


# Nutrient intake of Swiss toddlers

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## Abstract

**Purpose** During the first years of life, food preferences are shaped that might last throughout a person's entire life affecting his/her health in the long term. However, knowledge on early feeding habits is still limited for toddlers. Therefore, the goal of the present study was to: (1) assess toddlers' nutrient intake; (2) compare the findings to past studies as well as to national feeding recommendations and (3) identify major food sources for energy and macronutrients.

**Methods** A food survey using a 4-day diary was conducted. The dietary software nut.s<sup>®</sup> was used to analyse the data.

**Results** A cohort of 188 healthy toddlers (aged 1–3 years) was analysed. The energy intake of most toddlers was below the recommended daily intake (RDI) but in accordance with earlier studies. Protein intake was three- to fourfold higher than the RDI and reached the proposed upper limit of 15% of total energy intake. Fat intake was in accordance with the RDI, but the balance of saturated and unsaturated fatty acids should be improved. Carbohydrate intake met the RDI. For the micronutrients, iron and vitamin D intakes showed critical values.

**Conclusion** As in other European countries, the diet of Swiss toddlers in general seems adequate but does not meet all nutritional requirements. In particular, the quality of the fats and vitamin D supplementation should be improved. For proteins and iron, additional research is needed to gain more confidence in the recommendations.

**Keywords** Toddlers · Nutrient intake · Energy intake · Protein intake · Recommended dietary intake

## Introduction

The first 1000 days starting from conception seem to be a critical period for the development of later noncommunicable chronic diseases [1–3]. These first 1000 days are of particular interest, as toddlers' evolving digestive capacity [4] and motor skills [5] allow them the transition to table foods [6]. During that time, food preferences are shaped that might last throughout a person's entire life [7, 8] and therefore, affect the person's well-being and health in the long term [2]. The list of weight-related complications that are either caused or exacerbated by obesity in adulthood is long: type 2 diabetes, dyslipidaemia, hypertension, cardiovascular disease, non-alcoholic fatty liver disease, obstructive sleep apnoea and depression, just to name a few [9].

However, the complications are not restricted to adulthood; first consequences of an inadequate diet are already observed in childhood: the prevalence of childhood obesity has reached exceedingly proportions around the world [10, 11]. It has been shown that childhood obesity is associated with hypertension [12] and dyslipidaemia like hypertriglyceridemia and lower HDL-cholesterol levels in children [9]. In addition, there is a whole range of consequences stemming from social stigmatisation of these children [13, 14].

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Risk factors associated with early childhood overweight are manifold. Some of these, such as genetic, biologic and prenatal factors, may not be modifiable; others like dietary, environmental, social and behavioural ones can be subject to modification. For dietary and parent feeding practices, promising associations for interventions have been found [15]. A healthy diet in appropriate quantity during the first years of life is of paramount importance to establish long-term healthy food intake patterns [16].

Therefore, knowledge about food intake in childhood and especially in toddlerhood is crucial. Only based on accurate data, valid recommendations can be given and measures to improve food intake can be developed. A variety of studies dealing with toddler nutrition are available [17–30]. However, most of these studies investigate a much broader range of age than toddlerhood. Studies that are specifically dedicated to toddlerhood are still scarce. The large US Feeding Infants and Toddlers Study (FITS) in 2002 and 2008 [31, 32] and the German Representative Study of Toddler Alimentation (GRETA) are the exceptions [33]. Since dietary habits vary from one country to the other, this lack of studies is indefensible.

The goal of the present research is, therefore, to assess nutrient intake of Swiss toddlers, to compare the findings to past studies from other countries as well as to national feeding recommendations and to identify major food sources for energy and macronutrients. Switzerland is a country with one of the highest per capita incomes, which makes it interesting to study. If deficiencies are detected, they most likely do not stem from financial constraints.

## Methods

### Study sample

A food survey using a 4-day diary was conducted between November 2014 and July 2015 involving 188 Swiss parents (70% German speaking and 30% French speaking) of healthy one- to three-year-old toddlers. Most participants (110) were recruited from families who subscribed to a homepage to receive a newsletter with information and tips concerning the development of children from one of the largest baby food suppliers in Switzerland. To not only have participants from this source, additional addresses were supplied by a commercial address broker, which resulted in 60 further participants. Finally, 18 participants were recruited via personal contacts. The parents were asked to feed their children as they usually do. No specific recommendations were given prior to the study.

