

Factors associated with sugar intake and sugar sources in European children from 1 to 8 years of age

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Running title

Intake and sources of sugar in children

Conflict of interest statement

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Abstract

Background/Objectives: The WHO recommends to limit intake of free sugars to 5% of total energy per day because of the great impact of high sugar intake on body fat deposition, adiposity and dental caries. However, little data exist about total intake and sources of sugar in European children. Therefore, this paper aims to describe sugar intake and dietary sugar sources and associated factors.

Subjects/Methods: Three-day, weighed dietary records were obtained at eight time points from children one to eight years of age (n=995) in five European countries. Food items were classified into subgroups according to food composition. Linear mixed models were used to examine associated factors.

Results: Total sugar intake increased from 65 g/d (30.0 % of energy intake (E%)) at 12 months of age to 83 g/d (20.9 E%) at 96 months of age. Around 80% of children's sugar intake was derived from the following sources: milk and dairy products, fruits and fruit products, confectionary and sugar sweetened beverages (SSB). Total sugar intake and dietary sugar sources varied significantly by country of residence. Boys had a significantly ($p=0.003$) higher total sugar consumption than girls.

SSB consumption was significantly higher in children from young mothers while sugar intake from fruit products was lower in children from mothers with lower educational status and those with higher birth order.

Conclusions: Sugar intake in our population was lower than in other studies. Total sugar intake was associated with country of residence and gender, while dietary sugar sources varied by country of residence, maternal age, education and birth order.

Keywords

sugar intake, added sugars, sugar sweetened beverages, dairy, fruit, confectionary, Europe, children

Introduction

Obesity is one of the greatest current challenges for public health. A recent European survey showed a prevalence of overweight children aged 4 to 7 years in the range of 7.6% (girls in Germany) to 29.8% (girls in Spain), based on the WHO criteria. (1)

Changes in sources and the total intake of carbohydrates in the last century have been linked to an increase in the prevalence of obesity and diabetes (2). Several studies in children confirmed significant associations between the intake of sugar sweetened beverages and the risk of becoming overweight (3-6). Sugar sweetened beverages lead to short-term satiation that oftentimes results in an increase in the frequency of their consumption (7). No associations with body weight, however, have been found between consumption of 100% fruit juice and risk for being overweight in 2 - 11 years old children (8). High added sugar intake disturbs energy balance since frequent consumption of energy dense foods and liquids is associated with excessive weight gain (7). Te Morenga et al concluded in their review about the effect of dietary sugars on body weight that a higher intake of dietary sugars is associated with higher body weight, but not as a physiological or metabolic consequence of the sugar intake but as a consequence of an energy imbalance (7).

Simple sugars include monosaccharides (galactose, fructose and glucose) and disaccharides (lactose and sucrose). In general, simple carbohydrates taste sweet and are the building blocks of more complex carbohydrates like starches. Complex carbohydrates are generally considered as healthy, satiating and are often accompanied by valuable vitamins and minerals. Total sugar content consists of both naturally occurring sugars like fructose in fruits and vegetables and lactose in milk products as well as added sugars. Processed foods often have added sugars, which are simple carbohydrates added to food during industrial processing, production or food preparation. Added sugars are linked to high energy density and considered to be "empty calories" (9). Free sugars imply all monosaccharides and disaccharides added to foods during food production or processing, and sugars naturally present in honey, syrups, and fruit juices (10).

While there is no common recommendation for total sugar intake, the intake of added sugars has been recommended to be below 25% of the daily energy intake by the Institute of Medicine (11); several European countries advise to restrict added sugars to below 10% of the daily energy intake (12). The World Health Organization (WHO)

proposed in its recently released guidelines to reduce intake of free sugars to less than 5% of total energy per day because of the impact of free sugars on body fat deposition, adiposity and, especially, dental caries (10). Although caries development does not depend only on the amount of sugar consumed but also on many other factors (13), a recently released review about the relationship between sugars and caries advised to reduce the recommendation for total sugar intake to even 2-3% of energy intake (14).

