Sugar consumption and caries experience in 12- and 13-year-old Icelandic children

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Bjarnason S, Finnbogason SY, Norén JG. Sugar consumption and caries experience in 12- and 13-year-old Icelandic children. Acta Odontol Scand 1989;47:315–321. Oslo. ISSN 0001-6357.

Dietary habits with regard to sugar consumption and caries experience were studied in a group of 275 Icelandic children aged 12 and 13 years. The pattern of meals and sugar-containing food intake frequency were assessed by means of a dietary questionnaire. All dental examinations were performed by one examiner, using standardized methods and diagnostic criteria. Only 75% of the children had three regular meals daily. Breakfast and lunch were the most frequently omitted meals. Sweet buns were consumed by 32% of the children with meals and by 58% between meals, whereas soft drinks were consumed by 42% and 46%, respectively. Eighty-three per cent of the children reported eating sweets daily. The most popular products included confectionery, buns, cakes, and soft drinks, which constituted 53% of the intake with meals and 68% of that between meals. A higher caries incidence was associated with frequent intake of buns and cakes with meals and confectionery. □ *Dental caries; diet, cariogenic; dietary habits; soft drinks; sweets*

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Numerous observations have implicated dietary sugars as a major contributing factor in the etiology of dental caries (1). Populations consuming diets with a high sugar content generally have an increased caries prevalence—the per capita sugar supplies and DMFT indices show positive correlations in nations throughout the world (2).

In Iceland dental caries was virtually unknown until the 19th century, when the local diet, consisting predominantly of meat, fish, and milk products, underwent a rapid change with increasing cereal and sugar imports. Sugar availability has steadily increased, and since the 1950s, the Icelandic population has been among the heaviest sugar consumers in the world, with the current annual per capita supply of manufactured sugar exceeding 55 kg (3). Meanwhile, dental caries, especially among children, have reached one of the highest levels reported internationally. The decline in caries prevalence occurring in other countries has so far not been observed in Iceland, despite decades of free dental care and general acceptance of fluoride dentifrices (4).

The National Nutrition Survey, performed in Iceland in 1979–1980 (5), showed that children of school age constitute the group of highest sugar consumers. Their dietary habits from the perspective of dental health have not been investigated.

The purpose of this study was to describe sugar consumption and caries experience in Icelandic urban schoolchildren.

Materials and methods

In 1984 a comprehensive study of dental health in 11- and 12-year-old Icelandic children was conducted in Reykjavik (6). A year later 275 children were randomly selected from this material to participate in the present study.

The intake frequency of popular sugar (predominantly sucrose)-containing food was assessed by means of a dietary questionnaire. The selection of sugar-containing

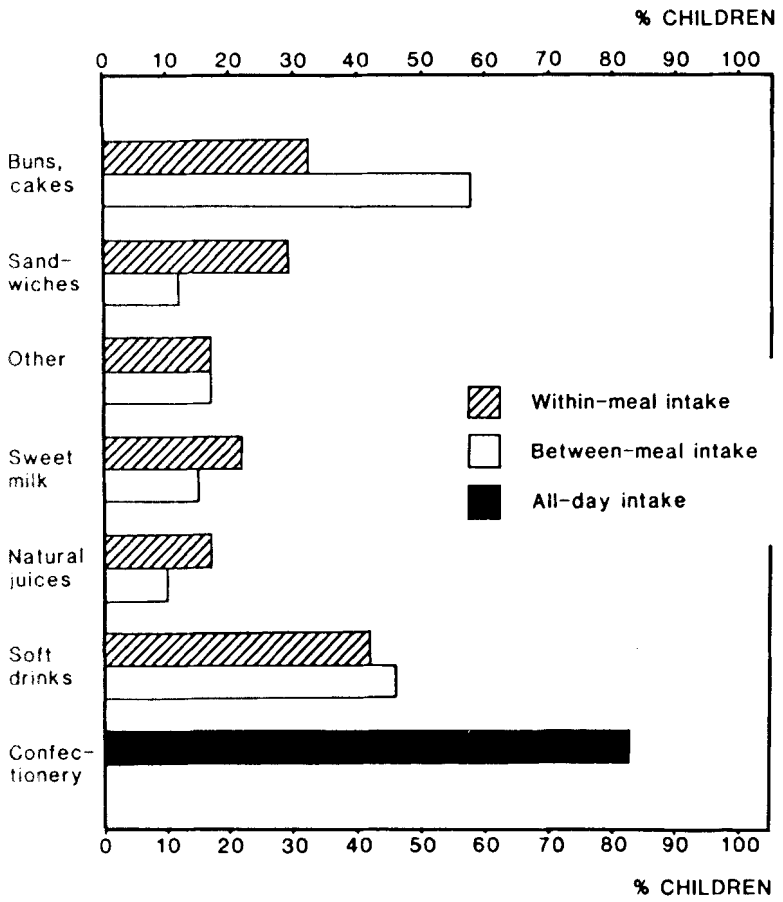

Fig. 1. Distribution of children in accordance with consumption of sugar-containing products with and between meals.

products was based primarily on the data from The National Nutrition Survey. The questionnaire was developed in collaboration with the group of children and school personnel. Only the most frequently consumed products were selected and specified, whereas non-specified products were listed as 'other'. The intake frequency was estimated by counting the number of items consumed during the previous day. Answers were categorized into intervals of once, twice, and three or more times per day. Breakfast, lunch, and dinner were defined as the main meals solely on the basis of the time of consumption and no specification about the content was made. The confectionery intake was recorded independent of meals; all other intakes were recorded separately as being with or between meals.