### Nutritional assessment

Caregivers participating in the diary study were asked to complete a nutritional diary in which they reported all foods and drinks (including vitamin supplements) consumed by their toddler during four consecutive days. Each participant was asked to start on a specified day to balance the days of the week across the sample, i.e., the 4-day period included at least one weekend day. In the diary, caregivers were instructed to list all foods and beverages per eating occasion. First, they marked the time at which they ate; then they listed all the foods and beverages and indicated the weight or volume. They were advised to provide the weight of the foods whenever possible. If this was not possible, they were encouraged to specify the portion size using a 42-page booklet including pictures of reference tableware, cups and glasses as well as cutlery and over 100 different referenced foods. In addition, caregivers were requested to note specific information from packages of processed food items consumed. For homemade food, information on recipes was requested and the single ingredients were listed. A six-page guide explained how to complete the diary and provided plenty of examples. Experiences from a pilot study were also included by, for example, drawing attention to foods that easily get forgotten, such as oils or a cup of water during the night. Participants were instructed to complete the information immediately after each eating occasion. If another person took care of the toddler at some point during the 4 days, they were asked to hand over the diary and explain to that person how to complete it. At the end of the 4 days, caregivers were asked to complete another short questionnaire including information about the toddler's anthropometry and parents' socio-demographics as well as some questions about eating habits and out-of-home eating. Once completed, the documents were sent back by postal mail using a reply-paid envelope. A telephone number was provided in case caregivers had questions and needed to contact the research team. They were also informed that one of the researchers might call them after handing in the diary if clarification was needed. No incentive was promised for taking part in the study, but all participants were sent a surprise voucher once the documents were received.

The information collected was then entered into *nut.s*<sup>®</sup>, a nutritional assessment software allowing the nutritional value of the toddlers' diet and the detailed intake of different nutrients to be analysed (*nut.s* nutritional software<sup>®</sup> version v1.32.35, dato Denkwirkzeuge, Vienna, Austria). Within *nut.s*<sup>®</sup> one can choose among various databases that contain brand as well as product names. Whenever possible, we used the Swiss Food Composition Database; if no Swiss data were available, the German (BLS) or Austrian (ÖNWT) databases were consulted. In addition, *nut.s*<sup>®</sup> supported us by including various additional foods that were

identified in the study and that were not yet registered in their database. The software also allowed foods and drinks to be added by the researcher and therefore to capture all the nutrient information.

The mean daily energy and nutrient intake for each toddler were calculated and used for the analyses. The results are organised in different age groups: 12- to 18-month-old, 19- to 24-month-old and 25- to 36-month-old toddlers. The second year was split into two cohorts since the changes in toddlers' eating behaviour are greater than in the third year of life. The means and medians were then compared to the recommendations as presented by the DACH references for Germany, Austria and Switzerland [34] for energy, protein, total fat, saturated fatty acids, fibre, calcium, iron, vitamin B2, B12 and folates, the references provided by the Swiss Federal Commission for Nutrition for carbohydrates [35] and for vitamin D [36] and the ones given by the Swiss Federal Food Safety and Veterinary Office [37] for mono- and poly-unsaturated fatty acids. Finally, the different food products were categorised into the following food categories: 'potatoes and potato products', 'milk', 'cheese and milk products', 'bread and cereal products', 'fruits and vegetables including pure juices', 'fish', 'meat including eggs and meat replacements', 'fats, oils and nuts', 'cakes and sweets', 'infant and follow-up formula' as well as a category labelled 'other' including sweet beverages. In the case of breastfeeding, the estimated amount of mother milk was based on the storage capacity found in the literature [38, 39], on the duration of breastfeeding, and the number of breastfeeding occasions as well as the amount of table food consumed by the child.

## Statistical analysis

All the statistical analyses were carried out using SPSS procedures (version 23, SPSS Inc, Chicago, USA). A  $p$  value of  $<0.05$  was considered statistically significant. Differences between boys' and girls' nutrient intake were tested with independent  $t$  tests; age groups with analysis of variance and Tukey's post hoc test. Since only healthy toddlers were included, mean scores of energy and nutrients above three standard deviations were considered incorrect and thus removed. These were between three and six cases per age group. No values below three standard deviations were observed.

## Results

### Study sample

A total of 188 dietary protocols were analysed. Sample characteristics are shown in Table 1. The three age groups consist of 49 (27.6%) 12- to 18-month olds, 82 (41.2%) 19- to 24-month olds and 56 (31.2%) 25- to 36-month olds (one participant did not report the age of the toddler). There were no significant differences in any of the investigated population characteristics among the different age groups. In addition, 2.2% of the study population was underweight (defined as weight-for-height  $\leq$ percentile 3), 3.7% obese (defined as weight-for-height  $\geq$ percentile 97, see Table 2). None of the toddlers was fully breastfed, but 7 (3.7%) of them were so partially.

**Table 1** Population characteristics

	12–18 months <i>n</i> (%)	19–24 months <i>n</i> (%)	25–36 months <i>n</i> (%)	<i>p</i> value
Gender				0.19
Boys	20 (40.8)	47 (57.3)	28 (50.9)	
Girls	29 (59.2)	35 (42.7)	27 (49.1)	
Region				0.16
French speaking	16 (32.7)	28 (34.1)	11 (19.6)	
German speaking	33 (67.3)	54 (65.9)	45 (80.4)	
SES household				0.28
4500 CHF and lower	4 (8.5)	6 (7.5)	1 (1.9)	
4501CHF to 7500CHF	17 (36.2)	36 (45.0)	19 (35.8)	
7501CHF to 10500CHF	19 (40.4)	32 (40.0)	22 (41.5)	
10501CHF and more	7 (14.9)	6 (7.5)	11 (20.8)	
First child				0.48
Yes	29 (59.2)	46 (56.8)	27 (48.2)	
No	20 (40.8)	35 (43.2)	29 (51.8)	

