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ORIGINAL CONTRIBUTION

Dietary sources of free sugars in the diet of European children: the IDEFICS Study

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Abstract

Objective To report dietary free sugars consumption and their different types and food sources in European children.

Methods The present study is based on the IDEFICS study, a European multicenter cohort study in children (2–9 years old) from eight countries, comprising 8308 children (51.4% males). Dietary intake of the previous 24 h was assessed using a computer-assisted 24-h dietary recalls (24-HDR) and the different types of sugars were assessed using the German food composition database.

Results Mean total energy intake was 1720 (SD 477) kcal/d for boys and 1631 (SD 451) kcal/d for girls. Total sugars intake was 98 (SD 52) g/day for boys and 93 (SD 49) g/day for girls. Free sugars intake was 81 (SD 49) g/day for boys and 77 (SD 47) g/day for girls. Girls had significantly lower intakes of energy, total and free sugars compared with than boys but did not differ in terms of percent of energy from total (23%) or free sugars (18%). There were large variations between countries in average % energy from free sugars (ranging from 13% in Italy to 27% in Germany). Less than 20% of children were within the recommended intake of 10% of energy from free sugars. The food groups that contributed substantially to free sugars intakes were “Fruit juices”, “Soft drinks”, “Dairy” and “Sweets and candies”.

Conclusions The contribution of free sugars to total energy intake in European children is higher than recommendations. The main food contributors to free sugars intake are sweetened beverages (“Fruit juices” and “Soft drinks”). It is especially important to reduce children’s intake of free sugars, focusing in target population on certain foods and food groups.

Keywords Children · Free sugars · Food sources · Sugar sweetened beverages · Sugar recommendations

Introduction

The effects on health of free sugars (energy-containing sweeteners often added in the processing or preparation of foods and beverages) have been highlighted in the recent years. As a consequence, governments and health associations agreed on the role of free sugars in the development of obesity and its related disorders, as well as impaired dental health and the World Health Organization (WHO) developed guidelines regarding sugar consumption [1].

The elevated consumption of free sugars has been associated with a low overall diet quality, as food rich in free sugars provide little nutritional value apart from energy [2, 3]. Free sugars consumption has been associated with cardiovascular diseases [4] and increased risk of type 2 diabetes [5, 6]. In children and adolescents, free sugars intake is also associated with the development of excess body weight and obesity [7–9], with high levels of low-density lipoproteins and triglycerides [10] and insulin resistance (HOMA-IR) [11]. In addition, free sugars consumption is the most important dietary risk factor for developing caries in children, adolescents and adults [12, 13].

Recently, WHO also published the updated recommendations on free sugars intake for adults and children, especially in relation to body weight and oral health: (1) to reduce intake of free sugars throughout the life-course (strong recommendation); (2) to reduce the intake of free sugars to < 10% of total energy (TE) intake in both adults and

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children (strong recommendation); and (3) to further reduce free sugars to below 5% of total energy intake to provide additional health benefits (conditional recommendation).

The terms total sugars, added sugars, and free sugars are often being used interchangeably in the literature and recommendations, and this can be somewhat confusing [14]. Total sugars (mono- and disaccharides) comprise intrinsic sugars (naturally occurring sugars, or sugars contained within unprocessed foods, commonly found in fruits and vegetables), lactose in milk, and free sugars. In general, added sugars comprise all sugars that are incorporated into foods and beverages during production. Free sugars are defined as all monosaccharides and disaccharides added to foods by the manufacturer, cook, or consumer; plus sugars naturally present in honey, syrups, and fruit juices [1].

The available data for 16 countries in Europe, North America and Australia suggest that intake of added sugars are higher in school-aged children and adolescents (up to 19% of total energy) compared to younger children or adults [15]. A recent review of European studies reports that the contribution of added sugars in children is between 11 and 17% of total energy intake, depending of the countries, and higher than the proportions observed in adults [16].

Little is known about recent consumption of free sugars and their main food sources in European children. Also, an advantage of the present study is that it can compare the difference in intakes between countries, since the same assessment method was used in the different study centers.

The purpose of this study was to provide estimates of free sugars consumption among European children and to analyze their main food sources.