This paper aims to determine the total sugar intakes and dietary sources of sugar in a longitudinal study of European children between one and 8 years of age. Furthermore, this paper investigates which factors are associated with dietary intake and sources of sugar in childhood.

Subjects and Methods

Our subjects participated in the European *CH*ildhood Obesity *P*roject (CHOP), a double-blind, randomized, multicenter intervention trial in Germany, Belgium, Italy, Poland, and Spain on the effect of the intake of higher or lower protein formula milk on growth in the first two years of life and adiposity at 6 years of age (15). Children were randomized to receive either a higher or lower protein formula during the first year of life. A group of breastfed children was followed as a control group. All participants were apparently healthy and full-term infants who were born from uncomplicated, singleton pregnancies. Informed consent was obtained from the parents at enrollment and again for further follow-up at 24 months. Additionally consent of children was obtained at 8 years of age. The study was approved by the ethics committees of all study centers. Trial registration number at www.clinicaltrials.gov is NCT00338689. (15)

Nutritional assessment

Breast milk intake was not quantified, so children with any breast milk intake past 12 months of age were excluded from this analysis. In total, 995 children were included. Three-day, weighed dietary records on three consecutive days (1 weekend day and 2 week days) were obtained at the ages of 12 (n=827), 18 (n=717), 24 (n=747), 36 (n=531), 48 (n=503), 60(n=445), 72 (n=468), and 96 (n=399) months. Parents were provided with food scales and explained how to weigh offered foods and leftovers. From 36 months on parents had the possibility to fill out an alternative dietary record by comparing consumed food with pictures of standardized and weighed portion sizes. Food intake at nursery school, school or anywhere else outside home that was not prepared by parents was recorded with the help of other proxy reporters (i.e. instructed educators). Standard operating procedures were applied for dietary data entry and plausibility checks. A trained dietician validated the protocols, clarified open issues with the parents and transferred the dietary records into the database in each study centre. The German food composition database, BLS 3.01 (Bundeslebensmittelschlüssel Version 3.01), was used to calculate nutrient intakes from the food intake data in all participating countries. So called “custom food items” were items not found in BLS and added by study dieticians. For custom food items,

information on nutrient content was either provided from the food manufacturer or was estimated through recipe simulation (16).

For the purpose of this study we investigated the joint intake of natural and added sugars in form of all mono- and disaccharides. In some cases, data on sugar content was not available and estimated by comparison with similar products. Food items were categorized into subgroups according to food composition.

4850 different food items were reported by the subjects in the 3-day dietary records and classified into food groups. Table 1 shows the food groups containing sources of sugar. Important sugar sources were selected on basis of their contribution to total sugar intake (>2% of total sugar intake) and relevance: milk and dairy products, fruit and fruit products, bread and cereals, confectionary and sugar sweetened beverages (SSBs).

Explanatory variables

Weight and height were measured at the age of 12, 24, 36, 48, 60, 72 and 96 months by trained study nurses. In all study centers the same scales and stadiometers were used (Seca 336 at ≤ 24 months and Seca 702 at ≥ 24 months; Stadiometer 242; Seca, Hamburg, Germany).

Maternal education was assessed according to the International Standard Classification of Education and categorized in high, middle and low. Maternal age at birth was categorized in younger (< 28 years), middle (28-33 y) and older (≥ 34 y). Pre-pregnancy weight was reported by the mother and maternal BMI was classified in normal (< 25 kg/m²), overweight (25-30 kg/m²), and obese (> 30 kg/m²). Subjects' birth order was reported at study entry.

Statistical analysis

Our primary endpoint was the total daily sugar intake (g/d) and energy intake from sugar in four main sugar sources (E%). Secondly we investigated the association of study country, age, gender, maternal age at birth, maternal education level, early feeding type and birth order with these outcomes.

Linear mixed models with random intercept and random linear (age) slope and fixed cubic age terms were used to describe group differences in sugar and energy intake from sugar in four main sugar sources from 12 to 96 months of age. Country-age

interaction terms were included together with main fixed effects of countries, gender, early feeding type (breastfeeding versus formula feeding), birth order, maternal age and education level.