SES socio-economic status by income group

**Table 2** Weight for length/height percentiles [50]

	All (%)	Boys (%)	Girls (%)
≥P97	7 (3.7)	3 (3.2)	4 (4.4)
≥P90 < P97	14 (7.5)	9 (9.4)	5 (5.5)
>P10 < P90	155 (82.9)	76 (80.0)	78 (85.7)
≤P10 > P03	7 (3.7)	4 (4.2)	3 (3.3)
≤P03	4 (2.2)	3 (3.2)	1 (1.1)

### Energy and nutrient intakes

An overview of energy and nutrient intakes is displayed in Table 3. A majority of the toddlers had an energy intake below the recommended daily intake (RDI, see Fig. 1). There were significant mean and median differences between boys and girls for the 19- to 24-month olds ( $p < 0.05$ ). For the girls, the oldest age group showed a significantly higher mean and median energy intake than the youngest age group ( $p < 0.05$ ).

Mean protein intakes were clearly above the RDI (see Fig. 1). For both, boys and girls, the youngest age groups showed a significant higher median protein intake than the oldest age groups (both  $p < 0.05$ ). No gender differences were found in any of the age groups. Expressed as the percentage of total energy intake, no differences were found whatsoever.

More girls than boys tended to have an increasing fat intake with age; the only significant difference ( $p < 0.05$  for means and  $p < 0.01$  for medians) between age groups was found between the youngest and oldest girl toddlers. Again, no differences were detected for fat intake expressed as the percentage of total energy intake. A different picture is presented when looking at the different qualities of fatty acids. All groups clearly exceed the recommendation to have saturated fatty acids comprising less than 10% of total energy. For monounsaturated and polyunsaturated fatty acids, however, the recommendations are mostly met, but clearly at the very low end of a rather large range.

For carbohydrates, no specific recommendations for toddlers are available. Figure 1 expresses the carbohydrate intake as the percentage of daily energy intake. Boys aged 12–18 and 19–24 months consume significantly more carbohydrates than girls in the corresponding age group (both  $p < 0.05$ ). However, expressed as the percentage of total energy intake, this difference disappears. No differences were found for the age groups.

Fibre intake was somewhat below the recommendations for all groups (according to DACH [34] the recommendation of 10 g per 1000 kcal can be used for children). No differences in fibre intake could be detected for gender or age groups. Mean calcium intakes were slightly above the RDI. Still, almost half the toddlers showed values below

the recommendation. For iron, the mean recommendations are clearly not met. No differences in iron intake could be detected for gender or age groups.

Vitamins B2 and B12 seem sufficiently supplied. A different result emerged for folates: their mean intakes are around or only slightly above the RDI. Because of the skewed distribution, all of the girl age groups and the youngest boy age group show a value of more than 50% of toddlers below the recommendation (see median values in Table 3). No differences in folate intake could be detected for gender or age groups. Mean vitamin D intakes are extremely lower than the RDI (only 17% of all toddlers received vitamin D supplements). No differences in vitamin D intake could be detected for gender or age groups.

### Major food sources of energy and macronutrients

Table 4 displays the major food sources for energy and macronutrients. Milk together with cheese and milk products are the main energy providers for all age groups (26.1% of total energy intake); bread and cereal products (21.9%) follow next.

The main protein supply for all toddlers is also the milk and milk product categories (35.8% of total protein intake), followed by meat (including eggs and meat replacements) together with fish (21.2%), then by bread and cereal products (20.4%).

For fat, once more, milk together with milk products is the main source for all toddlers (33.5% of total fat intake). The meat and fish categories (15.0%), and added fats and oils (13.3%) come next.

Bread and cereal products comprise the main carbohydrate providers for all toddlers (31.0%). In second place are fruit and vegetables with 18.4%. Milk together with milk products comes third, with an average value of 17.7%.

### Discussion

This is one of the few studies on dietary intake specifically on toddlers and the first with data from Switzerland. In general, the studied population achieves very well-balanced and healthy nutrition. Congruent results were found in existing studies from other European countries. It might be puzzling that most toddlers showed an energy intake below the RDI, as most other studies found averages above the recommendations. However, these recommendations have changed over time and there are different recommendations from different agencies (see Table 5). The DACH recommendations we used [34] were revised in 2015, which resulted in clearly higher recommended energy intakes for toddlers; therefore, earlier studies found energy intakes above the recommendations, whereas in this study the values are below the RDI.