Methods

Study design

IDEFICS (Identification and prevention of dietary and lifestyle induced health effects in children and infants) is a European multicenter cohort study in eight countries ranging from North to South and from East to West, with survey centers in Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden. The aim of the project is to describe the etiology of overweight, obesity and related disorders in 2–9 year-old children and to develop and evaluate a community-based primary prevention program [17]. The study design, sampling and procedures of IDEFICS have been described in detail elsewhere ([17, 18].

Kindergartens, preschools and primary schools (grades 1 and 2) in the survey regions were approached with the aim of including children of all social groups. All children in the defined age group attending the selected kindergartens and schools were invited to participate in the study. The baseline survey (T0) was the starting point of a prospective cohort study with the largest European children's cohort established to date. The survey included interviews with parents concerning lifestyle habits and dietary intakes as well as anthropometric measurements and physical examinations of the children. All measurements were taken using standardized procedures in all eight countries [19]. In this study, we analyzed data from the baseline cross-sectional survey (T0). Parents provided written informed consent for all examinations, subsequent analysis and storage of personal data, and each child was informed orally about the modules by field workers and asked to give verbal assent immediately before examination. In each country, participating centers obtained ethical approval from the local responsible authorities in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Dietary assessment

In the IDEFICS study, dietary intake of the previous 24 h was assessed using the computer-assisted 24-h dietary recalls (24-HDR), called SACINA ('Self- Administered Children and Infant Nutrition Assessment') [20]. The SACINA software was based on the previously designed and validated 'YANA-C' ('Young adolescents' nutrition assessment on computer') developed for Flemish adolescents and further adapted to European adolescents in the HELENA study [21, 22] (http://www.helenastudy.com). SACINA was developed to assess the children's absolute energy and nutrient intake, the percentage contribution from food and drinks to total energy and nutrient intake, as well as portion sizes and food groups during the previous 24 h. Parents or other caregivers as proxy respondents for children's diet gave information on amount (g) and type of all foods and drinks that were consumed during the previous day, starting with the first intake after waking up in the morning. The required time frame for one interview was 20–30 min [20]. School meals, drinks and snacks consumed the day prior to the 24-HDR were assessed using a standardized observer sheet, completed by trained personnel, attending the school canteen the day of the recall. School meal data were merged with the parentally reported 24-HDR data to enhance the completeness of dietary recalls [23].

The validity of proxy-reported energy intake from the 24-HDR was tested using the doubly labeled water technique in young children. The instrument was found to be valid to assess energy intake at group level [24].

Accurate estimation of portion sizes was assisted using standardized photographs. SACINA was structured according to six meal occasions: breakfast, mid-morning snack, lunch, afternoon snack, evening meal and evening snack, together with questions related to a range of chronological daily activities to help to remember [23].

Country-specific food composition tables (FCT) were used to match simple foods or European homogeneous multi-ingredient food items [25–29]. Hungary included local recipes into the German FCT, Estonia combined the Norwegian and Finnish FCT, [30, 31] whereas Cyprus included foods from the German and Swedish FCT. Uniquely coded food items were linked to these country-specific food composition tables. For harmonization, all energy and nutrient data of the country-specific FCT were expressed in 100 g edible portion. Standard units were taken from Widdowson's food tables [32]. The different types of sugars were assessed using the German food composition database (Bundeslebensmittelschlüssel des Bundesministeriums für Ernährung, BLS).

Incomplete interviews were excluded if the proxy did not know about at least one main meal or in case of missing school meal information. The IDEFICS study protocol required the assessment of one 24-HDR in all children and repeated 24-HDR interviews in a convenience sample (it was planned to assess repeated 24-HDR data in approximately 20% of the sample) using the second recall to correct for the day-to-day variation [23].

In all countries, we categorized foods and drinks containing free sugars. Ten food groups assessed by the SACINA software were included in the present analysis: (1) vegetables; (2) cereals, breads, pies, pizzas and bakery products; (3) soft drinks; (4) coffee, tea, herbal and similar; (5) dairy products; (6) fruit juices; (7) sweets and candies; (8) potatoes; (9) nuts and seeds and (10) other sources. In all groups, sugars that were incorporated into foods and beverages during processing or preparation, were considered. In the 'Other sources group', sauces, mayonnaises, soups, broths and gravies, and tomato ketchup were considered (Table S1, supplementary table).

