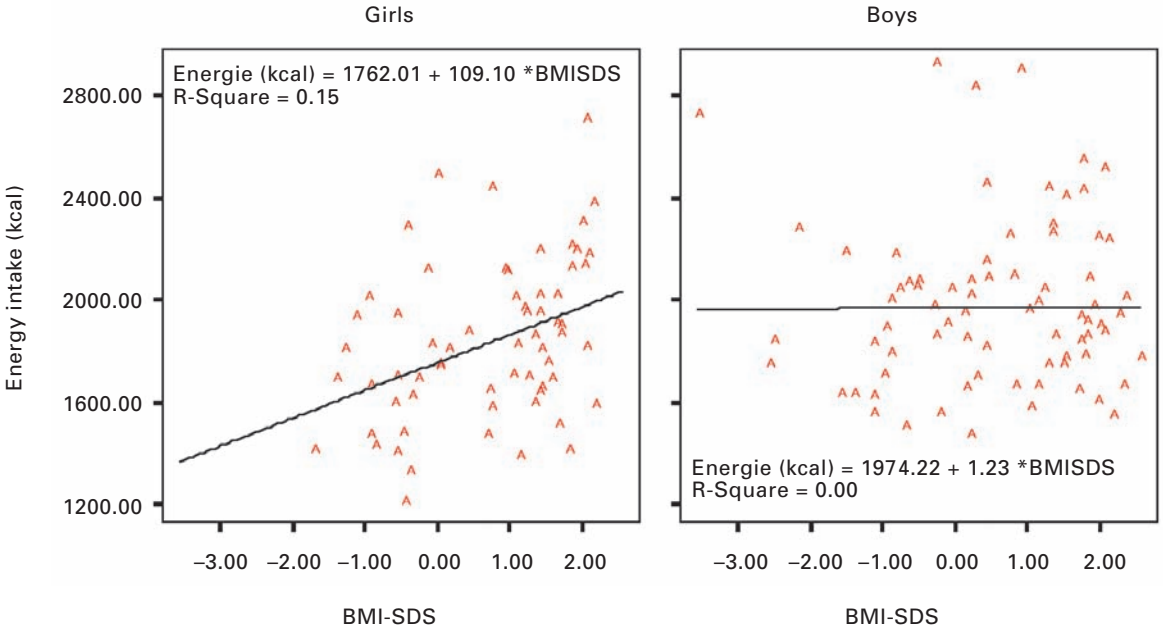

Table 4

Significant differences between boys and girls or overweight and normal weight children in the intake of macronutrients and food groups.

	Gender difference[1]					Group difference (normal weight vs overweight)[2]				
	Mean difference	SE	p	95% confidence interval		Mean difference	SE	P	95% confidence interval	
				lower	upper				Lower	upper
Energy intake (kcal)	128.7	50.4	0.012	29.0	228.3	57.3	50.2	0.256	–42.0	156.6
Fat intake (g)	4.3	2.9	0.155	–1.5	10.1	2.4	2.9	0.412	–3.3	8.2
Protein intake (g)	5.2	2.1	0.014	1.1	9.4	7.7	2.1	<0.001	3.5	11.8
% energy as protein	0.25	0.36	0.496	–0.5	1.0	1.2	0.36	0.001	0.5	1.9
Carbohydrate intake (g)[2]	17.3	7.6	0.025	2.2	32.4	1.2	7.6	0.871	–13.8	16.3
Fruit[3]	0.23	0.13	0.025	15.5	106.8	0.08	0.13	0.527	49.3	72.5
Meat products	21.8	7.3	0.003	7.6	36.2	27.9	7.3	<0.001	13.6	42.3
TV watching (min/week)	63.1	47.3	0.185	–30.5	156.6	100.5	47.1	0.035	7.4	193.7
Sport (organised) (min/week)	17.7	18.6	0.343	–19.1	54.5	20.4	18.5	0.273	–16.2	57.1

1 Analysis of variance with age and group (normal weight or overweight) as covariates
2 Analysis of variance with age and gender as covariates
3 not normally distributed data; log transformed for analysis

At all ages, boys and girls had 50–100% higher mean BF% than Swiss children from the 1960's and 1980's. And when using the current CDC BMI references [25], the prevalence of overweight had increased more than 5-fold in Swiss children since the mid-1980's. These findings suggested there has been a striking increase in BF% and the prevalence of overweight and obesity in Swiss children in the last 2 decades.