**Table 3** Overview of daily energy and nutrient intakes and comparison with recommendations

Nutrient	Age (month)	RDI	5th		25th		Mean (SD)		Median		75th		95th	
			♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Energy (kcal/day)	12–18	○	817.0	738.2	945.0	860.2	1081.1 (178.3)	982.3 (171.4) <sup>b</sup>	1065.7	962.4 <sup>b</sup>	1221.7	1100.2	1454.1	1288.5
	19–24	○	848.9	719.1	960.9	850.9	1141.5 (280.9) <sup>a</sup>	1020.3 (214.1) <sup>a</sup>	1086.4 <sup>a</sup>	984.5 <sup>a</sup>	1240.2	1149.6	1594.5	1479.5
	25–36	○	725.9	759.3	989.0	942.2	1150.8 (250.1)	1164.8 (382.1) <sup>b</sup>	1138.7	1071.6 <sup>b</sup>	1342.0	1254.5	1522.1	1622.9
Protein (g/kg/day)	12–18	1	2.3	2.2	3.0	2.9	3.5 (0.7)	3.6 (1.0)	3.5 <sup>b</sup>	3.5 <sup>b</sup>	3.8	4.3	5.1	5.3
	19–24	1	2.2	2.2	2.8	2.8	3.3 (0.8)	3.3 (0.7)	3.3	3.2	3.7	3.8	5.0	4.8
	25–36	1	1.9	1.6	2.4	2.7	3.0 (0.8)	3.2 (1.4)	2.9 <sup>b</sup>	2.9 <sup>b</sup>	3.5	3.5	4.2	5.3
% of total energy	12–18		8.8	10.3	12.1	12.8	14.1 (2.9)	15.2 (3.2)	14.1	14.5	16.6	18.0	18.8	20.5
	19–24		11.2	10.4	13.1	13.9	14.7 (2.4)	14.7 (2.0)	14.4	14.7	16.8	16.1	18.3	17.6
	25–36		10.5	9.2	12.7	12.6	14.2 (2.2)	14.2 (2.7)	14.4	14.0	15.7	16.7	17.7	19.1
Fat (g/day)	12–18		30.8	27.5	33.3	32.9	40.7 (8.2)	38.3 <sup>b</sup> (7.1)	39.1	37.2 <sup>bb</sup>	49.0	42.7	54.8	51.7
	19–24		26.1	26.4	34.3	33.5	43.5 (11.0)	43.3 (16.1)	41.8	40.0	50.2	46.3	64.2	93.6
	25–36		28.5	28.3	36.4	38.9	44.5 (11.2)	48.2 (14.5) <sup>b</sup>	45.2	45.6 <sup>bb</sup>	50.5	56.7	64.7	73.3
% of total energy	12–18	30–40	25.8	26.6	31.2	32.1	34.0 (4.4)	35.3 (4.7)	34.2	35.0	37.3	39.8	42.9	42.0
	19–24	30–40	25.6	28.0	30.4	32.8	34.6 (5.9)	36.7 (6.5)	36.0	36.7	38.8	40.4	43.2	45.0
	25–36	30–40	26.3	26.5	31.6	32.3	35.1 (5.7)	38.2 (11.1)	35.9	37.6	39.1	41.1	44.8	46.9
Fatty acids saturated (g/day)	12–18		13.2	10.4	14.7	14.8	18.6 (4.2)	16.9 (3.3) <sup>b</sup>	18.1	17.5 <sup>b</sup>	20.6	19.1	29.6	22.4
	19–24		12.3	9.2	16.0	15.7	19.3 (5.1)	20.6 (9.2)	18.8	18.6	21.7	22.1	30.1	46.3
	25–36		11.7	11.8	16.9	16.8	20.2 (5.5)	21.6 (5.8) <sup>b</sup>	19.9	21.8 <sup>b</sup>	23.8	26.3	26.0	30.9
% of total energy	12–18	<10	11.1	12.2	13.4	13.4	15.5 (2.5)	15.7 (3.2)	15.4	14.5	17.3	17.5	19.9	22.5
	19–24	<10	8.9	10.0	12.9	15.4	15.5 (3.5)	17.3 (4.5)	15.6	17.4	18.6	19.5	20.4	21.9
	25–36	<10	11.8	11.8	13.4	15.0	16.1 (3.4)	17.2 (4.3)	15.7	16.2	18.8	19.3	22.9	23.7
Fatty acids mono-unsaturated (g/day)	12–18		6.9	6.0	8.9	9.9	14.8 (9.8)	11.5 (3.6)	11.8	11.0	16.6	13.3	38.0	18.2
	19–24		6.7	7.9	9.0	9.3	12.7 (5.2)	12.6 (4.3)	11.4	12.0	16.4	14.5	23.7	21.5
	25–36		5.6	6.8	10.1	10.6	13.3 (4.7)	14.4 (5.7)	12.7	13.5	16.1	16.7	24.6	23.1
% of total energy	12–18	10–15	4.6	6.2	8.7	8.3	10.6 (3.3)	10.7 (3.2)	10.2	10.6	13.1	12.5	19.3	15.7
	19–24	10–15	5.7	6.8	7.8	9.5	10.0 (3.1)	10.9 (2.4)	10.0	11.1	11.7	12.8	15.5	14.5
	25–36	10–15	7.8	6.7	9.0	8.5	10.4 (2.4)	11.5 (5.0)	10.7	10.7	11.7	13.3	14.5	19.2
Fatty acids polyunsaturated (g/day)	12–18		2.2	2.2	3.0	2.7	4.3 (1.9)	4.1 (1.7)	3.2	3.7	5.6	5.1	9.1	7.0
	19–24		2.1	2.3	3.0	2.8	5.0 (3.1)	4.1 (1.5)	3.7	3.8	5.9	5.4	13.4	6.9
	25–36		2.1	2.3	3.4	3.9	5.0 (2.0)	5.5 (3.3)	5.1	4.5	5.7	5.7	9.2	14.1
% of total energy	12–18	3–11	2.0	2.0	2.2	2.8	3.7 (1.7)	3.8 (1.6)	3.4	3.3	4.3	4.6	8.3	7.9
	19–24	3–11	1.9	1.9	2.6	2.7	3.7 (1.9)	3.6 (1.1)	3.1	3.3	4.6	4.5	7.8	5.4
	25–36	3–11	1.8	2.5	3.1	3.1	3.9 (1.2)	4.2 (2.2)	3.8	3.5	4.9	4.8	5.7	7.4