Dietary data were analyzed for average energy intake in kilocalories (kcal) and kilojoules (kJ), carbohydrates, monosaccharides, disaccharides, total sugars, free sugars in grams (g), and percentages of energy from carbohydrates, total sugars and free sugars. As analytical data for lactose and fructose were available, free sugars content was calculated by subtracting the lactose and fructose of the total sugars of foods and beverages naturally containing these types of sugar, of each food group. Sugars in honey and in fruit juices were considered as free sugars.

Participants

Children aged 2–9 years participating in the IDEFICS baseline survey from autumn 2007 to spring 2008 were included in the study; from the originally invited 31,543 children, 16,864 were finally enrolled (response rate 53.4%). In total, 16,228 (51.4%) wished to participate and fulfilled the inclusion criteria of a completed parental questionnaire and measured weight and height. Owing to limited resources, it was not possible to collect 24-h dietary recalls for all IDEFICS children. However, at least one recall was collected for a total of 12,100 children, and 2527 individuals contributed more than one recall. Highest educational level of the parents according to International Standard Classification of Education (ISCED97) was used as proxy indicator for socio-economic status of the family [33].

Misreporting

Misreporting (over and underreporting) which comprises intentional and unintentional misreporting, is a well-known problem in dietary assessment and can be even more evident in data relying on proxy reports [34]. Goldberg [35] and Black [36] defined cutoff values to classify underreporters, plausible reports and overreporters, using the ratio of proxy reported energy intake over predicted basal metabolic rate [37]. These cutoffs are dependent on the duration of dietary assessment (number of recall days), the sample size, as well as variations in basal metabolic rate, physical activity level and energy intake. Minimum/maximum plausible levels of energy intake are defined as multiples of basal metabolic rate. The Goldberg cutoffs were considered of good predictive value and thus they are an appropriate alternative for characterizing misreporting in the absence of objective validation data [38]. As these cutoffs were developed for adults and do not consider differences in energy intake due to age and sex, the original cutoffs were adapted for use in children using age- and sex-specific reference values [23, 39]. In our study, out of 12,100 participants, 8308 children (4275 boys and 4033 girls) with one 24-HDR and covariate information were included in the final study, excluding misreporters (Fig. 1).

Statistical methods

For the descriptive analyses, mean intakes and standard deviation (SD) for continuous data are presented. Mean daily intake (g) and percentage of daily energy (% of *E*) of free sugars from the ten food groups consumed by boys and girls were calculated. Student's *t* tests and simple regression were used to compare these means by sex. Furthermore, mean intakes from the ten food groups, stratified by sex and age groups (2–< 6 years and 6–< 10 years) were calculated, and again, Student's *t* tests and simple regression were used to compare these means by age groups within sexes. In the analyses performed by country, non-parametric tests were done when data did not meet the assumptions of the parametric test (normally distributed data); in these cases, median and interquartile range were presented and differences of intake by age group were tested by Mann–Whitney *U* test.

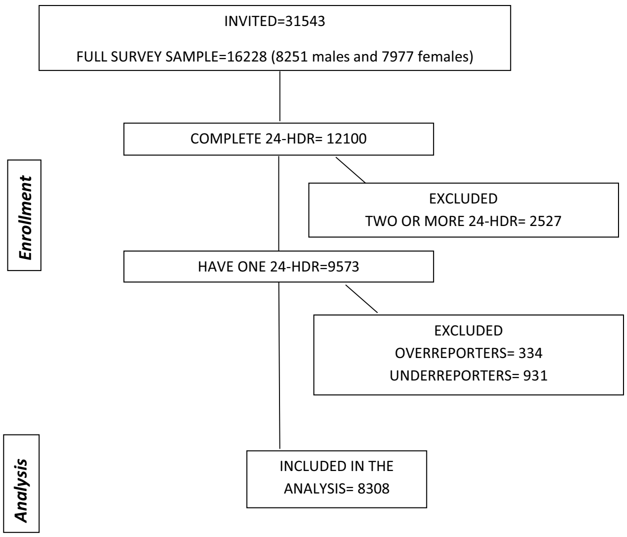

Fig. 1 Flowchart of the participants included in the analysis

The significance level was set to 0.05. The SPSS statistical software package version 18.0 (SPSS Inc., Chicago, IL, USA) was used to conduct all statistical analyses.