A fixed effect can be interpreted as the population average effect and a random effect as the individual deviation of that average effect. In this longitudinal model the intercept was set to age 12 months by subtracting age by 12

Dietary records with energy, fat, carbohydrate or protein intake 3 SD above or under the mean intake by time point and country were excluded.

Data management and statistical analyses were carried out with the software packages SPSS Statistics 22 (SPSS Inc, Chicago, IL) and Stata version 13.1 (StataCorp LP, College Station, TX).

Results

Table 2 shows the characteristics of the study population with completed 3-day dietary records at any time point (n=995). The number of available dietary records ranged from 827 at 12 months to 399 at 96 months of age. About 70% (n=692) of infants were originally in the intervention group that received study formula during the first year of life and 30% (n=303) of the infants were exclusively breastfed for at least the first three months of life. More than half of the mothers had a middle educational level. The mean age at birth was 30.7 (5.0) years; mean maternal pre-pregnancy BMI was 23.4 kg/m², with 7.3% of the mothers being obese and 20.7% overweight.

Total intake of macronutrients and sugar

Mean energy intake increased from 3658 kJ/d at 12 months to 6662 kJ/d at 96 months (Table 3) while mean energy intake per kg body weight decreased from 377 kJ/kg/d to 240 kJ/kg/d. While the carbohydrate intake increased from age 12 months to 96 months, the contribution of sugar declined from 57% to 43%. The average contribution of carbohydrates to total energy intake varied between 52% and 48% with a slight decrease over time. The observed decline was generally most pronounced between 12 and 36 months of age (data not shown). Total sugar intake increased from 65 g/d (30 % of energy intake (E%)) at the age of 12 months to 83 g/d (21 E%) at the age of 96 months.

Factors associated with total sugar intake

Table 4 shows the factors associated with total sugar intake and dietary sugar sources. Greatest differences were found between countries. Italian children had the lowest and Polish children the highest daily sugar intakes over the whole study period, ranging from 51g/d to 73g/d and 76g/d to 93g/d, respectively, from 12 months to 96 months of age. Boys had a significantly ($p=0.003$) higher total sugar consumption than girls. Total sugar intake was not associated with any of the other variables.

Dietary sugar sources

Around 80 % of children's sugar intake derived from the following sugar sources at all time points: milk and dairy products, fruits and fruit products, confectionary products, bread and cereals, and sugar sweetened beverages. Sugar intake from milk and dairy products decreased from 47% to 19% of total sugar intake from 12 to 96 months of age; sugar intake from fruit and fruit products and bread and cereals was relative stable around 30% and 5%, respectively, over the whole study period while the proportional sugar intake from the other food groups increased: for confectionary from 5% to 24% of total sugar intake and for sugar sweetened beverages from 2,0 to 6,7%. The overall energy contribution of sugar sweetened beverages was negligible (<1%). While sweetened infant teas contributed most sugar up to two years of age, carbonated drinks followed by fruit juices were the mayor source at later ages (data not shown).

While the overall contribution of sugar to energy intake decreased from one year to 8 years of age, the E% from sugars from confectionaries and sweetened beverages increased from 2 to 5 E% and 0.6 E% to 1.4 E%, respectively. The overall decline was mainly accounted by the reduction in the sugar intake from milk and dairy products: 14 E% at one year and 4 E% at 8 years of age (Figure 1).

Comparison amongst European countries

Country of residence had the strongest association with dietary sources of sugars with differing trends over the study period (Table 4 and Figure 1). Spanish children had the highest E% from sugar in dairy products throughout the whole study period while Italian and German children had the lowest. E% from sugar intake in fruits was highest in German children and lowest in Spanish and Belgian children at almost

every time point. SSB consumption was low in all participating countries with the lowest intake levels in Spain and the highest in Italy.

Other factors associated with E% by sugar sources

SSB consumption was significantly ($p < 0.001$) higher in children from younger mothers while sugar intake from fruit products was significantly lower in children with lower educated mothers and in children with higher birth order. Furthermore, formerly breastfed children had a significantly lower consumption of sugars from confectionary (Table 4).