**Table 3** (continued)

Nutrient	Age (month)	RDI	5th		25th		Mean (SD)		Median		75th		95th	
			♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Carbohydrate (g/day)	12–18		95.2	80.9	109.3	94.1	134.9 (30.9) <sup>a</sup>	117.5 (24.5) <sup>a</sup>	126.3	121.2	148.0	133.4	225.5	154.8
	19–24		87.5	70.7	110.9	99.0	140.3 (51.0) <sup>a</sup>	117.4 (27.8) <sup>a</sup>	130.4 <sup>a</sup>	113.0 <sup>a</sup>	153.9	136.2	223.2	170.7
	25–36		77.9	76.0	109.2	112.2	138.6 (42.1)	135.0 (60.6)	144.3	127.9	159.0	155.8	206.0	199.7
% of total energy	12–18	45–55	39.5	38.2	45.3	44.1	49.8 (5.7)	47.8 (5.2)	50.1	49.0	52.4	50.2	62.0	56.7
	19–24	45–55	39.8	32.9	44.1	42.9	48.5 (6.6)	46.2 (6.7)	47.9	45.7	50.6	49.9	60.3	57.7
	25–36	45–55	34.9	37.0	42.6	42.4	47.5 (7.3)	45.7 (9.7)	47.4	46.1	52.7	51.6	55.5	54.6
Fibre (g/day)	12–18		5.8	5.2	7.0	6.8	10.1 (2.9)	9.0 (2.7)	11.2	8.5	12.5	11.1	14.9	13.5
	19–24		6.2	4.5	7.4	7.0	10.3 (3.3)	9.9 (6.1)	10.4	8.0	12.4	11.7	16.6	18.1
	25–36		4.5	5.0	8.3	7.4	11.2 (4.0)	9.8 (3.1)	11.4	9.8	13.8	11.8	18.3	14.7
Fibre (per 1000 kcal)	12–18	10	5.1	6.1	7.0	7.2	9.4 (2.6)	9.2 (2.7)	8.9	8.6	11.5	10.5	15.1	15.1
	19–24	10	6.0	5.2	7.3	6.9	9.3 (2.8)	8.9 (3.0)	9.0	7.9	10.9	10.9	14.0	15.7
	25–36	10	6.1	5.5	7.5	6.8	9.9 (3.1)	9.0 (3.0)	9.6	8.1	12.6	10.9	14.2	14.2
Calcium (mg/day)	12–18	600	292.5	355.9	424.8	511.6	606.5 (192.0)	638.5 (197.3)	684.4	633.7	737.3	759.4	921.0	967.0
	19–24	600	336.0	448.6	478.8	536.5	684.2 (268.3)	687.8 (191.0)	596.1	668.8	838.0	789.8	1184.9	1068.0
	25–36	600	329.8	233.5	502.9	527.1	657.2 (296.6)	675.8 (378.2)	608.3	601.4	775.8	750.2	1251.2	1170.6
Iron (mg/day)	12–18	8	2.5	2.4	4.3	4.0	5.6 (2.0)	5.6 (2.6)	5.1	5.0	7.0	6.9	9.7	11.0
	19–24	8	3.1	2.7	4.3	3.6	7.2 (5.5)	5.8 (3.6)	5.7	5.1	7.4	6.5	17.4	15.7
	25–36	8	3.1	2.6	4.3	3.5	5.5 (2.1)	5.2 (2.0)	5.4	4.8	5.9	7.0	10.5	8.3
Vitamin B2 (mg/day)	12–18	0.7	0.4	0.5	0.6	0.8	1.0 (0.4)	1.0 (0.3)	1.0	1.0	1.2	1.3	1.9	1.6
	19–24	0.7	0.6	0.7	0.8	0.8	1.2 (0.8)	1.1 (0.3)	1.0	1.0	1.4	1.3	2.3	1.6
	25–36	0.7	0.4	0.4	1.2	0.8	2.2 (0.9)	1.1 (0.8)	1.0	1.0	1.3	1.2	1.7	1.9
Vitamin B12 (µg/day)	12–18	1	0.9	1.0	1.7	1.6	2.4 (1.2)	2.2 (0.8)	2.3	2.2	2.9	2.5	4.3	3.4
	19–24	1	0.9	1.0	1.6	1.5	2.5 (1.2)	2.2 (0.9)	2.3	2.2	2.9	2.9	4.2	3.9
	25–36	1	0.7	1.0	1.6	1.7	2.6 (1.4)	2.4 (1.0)	2.3	2.3	3.3	2.6	4.8	4.4
Folates (µg/day)	12–18	120	59.5	73.5	96.1	94.9	114.5 (30.7)	119.9 (37.1)	114.2	113.2	133.6	137.2	179.1	193.4
	19–24	120	65.7	67.3	92.3	92.5	128.7 (48.4)	122.6 (48.0)	125.4	112.2	150.1	149.3	226.6	210.4
	25–36	120	76.1	72.3	101.4	96.1	135.7 (46.4)	119.7 (41.4)	127.9	110.7	160.7	134.5	223.8	209.5
Vitamin D (µg/day)	12–18	15	0.5	0.6	1.1	1.3	6.5 (6.7)	4.2 (4.8)	3.3	2.4	13.0	4.9	24.2	15.7
	19–24	15	0.5	0.7	1.0	0.9	4.5 (6.2)	4.6 (5.2)	2.4	1.7	4.7	7.4	17.8	17.7
	25–36	15	0.4	0.7	1.0	0.9	2.8 (3.3)	3.6 (5.4)	1.5	1.6	3.2	3.3	11.7	11.6