Results

The characteristics of the study population and misreports are presented in Table 1. Approximately 20% of the study population was overweight or obese. The study sample included the highest proportion of dietary data from Italy (21.1%) and the lowest from Belgium (4.1%). Misreporting of energy intake was more likely in girls, in the older age group and in overweight or obese children and less likely in the highest educated parental group.

Mean total energy intake was 1720 (SD 477) kcal/d for boys and 1631 (SD 451) kcal/d for girls. Total sugars intake was 98 (SD 52) g/day for boys and 93 (SD 49) g/day for girls. Free sugars intake was 81 (SD 49) g/day for boys and 77 (SD 47) g/day for girls. Girls had significantly ($p<0.001$) lower intakes of energy, carbohydrates, total and free sugars, compared to boys. Total sugars and free sugars intake, expressed as percentage of energy, represent 23% and 18% of energy intake, respectively, with no difference between the sexes (Table 2).

The food groups “Fruit juice”, “Soft drinks”, “Dairy” and “Sweets and candies” each contributed between 26 and 16% to the free sugars intake of the children. While less than 2% came from each of the groups “Vegetables”, “Other sources”, “Nuts and seeds” and “Potatoes” (Table 3).

Mean and standard deviation of the percentage contribution from the selected food groups, to total free sugars intake, in boys and girls, is shown in Fig. 2. The most important contributors were “Fruit juices” and “Soft drinks”.

Table 1 Descriptive characteristics of the study population and of the misrreporters (total numbers and percentages): children aged 2–9 years, IDEFICS study

	Normal reporters		Misreporters	
	n	%	*n*	%
Sex of the child				
Male	4275	51.4	556	44
Female	4033	48.6	709	56
Age group				
2–<6 years	3631	43.7	408	32.2
6–<10 years	4677	56.3	857	67.7
Weight status[a]				
Thin/normal weight	6618	79.6	872	69
Overweight/obese	1690	20.4	393	31
Study center				
Italy	1757	21.1	223	11.3[b]
Estonia	653	7.8	82	11.1
Cyprus	982	11.8	234	19.2
Belgium	345	4.1	47	10.7
Sweden	1166	14	69	5.6
Germany	1558	18.7	273	14.9
Hungary	1259	15.1	298	19.1
Spain	588	7.1	39	6.2
ISCED-level[c]				
Primary education	125	1.5	37	2.9
Lower secondary education	680	8.2	131	10.3
(Upper) secondary education	2993	36	492	38.9
Postsecondary, non-tertiary education	1156	13.9	185	14.6
First stage of tertiary education	3112	37.4	379	30
Not known	242	2.9	41	3.2

[a]Weight categories according to Cole et al

[b]Percentage of misreporting per country

[c]International Standard Classification of Education (ISCED). Maximum of both parents

Table 4 shows the mean daily intake in grams and percentage of daily energy of free sugars provided by different food sources and consumed by boys and girls, stratified by age groups. Free sugars intake was significantly higher in older boys than in younger ones in the group of “Fruit juices”, “Cereals, breads, pies, pizzas and bakery products”, “Vegetables” and “Other sources”, and significantly higher in younger girls than in older ones in the groups of “Dairy” and “Other sources”. Likewise, mean daily intake in grams and percentage of daily energy of free sugars provided by all food sources and consumed by boys and girls, stratified by age groups were analyzed (data not shown) and not significantly differences were found

Table 2 Descriptive analyses of continuous covariables (means and standard deviations): children aged 2–9 years, IDEFICS study

	Per capita[a]			
	All (8308)	Boys (4275)	Girls (4033)	p[b]
Energy (kcal/day)	1677 (467)	1720 (477)	1631 (451)	< 0.001
Total carbohydrates (g/day)	205 (71)	212 (73)	198 (67)	< 0.001
Total sugars (g/day)[c]	96 (51)	98 (52)	93 (49)	< 0.001
Total monosaccharides (g/day)	34 (28)	34 (28)	33 (28)	0.188
Total disaccharides (g/day)	62 (36)	64 (37)	59 (35)	< 0.001
Free sugars (g/day)	79 (48)	81 (49)	77 (47)	0.001
Energy from total sugars (%)	23 (10)	23 (10)	23 (10)	0.729
Energy from free sugars (%)	18 (10)	18 (10)	18 (10)	0.731