Discussion

Total sugar intake in our study population increased over the investigated time period, but E% from sugar intake decreased. Around 80% of total sugar intake was from five main food sources over all time points: milk and dairy products, fruit and fruit products, confectionary, bread and cereals and SSBs. Total sugar intake was significantly associated with country of residence and gender, dietary sources of sugars varied considerably by country of residence, mother's age and education and birth order.

Total sugar intake

In a Canadian study with data from 2004 total sugar intake was about 110g/d (27 E%) in 1 to 3 year old children and about 120g/d (26 E%) in 4 to 8 years old children (17), an US study from 1981 reported a total sugar consumption of 134.3 g/d in 5 - 12 years old children (18). The European wide IDEFICS study investigated total sugar intake in children aged 2 - 9 years: total sugar intake ranged from 77 g/d (19 E%) in Estonia to 114 g/d (30 E%) in Germany (19). The European Nutrition and Health report of 2009 reports a mean E% of sucrose of 15.5 in European children aged 4 to 14 years (20). A recently released review on sugar consumption in dietary surveys worldwide showed a range of mean total sugar intake in 4-10 years old children from 83.6 g/ (4 years old Irish children) to 167 g/d (12 years old German boys). E% from total sugar ranged from 17% in 3-10-year-old Italian children to 34.8% in Dutch 4-6 years-olds. (21) Total sugar intake is much lower in our population while energy contribution is comparable to the Canadian and the IDEFICS study and to data in 4 to 10 years-olds from the worldwide review (21). These differences probably derive from different methods for dietary assessment and different populations.

Sugar intake also varied between study countries. Whereas some countries have recommendations on sugar intake, there is no common recommendation on sugar intake in Europe (13). The WHO recently released guidelines on free sugar intake, proposing to reduce the intake of free sugars to 5% of total energy per day (10). We did not distinguish between natural occurring and added sugar or free sugar, so we cannot directly compare actual intake to recommended intake. However, at 96 months of age about 6.5 % of total energy intake was taken from sugar in confectionary and sugar sweetened beverages, which represent 100% free sugar.

Thus, together with free sugar from dairy products, fruit products or other sources most of our eight-year-old children consumed more than 5% of total energy intake from free sugars.

Dietary sources of sugar

Negative health impacts of sugar function mainly via an energy imbalance than via sugar itself (7). By this it is important to investigate from which sources sugar is taken, as in some sources sugar is accompanied by fat leading to high energy density (e.g. confectionary) and in some not (e.g. fruits).

In Canada as well as in the United States, milk contributed greatly to sugar intakes; 19.9% of total sugar intakes in the Canadian study (17) and 20.4% of sugar intakes in the 5 - 12 years-old US-children (18). In our population, milk and dairy products were the top source of sugars at 12 months of age, but at 96 months of age, more sugar was taken from fruit and fruit products. At 12 months of age formula milk and milk based baby food has a high energy contribution and many of these baby foods contain next to lactose glucose or sucrose which can explain the high sugar intake from milk and dairy products in this age (22).

Fruits generally played a greater role in the diets of the children in our study population, compared to the US and Canadian studies. Canadian children reported 14.9% of sugars from fruits and US children reported only 11.5% (17, 18). As sugars are almost the only energy source in fruits, high sugar intake from fruits and fruit products means high intake of fruit and fruit products, which might positively affect children's health. The slightly higher contribution of fruits and fruit products to total sugar consumption at 12 months might have two reasons: on the one hand baby fruit jars with added sugars are common in many European countries (22), on the other hand at 96 months of age other sources of added sugars like confectionary or sweetened beverages replace sugar intake from fruits and fruit products in parts.

Sugar intake from SSB was much lower in our study (6% of total sugar intake at 96 months): in the Canadian study 9.8% of total sugar intake was taken from regular soft drinks and fruit drinks (17) and in the US study 13.8% from SSB (18). As sugar in beverages lead to high energy intake without satiating effects, a low sugar intake from beverages might have positive health impacts (7).