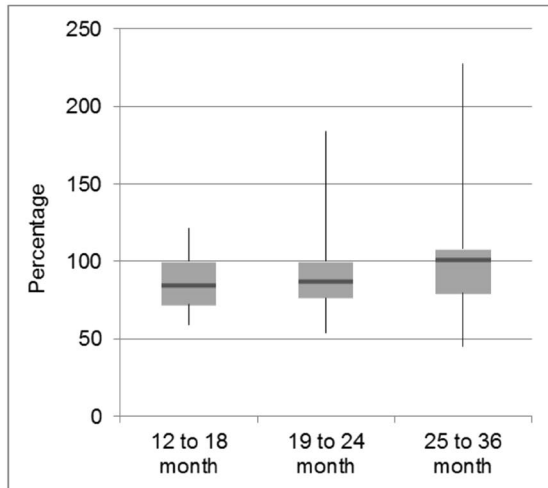
<sup>c</sup> The recommended ranges of total energy intake is 1200–1300 kcal for boys and 1100–1200 kcal for girls (with a PAL value of 1.4)

<sup>a</sup> Significant difference ( $p < 0.05$ ) between boys and girls

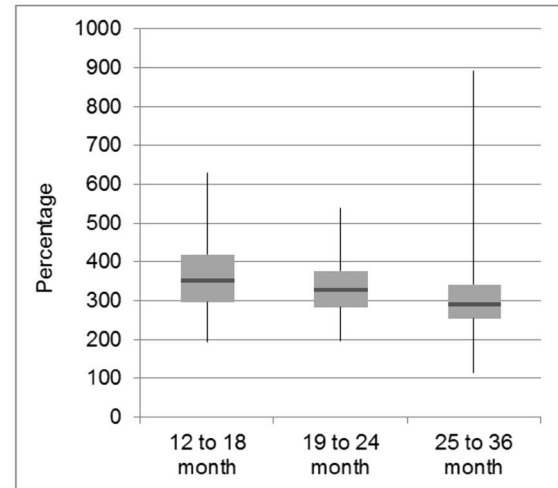
<sup>b</sup> Significant difference ( $p < 0.05$ ) between 12- to 18- and 25- to 36-month olds

<sup>bb</sup> Significant difference ( $p < 0.01$ ) between 12- to 18- and 25- to 36-month olds