[a]Per-capita analysis included all respondents with data from 24 h recalls. It represents the mean intake of the population

[b]Sex differences using *t* test for continuous variables

[c]Defined as all monosaccharides plus disaccharides

Table 3 Free sugars provided by the different food sources (mean daily intake) in boys and girls

	Per consumer								
	Number of consumers								
	Boys	Girls	Total g[a]	%[b]	Boys[a]	% of E[c]	Girls	% of E	p[d]
Fruit juices	1671	1437	40.5 (41.5)	25.8	40.6 (41.3)	10 (10.4)	40.5 (41.9)	10.7 (11.8)	0.051
Soft drinks	1618	1513	39.5 (39.4)	25	38.3 (35.4)	9.4 (9.2)	40.8 (43.2)	10.7 (11.7)	< 0.001
Dairy	2526	2332	38.2 (46)	24.2	39.2 (47.8)	9.7 (12)	37.2 (44)	9.8 (11.8)	0.744
Sweets and candies	2750	2537	24.7 (26.2)	15.6	24.9 (27.1)	6.1 (6.5)	24.4 (25.2)	6.3 (6.5)	0.136
Cereals, breads, pies, pizzas and bakery products	3947	3605	14 (16.7)	8.9	14.4 (17.3)	3.5 (4.1)	13.5 (16.1)	3.5 (4.3)	0.826
Coffee, tea, herbal and similar	691	680	6.1 (11.3)	3.9	6.2 (11.4)	1.6 (3.2)	6 (11.2)	1.6 (3.2)	0.953
Vegetables	2170	2199	2.9 (3.5)	1.8	2.9 (3.4)	0.7 (0.9)	3 (3.5)	0.8 (1)	0.015
Other sources	2297	2151	2.5 (2.8)	1.6	2.6 (2.9)	0.7 (0.9)	2.4 (2.7)	0.7 (0.9)	0.460
Nuts and seeds	154	179	1.4 (2.5)	0.6	1.1 (1.5)	0.2 (0.3)	1.6 (3.1)	0.4 (0.8)	0.042
Potatoes	1485	1390	0.9 (0.8)	0.05	0.9 (0.7)	0.2 (0.2)	0.9 (0.8)	0.2 (0.2)	0.429

Per-consumer analyses included only subjects who reported the consumption of food items in the food groups tested

[a]Data are presented as mean daily intake of free sugars in grams and standard deviation

[b]Percentage contribution to total free sugar intake

[c]Free sugars intake as percentage of E (kcal/day)

[d]Student's *t* tests analyses and simple regression were used to compare means of free sugars intake (in % of E) by gender

between younger and older boys and girls, respectively. Similar results were observed in the eight single countries (TS2, supplementary table).

The percentage contribution of free sugars to total daily energy intake, per country, is shown in Fig. 3. Free sugars intake averages 18% of total energy intake, ranging from 13.3% of energy intake in Italy to 27.2% in Germany. Only 19.6% of the studied children met the WHO guideline that recommends a daily intake of free sugars less than 10% of their total energy intake, and only 4.1% of the children met the WHO guideline that recommends a daily intake of free sugars less than 5% of their total energy intake.

Discussion

Our findings provide an overview of the intakes and food sources of total and free sugars of a large sample of European children in 2007/8. In line with other studies, girls in our study had lower intakes of energy, total and free sugars than boys, due to higher total energy intake of boys, but did not differ in terms of percent of energy from total or free sugars. Average intake of free sugars was 18% of energy with a large variation between countries from 13% in Italy to 27% in Germany. Less than 20% of children