Canadian children 1 to 8 years take 19.4% of total sugar intake from confectionary, sugar and syrups (17), which is approximately comparable with our classification 'confectionary'. We could show that sugar intake from that food group strongly increases during the investigated period and delivers at the age of 8 years almost a quarter of consumed sugars. The German DONALD study shows that consumption of confectionary rich in sugar and fat increases until the age of 14 years and decreases after that age (23).

Variables associated with dietary sugar sources

Dietary sources of sugars seemed to be associated mainly with country of residence. Further associated factors were maternal age at birth, maternal education level and the child's birth order.

Country

To our knowledge there is no other study that compares the sources of sugars in different European countries. The European wide IDEFICS study found wide ranges of total sugar intakes in different European countries (ranging from 77g/d to 114g/d), suggesting also differences in the sugar sources (19). Comparing our results with sugar sources in the US, Swedish or Canadian studies, we observed great differences. The selection of sugar sources seem to be strongly influenced by eating culture in the participating countries. Therefore it is important to consider this in the specific countries before determining recommendations for intake of sugar or food groups.

Maternal age and education

Children with mothers in the older age category had a significantly lower sugar intake from SSB than children with younger mothers. In the American Feeding Infants and Toddlers Study, higher maternal age was associated with multiple positive feeding practices in infant and toddlers aged 4 to 24 months (24). Karp and Lutenbacher investigated infant feeding practices of young American mothers and found high rates for inappropriate feeding practices like putting additional cereals in the bottle or inappropriate food selection (25).

Sugar intakes from fruits and fruit products was significantly lower in children of mothers with low educational status compared to children from mothers in the higher or middle educational category. This result is not surprising as several studies

confirmed the healthier lifestyle in children with higher educated parents as for example the Feeding Infants and Toddlers Study, in which a mother's college education was associated with the largest number of positive feeding behaviors (24). This is an important observation, since parental education is also associated with fruits and vegetable intake in adolescents, making it a consistently influential variable throughout childhood (26). It should be investigated to what extent parents read and understand food labels. Improvement in the quality of children's diet involves nutrition education especially for parents with a low educational status (27). This fact leads to the conclusion that nutritional recommendations should especially focus to young and lower educated parents.

Birth order

Increasing birth order posed a significant dietary risk, as children with higher birth orders had a lower sugar intake from fruits and fruit products. On the one hand, offering children fresh fruit may be more time consuming than offering convenience food. On the other hand, time and motivation to encourage children to eat healthy food is maybe less in parents with more children. A review on the family environment and fruit and vegetable intake showed that there were positive associations between parental encouragement to try and eat fruits and vegetables and actual intake of these foods in children (26).

Strengths and limitations

Over a span of seven years, the number of participants decreased from 827 at the age of 12 months to 399 at the age of 96 months. Attrition was thought to be partly due to the time consuming and demanding task of completing the three-day dietary records, in addition to the request to complete multiple other questionnaires. Except for the first year of life, when formula milk was provided free of charge, the participants had no benefit from study participation. In long-term follow-up studies of healthy infants, high participation rates are generally difficult to achieve. It was proposed that follow-up rates of 50-80% are acceptable in longitudinal epidemiological cohort studies (28).

Families with higher education and former breastfeeders were more inclined to stay in our study. On the other hand children from lower educated families and formula

fed children are more likely to have a poorer diet (24, 29, 30). So we would expect, that the shift towards unhealthy food choices would be even greater with a higher participation rate of children from lower educated families and formula fed children. Furthermore, there was differential loss to follow-up seen between countries with higher attrition rates in Italy and Belgium due to logistical problems at 96 months only. However, any mayor effect resulting from differences in follow-up rates between countries should have been captured by adjusting for country-age interactions in the longitudinal model. Nevertheless, part of the observed effects might be due to attrition bias.