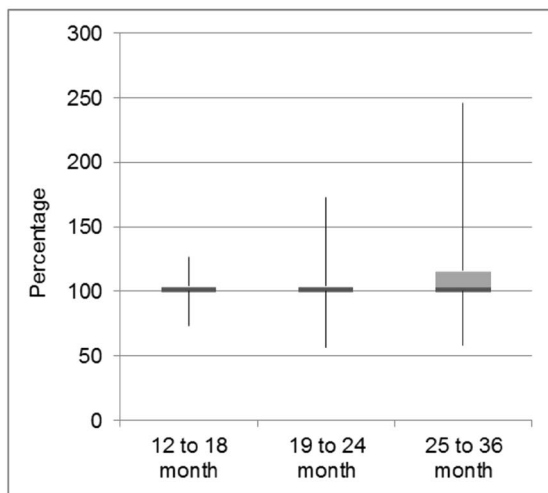
## Energy



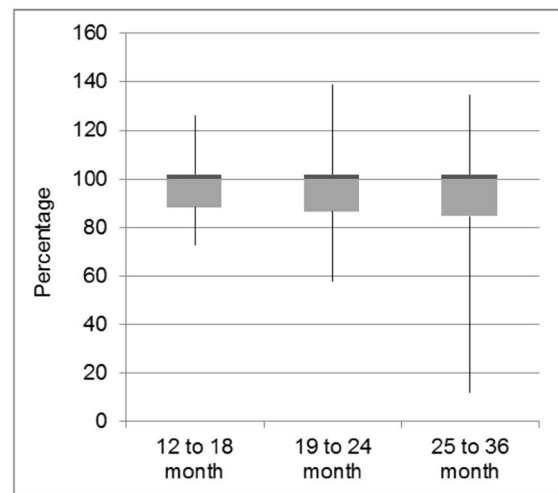
## Proteins



## Fat



## Carbohydrates



**Fig. 1** Intake of energy and macronutrients as percentage of recommendation; median (–), 25th and 75th percentile (*box*), minimum and maximum value (*lines*). Note Fat and carbohydrate intakes are measured as percentages of daily energy intakes. All values within

the recommendation ranges were set to a compliance of 100% (1200–1300 kcal/day for boys and 1100–1200 kcal/day for girls; 1 g/kg/day for proteins; 30–40% for fats and 45–55% for carbohydrates)

Looking at the absolute intake of energy, the present results are in line with other studies [25]. Reported median energy intakes in the GRETA study with toddlers from Germany [33], for example, are even slightly lower than the intakes found here for Switzerland. Compared to the reference values by the European Food Safety Authority (EFSA) [47] and WHO [40, 49] most toddlers are above the RDI. Only the 25- to 36-month-old girls show an energy intake around the RDI. For this study, we used the DACH values wherever possible since they were particularly developed for the German-speaking countries and therefore seem most appropriate for Switzerland, even though their energy intake values are rather high.

Protein intakes clearly exceeded the RDI and were found to comprise almost 15% of total energy intake. This is also in line with former studies, which report protein intakes of between 13 and 17% of total energy intake [24–26, 28, 31, 32]. Therefore, across Europe, toddlers' protein intake is three- to fourfold higher than the RDI. Most European countries base their recommendations on the ones provided by the EFSA [47] and are around 1 g/kg/day (see Table 5). There is an ongoing debate about an upper limit (UL) recommendation for protein intake [42–44], and a UL of 20% of total energy intake has been suggested for toddlers by the Health Council of the Netherlands [44]. Later, the European Society for Paediatric Gastroenterology, Hepatology and

**Table 4** Food sources for energy and macronutrient intake (in %)

Nutrient	Age (month)	Potatoes and potato products	Milk	Cheese and milk products	Bread and cereal products	Fruits and vegetables	Fish	Meat (incl. eggs and meat replacements)	Fats, oils and nuts	Cakes and Sweets	Infant and follow-up formula	Other, non-categorised
Energy	12–18	3.9	15.9	10.7	21.5	11.2	1.8	6.8	4.5	10.7	6.9	6.0
	19–24	3.4	19.4	8.7	21.0	11.0	1.4	7.8	4.5	13.2	2.9	6.8
	25–36	2.5	12.5	10.3	23.6	12.3	0.9	9.5	6.1	12.3	1.9	8.2
Protein	12–18	2.9	22.2	13.6	19.9	6.4	3.6	16.4	0.1	5.9	5.0	3.8
	19–24	2.3	27.0	11.4	19.6	5.3	3.5	16.8	0.3	7.0	2.0	4.9
	25–36	1.9	18.5	13.6	22.0	7.2	2.7	20.8	0.7	6.2	1.5	4.8
Fat	12–18	2.5	21.8	12.4	11.3	3.9	2.2	11.1	12.2	8.3	7.5	6.7
	19–24	1.9	25.0	11.2	9.8	3.1	1.8	12.7	12.8	11.8	3.1	6.7
	25–36	1.9	15.6	13.2	11.3	3.8	1.0	16.1	15.0	12.8	2.2	6.9
Carbohydrates	12–18	5.3	10.3	8.5	29.8	17.3	0.9	0.6	0.1	13.8	7.3	6.1
	19–24	4.9	13.0	5.7	29.9	17.8	0.5	1.5	0.1	16.6	3.2	6.9
	25–36	3.2	8.4	7.0	33.6	20.2	0.3	1.2	0.2	14.4	1.8	9.7

Nutrition (ESPGHAN) concluded that a value of 15% might be more appropriate [4]. This percentage also results when following the optimised mixed diet (OMD) guidelines developed by the German Research Institute of Child Nutrition (FKE) [45]. Taken together, it seems that protein intake is in line with a yet to be defined upper limit. The recommendation of 1 g/kg/day, however, needs to be critically reevaluated. At least in Western countries, such a low intake does not seem realistic and would likely cause other problems such as calcium deficiency when reducing the main sources of protein, which are milk and milk products. More research on protein intake is clearly warranted.