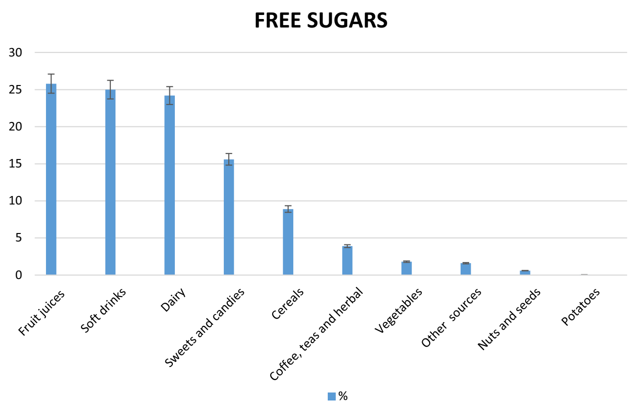

Fig. 2 Mean and standard deviation of the percentage contribution from the selected food groups to total free sugars intake, in boys and girls (per-consumer analyses)

were within the recommended intake of 10% of energy from free sugars. The food groups that contributed substantially to free sugars intakes were "Fruit juices, Soft drinks, Dairy and Sweets and candy".

Although the international dietary guidelines in relation to sugar consumption and oral health refer to a reduction in free sugars, only a few of the national surveys available calculated intakes of free sugars using the WHO definition. In our study, mean free sugars intake was 79 g/day, representing 18% of total energy intake, similar to other studies. This is, current intakes of free sugars from a few national representative dietary surveys across the world have been recently reported. In the UK in 2008–2012, free sugars intake as contribution to total energy intake was 11.8% and 14.7% in the 1.5–3 and 4–10 years age groups, respectively [40]. And, recently, in the UK National survey 2013/2014, intake of free sugars as contribution to total energy intake was 12.2% and 13.4% in the 1.5–3 and 4–10 years age groups, respectively [41]. In The Netherlands in 2007-2010 free sugars intake as contribution to total energy intake was 20.3%, in 7–8 years old children [42]. In Australia in 2011–2012, free sugars intake as contribution to total energy intake ranged from 11.5% (2–3 years) to 13.8% (9–13 years) [43]. In a study in 2013 with Spanish children 9–12 years, free sugars intake represented 9.8% of total energy intake [44].

Because total sugars can be analytically measured in foods, these values are included in most food composition databases and it is relatively straightforward for researchers to report intakes of total sugars based on food intake data. The majority of studies report estimates of total sugars, fewer report intakes of added sugars, or sucrose and even fewer are assessing intakes of free sugars [15]. In our study, total sugar contributed to 23% of energy intake, similar to other studies. The available data in a review of 18 countries across the world suggest that total sugars as a percentage of energy were highest in infants and decreased over the lifespan: for infants (< 4), total sugar intakes expressed as a percentage of total energy (% TE) ranged from 20% for 1-year-olds in Iceland [45] to 38.4% for 4–6-month-olds in the UK [46]. For children aged 4–10 years, total sugar intakes expressed as a percentage of total energy (% TE) ranged from 17% in 3–10-year-olds in Italy [47] to 34.8% for 4–6-year-old girls in the Netherlands [48]. Moreover, in a study in five European countries with children 1–8 years of age, total sugar intake increased from 65 g/day (30.0% of energy intake (*E*%) at 12 months of age to 83 g/day (20.9 *E*%) at 96 months of age [49]. In a recent review of European studies [16], total sugars intake in children ranged between 16 and 26% of total energy intake.

Intakes of added sugars were higher in school-aged children and adolescents compared to younger children or adults [15]. For children aged 4–10 years, intakes of added sugars (% TE) ranged from 9.0% for 5-year-olds in Iceland [44] to 18% for 7–8-year-olds in the Netherlands [48].

Finally, few studies report intake of sucrose as % TE in the group aged 4-10 years, which ranged from 10.0% for 10–12-year-old boys in Austria [50] to 17.0% for 7–8-year-old boys in the Netherlands [48].