In our study it was not possible to distinguish between natural and added sugars, which limits the information available on the dietary sources of added or natural sugars in this cohort. A distinction of added and natural sugar is easier in a dietary assessment via food frequency questionnaires with limited number of food items and predefined values for added or natural sugars but not in our method with an incomparable higher number of food items actually consumed. So on the one hand conclusions about the relation of added and natural sugars could improve explanatory power and show more approaches to improvement but on the other hand a dietary assessment via detailed three day dietary records is considered to be the most precise method of dietary intake assessment in young children (16). We used a standardized approach with quality assurance to data collection and evaluation that is expected to reduce bias and errors.

One strength of our study is the longitudinal assessment with sound methodology allowing for direct comparison between study countries. Furthermore, we could see that there are great differences in total sugar intakes, depending on sociocultural factors and country of residence.

Conclusion

Children from the five European countries in this study had a lower total sugar intake than children in the US, Canada, or the population investigated in the IDEFICS study. Eating habits in the participating European countries were very different during the complementary feeding period and in later childhood. Total sugar intake was associated with the country of residence and gender, while dietary sugar sources varied by country of residence, maternal age and education and birth order.

Our results show, that it is important to address European-wide nutrition-related recommendations especially in the complementary feeding period in consideration of different country-specific eating cultures. Further efforts have to be done to reach parents of children with nutritional risks, namely young and lower educated parents.

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Conflict of interest statement

The authors declare no conflict of interest.

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Table 1: Classification of sugar containing food items reported in the 3-day dietary protocols

Name of subgroup	Milk and milk products	Fruit and fruit products	Confectionary	Bread and cereals
Infant formula milk, breast milk	X			
Milk and milk products without added sugars	X			
Milk and milk products with added sugars	X			
Fresh fruits		X		
Fruit mash or compote		X		
Fruit jam		X		
Fruit concentrate		X		
Dried fruits		X		
Fruit juice		X		
Pastry			X	
Desserts			X	
Sugar, honey			X	
Sweets			X	
Infant cereals, muesli without added sugars				X
Cereals with added sugars				X
Bread and bread product				X
Sugar sweetened beverages				

Table 2: Characteristics of study population with completed 3-day dietary protocol at at least one time point between 12 and 96 months (n=995)

		n (%)
Country	Germany	159 (16.0)
	Belgium	120 (12.1)
	Italy	276 (27.7)
	Poland	183 (18.4)
	Spain	257 (25.8)
Sex	Boys	477 (47.9)
	Girls	518 (52.1)
Breastfeeding status	FF	692 (69.5)
	BF	303 (30.5)
Maternal educational level	Low	220 (22.2)
	Middle	504 (50.8)
	High	269 (27.1)
	Unknown	2 (0.2)
Maternal age at birth	< 28 y	280 (28.2)
	28 - 34 y	391 (39.3)
	> 34 y	323 (32.5)
	Unknown	1 (0.1)
Maternal pre-pregnancy BMI	<20	176 (18.4)
	20-<25	513 (53.6)
	25-<30	198 (20.7)
	>=30	70 (7.3)
	Unknown	38 (3.8)
Birth order	1st child	579 (58.2)
	2nd child	317 (31.9)
	>2nd child	98 (9.9)

Table 3: Mean intake of energy (kJ/d) and macronutrients (g/d) from 12 to 96 months