Although excess energy intake is suspected to be the main cause of overweight and obesity in both children and adults, this has been difficult to demonstrate [10, 11, 29]. One reason for this is that accurately measuring dietary intake is difficult, particularly in children, due to methodological difficulties and underreporting. Many dietary assessment methods have been validated only in adults. Several validation studies have suggested energy intakes derived from various dietary assessment methods in children (particularly in overweight children) may not reflect the habitual diet, and obese and non-obese children and adults tend to underestimate self-reported dietary intakes [22, 23]. In this study we chose to use two 24-hour recalls and a 1-day-food record to obtain accurate information with a low subject burden; this approach has been previously validated for children as young as 8 years [22]. Because we enrolled a convenience sample, there may have been recruitment bias; that is, it is possible that participating children had food and activity habits that are not representative of the general population or that their parents may be more interested in nutrition than the average population. Underreporting is another source of potential bias, and is more common in overweight than in normal weight subjects [30–32]. To minimise this, we excluded data from children who reported energy intakes below estimated minimal energy needs. Of the 14 children who had to be excluded, 12 were overweight and only 2 normal weight, supporting data from the previous studies sited above.

Tucker et al. analysed the diet of 262 children (mean age 9.8 years) and found that energy intake as well as energy from fat were positively correlated with adiposity; energy from carbohydrates was inversely correlated with adiposity [12]. Similar findings were reported by Gazzaniga and Burns who examined the diet of 48 children (9 to 11 years old) and reported that diet composition, independent of energy intake or physical activity, contributed to childhood obesity [11]. In 114 pre-pubertal children, McGloin et al. found dietary fat was the only macronutrient which significantly predicted body fatness [33]. In contrast, in our sample, neither energy from fat nor from carbohydrates was correlated with the degree of adiposity. However, there was a significant difference between normal weight and overweight children in the intake of energy from protein as well as the absolute protein intake both controlled for age and gender. This may be explained by higher intakes of protein-rich foods, such as meat. Meat intake was also higher in overweight children after controlling for age and gender. However, no significant difference could be found for the intake of dairy products. Although there was a significant difference in protein intake between normal and overweight children, the actual difference in our sample was modest (7.7 g) and may not to be clinically relevant. However, higher intakes of protein in overweight children have been reported in previous studies [12, 34]. High protein intake in childhood may be linked to anthropometric characteristics, such as increased stature and increased muscle mass that are characteristic of childhood obesity [35]. With the exception of meat intake, there were no predictions of BMI by the other food groups. However, potential associations may have been obscured by the large variations in daily intakes.

The recommendations for the macronutrient composition of children's diet given by the Swiss Nutrition Society are 12–15% energy from protein, ≤30% energy from fat (≤10% from saturated fat) and ≥55% energy from carbohydrates [27]. Compared to these recommendations, in our sample, in both normal and overweight children, median energy intake from fat was >35% of energy and about 15% of energy came from saturated fat. These data indicate that intakes of fat and saturated fat in Swiss children are 20% and 50%, respectively, above recommended levels. These findings are similar to those from a 2000 study in the canton of Vaud in a slightly older sample of 9- to 19-year olds. In that study, 14% energy came from protein, 37% from fat and 49% from carbohydrates.

The question whether overweight and obese children are less physically active than normal weight children remains unclear. Low physical activity levels may be as important as excess energy intake [36], but data from previous studies are equivocal. Swinburn et al. (2006) found energy intake was a more important determinant of high body weight than low physical activity [37]. In a study in Belgian boys, Beunen et al. could not demonstrate an effect of physical activity on adiposity [38]. In contrast, Deheeger et al. reported physical activity was significantly correlated with less adiposity in 10-year-old French children [39]. An important factor determining physical activity levels of children is time spent watching TV and playing computer or video games [16, 39]. In the present study, the median time per week overweight children spent watching TV or playing computer games was 100 minutes higher than for normal weight children. Furthermore a trend can be observed for overweight boys spending less time in organised sports activities than normal weight boys. These data suggest lower physical activity levels may play a role in the aetiology of overweight in Swiss children; however, this association could also be explained by excess body fat reducing the desire and/or interest for physical activity in overweight children.

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