The main contributor to free sugars intake in our study was the group of "Fruit juices" followed by "Soft drinks" and "Dairy". Similar findings were observed in other studies. Among children and adolescents from the UK, the highest proportion of free sugars was consumed in the form of sugar-sweetened soft drinks, followed by fruit juices and sugar confectionery. Conversely, breakfast cereals and milk and yogurt provided a low proportion of free sugars [40]. In the recent UK National Survey 2013/2014, the main sources of free sugars in children aged 18 years and under were cereal and cereal products (mainly cakes and biscuits), nonalcoholic beverages (soft drinks and fruit juice), sugar, preserves and confectionery and (in younger children) milk and milk products (sweetened yogurt, fromage frais and other dairy desserts) [41]. In The Netherlands, non-alcoholic beverages, sweets and candies and dairy were the main contributors in children 7–18 years [42]. In Australia, sugar-sweetened beverages accounted for the greatest proportion of the free sugars intake, followed by sugar and sweet spreads and cakes, biscuits, pastries and batter based products [43]. In the Spanish survey, the major contributors to free sugars intake in children were soft drinks, sugar and bakery and pastry items [44]. A reduction of consumption of soft drinks could be important in children not only to achieve the WHO goals for free sugars but for many other reason: a vast number of studies in children and adults have found that reducing sugary drink consumption can lead to better weight control among those who are initially overweight [51].

When non-milk extrinsic sugars or free sugars are considered rather than added sugars, fruit juices became important

Table 4 Free sugars provided by the different food sources (mean daily intake) in boys and girls, stratified by age groups (per-consumer analyses)

	Boys					Girls				
	2–<6 (n=1912)[a]	% of E[b]	6–<10 (n=2363)	% of E	p[c]	2–<6 (n=1719)	% of E	6–<10 (n=2314)	% of E	p
Fruit juices	34.8 (37.5)	9.2 (10.6)	44.6 (43.3)	10.5 (10.2)	0.009	39.2 (42.5)	10.9 (12.1)	41.3 (41.4)	10.6 (11.7)	0.605
Soft drinks	33.8 (32)	8.8 (8.8)	40.9 (37.1)	9.7 (9.5)	0.053	37 (38.3)	10.3 (10.9)	43 (45.6)	11 (12.2)	0.249
Dairy	38.6 (48.3)	10 (12.2)	39.7 (47.5)	9.5 (11.8)	0.265	38.5 (46.8)	10.9 (13.5)	36.3 (41.9)	9.1 (10.5)	0.001
Sweets and candies	22.4 (23.9)	5.8 (6.2)	26.7 (29.1)	6.3 (6.7)	0.067	22.4 (23.2)	6.2 (6.5)	25.7 (26.3)	6.5 (6.5)	0.278
Cereals, breads, pies, pizzas and bakery products	12.7 (14.7)	3.2 (3.7)	15.6 (18.8)	3.7 (4.4)	0.001	12.7 (14.6)	3.5 (4)	14 (16.9)	3.5 (4.4)	0.716
Coffee, tea, herbal and similar	5.7 (10.9)	1.6 (3.1)	6.6 (11.8)	1.8 (3.2)	0.641	4.9 (10)	1.4 (3.1)	6.6 (11.8)	1.7 (3.2)	0.269
Vegetables	2.5 (2.8)	0.7 (0.8)	3.2 (3.8)	0.8 (1)	0.001	2.7 (2.9)	0.8 (0.8)	3.2 (3.8)	0.8 (1)	0.233
Other sources	2.7 (3.2)	0.7 (0.8)	3.2 (3.7)	0.8 (0.9)	0.046	3 (3.7)	0.8 (1)	2.7 (3.3)	0.7 (0.8)	0.001
Nuts and seeds	1 (1.4)	0.2 (0.3)	1.2 (1.5)	0.3 (0.3)	0.542	1.2 (2.1)	0.4 (0.7)	1.8 (3.5)	0.4 (0.9)	0.723
Potatoes	0.8 (0.7)	0.2 (0.2)	1 (0.8)	0.2 (0.2)	0.053	0.8 (0.7)	0.2 (0.2)	0.9 (0.9)	0.2 (0.2)	0.064

Per-consumer analyses included only subjects who reported the consumption of food items in the food groups tested

[a]Data are presented as mean daily intake of free sugars in grams and standard deviation

[b]Free sugars intake as percentage of E (kcal/day)

[c]Student's t tests and simple regression analyses were used to compare means of free sugars intake (in % of E) by age group in boys and girls, separately