	Age (months)							
	12 (n=827)	18 (n=717)	24 (n=747)	36 (n=531)	48 (n=503)	60 (n=445)	72 (n=468)	96 (n=399)
Energy								
kJ/d (SD)	3657.6 (720.7)	4274.8 (834.6)	4621.6 (959.6)	5077.0 (976.2)	5487.3 (990.4)	5795.2 (1081.1)	6143.9 (1022.2)	6662.0 (1190.9)
kJ/kg/d (SD)	377.0 (79.3)	Not available	375.5 (83.3)	348.6 (72.7)	328.3 (66.8)	304.3 (67.2)	283.9 (57.8)	240.3 (56.6)
Fat								
g/d (SD)	31.8 (8.2)	37.7 (9.7)	42.0 (11.7)	46.7 (12.5)	51.5 (13.5)	54.2 (14.1)	57.5 (14.0)	64.8 (16.9)
g/kg/d (SD)	3.3 (0.9)	Not available	3.4 (1.0)	3.2 (0.9)	3.1 (0.9)	2.9 (0.8)	2.7 (0.7)	2.3 (0.7)
Protein								
g/d (SD)	32.1 (9.6)	41.7 (11.4)	44.9 (12.8)	46.7 (11.8)	49.7 (12.6)	51.7 (13.3)	54.7 (12.4)	60.7 (15.0)
g/kg/d (SD)	3.3 (1.0)	Not available	3.6 (1.1)	3.2 (0.8)	3.0 (0.8)	2.7 (0.8)	2.5 (0.6)	2.2 (0.6)
Carbohydrates								
g/d (SD)	114.4 (26.9)	128.5 (30.6)	136.6 (32.6)	151.7 (35.4)	163.0 (33.9)	173.4 (39.6)	183.8 (38.4)	192.3 (40.7)
g/kg/d (SD)	11.8 (3.0)	Not available	11.1 (2.8)	10.4 (2.6)	9.8 (2.3)	9.1 (2.3)	8.5 (2.1)	6.9 (1.8)
Sugar								
g/d (SD)	65.2 (20.3)	65.9 (21.8)	69.7 (23.2)	75.3 (24.3)	78.5 (24.1)	81.6 (26.7)	83.6 (25.1)	82.9 (27.2)
g/kg/d (SD)	6.7 (2.1)	Not available	5.7 (2.0)	5.2 (1.8)	4.7 (1.6)	4.3 (1.5)	3.9 (1.3)	3.0 (1.1)
	n=815		n=726	n=508	n=490	n=438	n=461	n=395
Weight kg (SD)	9.8 (1.1)	Not available	12.4 (1.4)	14.7 (1.8)	16.9 (2.1)	19.4 (2.9)	22.1 (3.8)	28.6 (6.1)
BMI-for-age z-score (SD)	0.35 (1.01)	Not available	0.26 (0.94)	0.29 (0.98)	0.36 (0.96)	0.36 (1.04)	0.34 (1.18)	0.46 (1.21)

Table 4: Effects of country, gender, maternal age, maternal education level, breast vs. bottle feeding, birth order on total sugar intake and sugar intake from four main sugar sources (4445 observations)

	total sugar intake (g/d)	% sugar intake from milk and milk products	% sugar intake from fruit and fruit products	% sugar intake from confectionary	% sugar intake from SSB ₃
Country₁					
GE	Baseline group				
BE	3.981 [-0.876,8.838]	0.054** [0.018,0.090]	-0.039* [-0.077,-0.001]	0.060*** [0.034,0.087]	-0.026** [-0.042,-0.011]
IT	-10.337*** [-14.281,-6.394]	-0.000 [-0.029,0.029]	0.018 [-0.013,0.049]	0.021 [-0.001,0.043]	0.019** [0.006,0.032]
PO	13.952*** [9.632,18.272]	0.084*** [0.052,0.116]	-0.051** [-0.085,-0.017]	0.016 [-0.007,0.040]	0.004 [-0.011,0.018]
ES	13.116*** [9.113,17.119]	0.092*** [0.063,0.122]	-0.123*** [-0.155,-0.092]	-0.010 [-0.032,0.012]	-0.029*** [-0.042,-0.016]
Age	0.188 [-0.200,0.576]	-0.013*** [-0.015,-0.010]	0.003 [-0.001,0.006]	0.014*** [0.011,0.016]	0.000 [-0.001,0.002]
GE x Age	Baseline group				
BE x Age	0.355 [-0.252,0.962]	0.001 [-0.004,0.005]	-0.010*** [-0.015,-0.005]	-0.008*** [-0.011,-0.004]	0.002 [-0.000,0.004]
IT x Age	0.292 [-0.188,0.771]	0.001 [-0.003,0.004]	-0.004* [-0.008,-0.000]	-0.004** [-0.007,-0.001]	0.000 [-0.002,0.002]
PO x age	0.796** [0.272,1.321]	-0.011*** [-0.014,-0.007]	0.004* [0.000,0.009]	-0.002 [-0.005,0.001]	-0.000 [-0.002,0.001]
ES x Age	-0.147 [-0.636,0.342]	0.002 [-0.002,0.006]	-0.000 [-0.004,0.003]	-0.004** [-0.007,-0.002]	-0.000 [-0.002,0.002]
Age ²	0.009 [-0.003,0.021]	0.000*** [0.000,0.000]	-0.000 [-0.000,0.000]	-0.000*** [-0.000,-0.000]	-0.000 [-0.000,0.000]
GE x Age ²	Baseline group				
BE x Age ²	-0.005 [-0.025,0.014]	-0.000 [-0.000,0.000]	0.000** [0.000,0.000]	0.000** [0.000,0.000]	-0.000 [-0.000,0.000]
IT x Age ²	-0.008 [-0.023,0.007]	-0.000 [-0.000,0.000]	0.000 [-0.000,0.000]	0.000** [0.000,0.000]	-0.000 [-0.000,0.000]
PO x age ²	-0.027** [-0.043,-0.011]	0.000*** [0.000,0.000]	-0.000 [-0.000,0.000]	0.000 [-0.000,0.000]	-0.000 [-0.000,0.000]
ES x Age ²	-0.004 [-0.019,0.012]	-0.000 [-0.000,0.000]	-0.000 [-0.000,0.000]	0.000*** [0.000,0.000]	0.000 [-0.000,0.000]
gender					
Girls	-2.955** [-4.843,-1.068]	0.006 [-0.006,0.019]	0.003 [-0.011,0.016]	0.003 [-0.006,0.013]	-0.000 [-0.006,0.006]