The findings regarding fats are also in accordance with earlier studies [25, 32, 33]. The problem here is not so much the quantity but the quality of fat intake. Saturated fats are exceeding the recommendation of less than 10% of total energy intake in Europe [33] and the US [32]. Carbohydrate intakes were in accordance with the recommendations and were in line with the findings of former studies [25, 32, 33].

Regarding micronutrients, for iron and vitamin D intakes critical values were found and need to be discussed. They both show mean values clearly below the recommendations. For iron, studies conducted in other European countries [33, 46] detected similar values, whereas the FITS study with a US sample [32] found values that meet the recommendation presented in this paper, which might be due to more fortified foods in that market. Therefore, the lack of iron seems to be more of a European phenomenon. Research on infants provides evidence that an iron intake of about 25% below the recommendation does not increase the risk for iron deficiency [46]. However, more research is needed to ascertain whether these results can be transferred to toddlers.

The situation with vitamin D is even more severe; the intakes are extremely lower than the RDI. The values of the German GRETA study [33] are still lower than the ones found in the present study. Clinical studies confirm that vitamin D deficiencies are highly prevalent in Western Europe [46]. Although the US FITS study [32] found higher intakes, they still do not come close to meeting the recommendation displayed here. One reason might be that in some European countries, including Switzerland, only recently the paediatric guidelines changed from supplementing vitamin D only during the first year of life to a supplementation up to three years. It might be due to the fact that not all paediatricians follow these new guidelines and/or that the caregivers' compliance decreases over time. In our sample, only 17% of all toddlers received vitamin D supplements, although data were collected mostly during winter time when a supplementation is even more important than during the summer season. It also has to be noted that it is not possible to meet the vitamin D requirements with a normal healthy diet; individuals have to be exposed to sufficient sunlight to produce additional vitamin D.



**Table 5** Different dietary reference intake for energy and protein

Nutrient	Age (month)	DACH [34]		EFSA [47]		WHO [40, 51]	
		♂	♀	♂	♀	♂	♀
Energy (kcal/day)	12–18	1200–1300	1100–1200	777 (12 m)	712 (12 month)	948	865
	19–24	1200–1300	1100–1200	1028 (24 m)	946 (24 month)	948	865
	25–36	1200–1300	1100–1200	1174 (36 m)	1096 (36 month)	1129	1047
Protein (g/kg/day)	12–18	1	1	1.14–1.03	1.14–1.03	0.95–0.85	0.95–0.85
	19–24	1	1	1.03–0.97	1.03–0.97	0.85–0.79	0.85–0.79
	25–36	1	1	0.97–0.90	0.97–0.90	0.79–0.73	0.79–0.73

There are several limitations that need to be considered when interpreting the data. First, the study sample clearly is not fully representative. Most participants were recruited using addresses from a large baby food company in Switzerland. Parents who sign up for such a newsletter might be more interested in the development of children and they might be more open to use industrially produced baby food than the average caregiver. However, participants who are willing to take part in such an extensive study might be more interested in these topics, regardless of how they are recruited. The results are congruent with studies from other European countries, which seems very plausible and creates confidence in the validity of the present data. Therefore, it is assumed that it is safe to generalise the findings to all of Switzerland.

Another issue was that the reference foods in the booklet were taken from a manual with portion sizes for adults. However, for each food there were several portion sizes. For the booklet, the smallest size was always chosen, a size that seemed rather plausible for toddlers (e.g., eight pieces of small ravioli). Participants were instructed to list the toddlers' intake in reference to this picture, for example as  $\frac{1}{2}$  R or  $\frac{1}{4}$  R or 2 R. The fractions were purposely mentioned first, so participants knew that they could list smaller portions than the one in the picture.

Finally, the study results are based on questionnaires; therefore, actual blood values for the assessment of micro-nutrient deficiency have not been gathered.

In conclusion, the diet of Swiss toddlers in general seems adequate but does not meet all nutritional requirements. The results of the present study correspond very well with the findings of other European studies. In a review of relevant research, the EFSA identified omega-3 fatty acids, iron and vitamin D as critical nutrients [47], which is congruent with the present results. It seems that these deficiencies are not related to financial constraint since they were found even in a rich country like Switzerland. As in other European countries, protein intake exceeds the present recommendation and the share of saturated fats is too high. On the other hand, the intakes of iron and vitamin D are well below the recommendations. For protein intake, it seems too early to

draw conclusions regarding diet [48]. Recommendations should be reevaluated and more research is needed to define an upper limit. However, special attention should be paid to the choice of foods parents give their toddlers to improve the balance of fatty acids. Efforts to increase parents' education and knowledge by recommending healthy eating models that are respectful of their culture, beliefs and economic conditions while also taking into account the availability of local foods are needed to achieve balanced nutrition. In the case of iron, more research is necessary to find out more about the long-term consequences of intakes below the recommendation. Regarding vitamin D, the supplementation should be done according to the new guidelines.

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#### Compliance with ethical standards

**Ethical approval** The manuscript does not contain clinical studies or patient data. Therefore, no approval by an ethical committee was necessary.

**Conflict of interest** The authors declare that they have no conflict of interest.

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