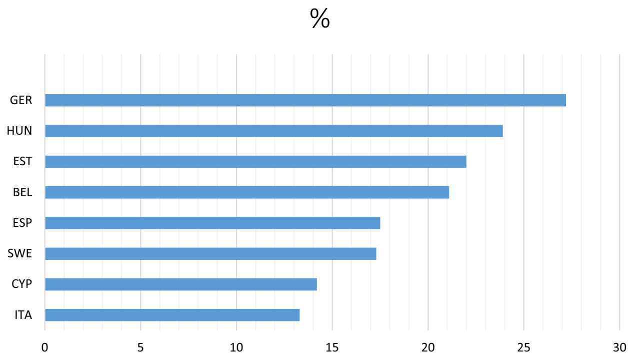

Fig. 3 Mean percentage contribution of free sugars to total daily energy intake, per country

contributors, which translated into a higher overall contribution of beverages in the UK, as in our study [16].

Adherence to the WHO free sugars guidelines of < 5% TE and < 10% TE is generally low in the reviewed studies, particularly in children. In our study, mean free sugars intake represents 18% of total energy intake, far from the recommended < 5% TE and < 10% TE. The eight studied countries exceeded the cut-off WHO's recommendations. Only 19.6% of the studied children met the < 10% cut-off WHO's recommendation, and only 4.1% of the children met the < 5% cut-off WHO's recommendation.

Limitations and strengths

A limitation of the present study concerns the dietary assessment method used, that is, the computer-assisted 24-HDR. SACINA has for example the limitations, that the reporting of foods and portion size is dependent on the (proxy) respondent's memory and ability to correctly assess the amounts of foods consumed—as other 24-HDR methods in children. In order to overcome some of these difficulties, SACINA uses photographs of serving sizes, standard portions, customary packing sizes and foods in pieces or slices to help the respondent to estimate portion size. However, inaccuracy of portion size estimation cannot be entirely ruled out and may have led to misreports of energy intake in the survey sample.

One important factor limiting completeness of food reporting in our study was the consumption of foods without parental control, such as meals and beverages consumed in school and/or pre-school. The collection of dietary information by observation using trained personnel during school time for the day prior to the 24-HDR helped to overcome the problem of incomplete recalls. The validity of proxy-reported energy intake from the 24-HDR was tested however using the doubly labeled water technique. The instrument was found to be valid to assess energy intake at the group level [24].

The present analysis is based on one 24-HDR per child, which is a limitation, as a single day may not reflect the individual usual intake due to the daily variation in diet. However, single 24-HDR are considered as a valid tool for the estimation of large population means [52].

The main proportion of 24-HDRs was collected on workdays. Children and adolescents tend to consume more sugar-rich foods and beverages during weekends compared with workdays [53]. This fact may have led to a certain underestimation of the present data.

A particular strength of our study is the large sample size, the geographical spread over eight European countries. The data were obtained using highly standardized and validated procedures; for example, all countries used SACINA as a standardized method of dietary assessment, which makes the intakes of children across the different countries comparable. Data were obtained using the same food composition database (BLS), and therefore, it was possible to specify intakes of free sugars (that is, all different types of sugars, besides mono- and disaccharides) for the international sample of children in the present study. Due to the assessment of free sugars, they could be compared with the recommendations of > 10% and > 5% of total daily energy limitations from free sugars by the WHO.

24-HDRs with missing meals and incomplete ones were excluded from the study. Moreover, the exclusion of underreporters, identified using the Goldberg cut-offs as described elsewhere [35, 36], improved the quality of the data, although the exclusion can be a limitation and might have induced selection bias since the misreporters might have a special food choice or eating behavior.

Conclusion

This study provides important information about free sugars intake in European children. Data confirm that the 18% contribution of free sugars to total energy intake is higher than the recommended 10% and point to a broad variety in foods providing free sugars. The main food contributor to free sugars are beverages such as "Fruit juices" and "Soft drinks".

The results suggest that it is especially important to reduce children's intake of free sugars to reach the recommendations, focusing in target population on certain foods and food groups.

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Compliance with ethical standards

Conflict of interest The authors have declared that no competing interests exist. The content of this article reflects only the author's views and the European Commission is not liable for any use that may be made of the information contained herein.

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