Maternal age					
<28	Baseline group				
28-<33	-1.842 [-4.336,0.652]	0.020* [0.003,0.037]	0.003 [-0.015,0.021]	0.001 [-0.011,0.013]	-0.013*** [-0.021,-0.005]
33-44	-1.164 [-4.015,1.686]	0.018 [-0.001,0.037]	0.013 [-0.008,0.034]	-0.000 [-0.014,0.014]	-0.015*** [-0.024,-0.006]
Maternal education					
no/low	Baseline group				
middle	0.828 [-1.634,3.289]	-0.008 [-0.025,0.008]	0.020* [0.002,0.038]	-0.004 [-0.016,0.009]	-0.006 [-0.013,0.002]
high	-0.130 [-3.077,2.817]	-0.016 [-0.035,0.004]	0.036*** [0.015,0.058]	-0.002 [-0.017,0.012]	-0.006 [-0.015,0.004]
Breastfeeding status					
FF	Baseline group				
BF	0.336 [-1.842,2.513]	0.002 [-0.012,0.017]	0.008 [-0.008,0.024]	-0.012 [-0.023,0.001]	-0.001 [-0.008,0.005]
Birth order					
1st child	Baseline group				
2nd child	0.448 [-1.712,2.608]	-0.012 [-0.026,0.002]	-0.004 [-0.019,0.012]	0.008 [-0.003,0.018]	0.008* [0.001,0.014]
>2nd child	3.225 [-0.259,6.710]	-0.003 [-0.027,0.020]	-0.038** [-0.064,-0.012]	0.016 [-0.001,0.034]	-0.001 [-0.011,0.010]
total sugar intake		-0.001*** [-0.001,-0.001]	0.001*** [0.001,0.001]	-0.000 [-0.000,0.000]	0.000*** [0.000,0.001]
Constant	69.945*** [62.757,77.133]	0.430*** [0.379,0.481]	0.256*** [0.201,0.312]	0.050** [0.012,0.089]	-0.000 [-0.024,0.023]

95% confidence intervals in brackets

* p<0.05, ** p<0.01, *** p<0.001

₁ GE=Germany, BE=Belgium, IT=Italy, PO=Poland, ES=Spain

₂ FF=formula-fed, BF=breastfed

₃ SSB=Sugar sweetened beverages

Figure 1: Percentage of total sugar intake from main sources from 12 to 96 months of age