The questionnaires, identified only by a code number, were answered by the children during school hours and collected anonymously after completion. Each child answered the questionnaire only once. On the average, 10 questionnaires were collected daily through February and March, yielding dietary information about all weekdays except for Friday and Saturday over a 2-month period.

All dental examinations were performed by the same examiner, in accordance with previously described criteria (6). Relationships between 1-year incidence of initial (DF_i), manifest (DFS), and total (DFS_{tot})

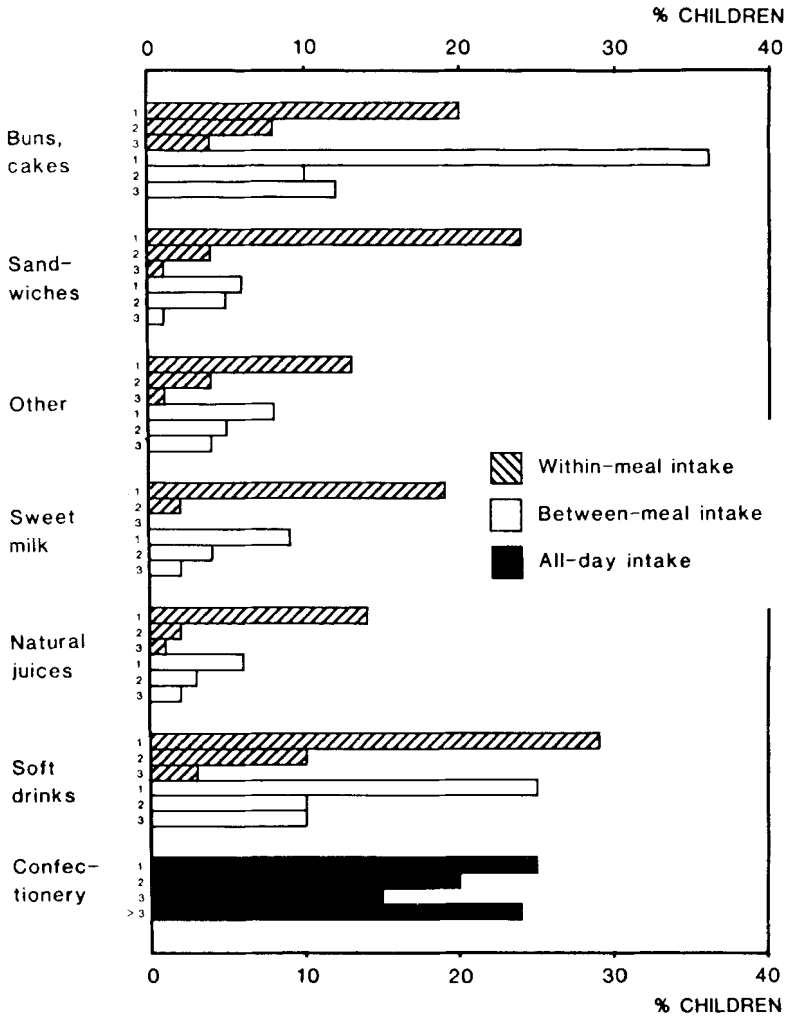

Fig. 2. Distribution of children in accordance with frequency of daily consumption of sugar-containing products.

caries scores and dietary variables were studied by means of multiple linear regression analyses. Mean aggregate data of caries indices and dietary variables were used to test the differences between the sexes and the two age groups by Student's t test. The level for statistical significance was set at 5%.

Results

Two hundred and sixty-three complete questionnaires were available for statistical analysis. Seventy-five per cent of the children reported having three regular meals daily; among them, 87% had breakfast, 90% lunch, and 95% dinner. The average number of meals consumed at regular mealtimes was 2.7 per day for both sexes. The 13-year-olds omitted lunch more frequently than the 12-year-olds ($p < 0.05$), whereas no differences were found between the two age groups with regard to breakfast and dinner.

The percentage of children consuming various listed sugar-containing products daily is presented in Fig. 1. The distribution was similar in both sexes and age groups, except for the consumption of confectionery

Table 1. The mean frequencies of daily intake from each food category

	With-meal intake				Between-meal intake			
	Boys		Girls		Boys		Girls	
Food category	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Buns, cakes*	0.6	1.0	0.4	0.1	1.3	1.6	0.8	1.1
Sandwiches†	0.4	0.7	0.3	0.5	0.2	0.6	0.2	0.6
Other	0.3	0.6	0.2	0.5	0.4	0.9	0.3	0.7
Sweetened milk	0.2	0.4	0.2	0.6	0.2	0.6	0.2	0.6
Juices	0.2	0.5	0.2	0.4	0.2	0.6	0.1	0.5
Soft drinks	0.7	0.9	0.5	0.8	1.0	1.4	0.7	1.0
	All-day intakes							
Confectionery‡	2.7	3.3	2.6	2.4				

* Large sugared cakes and biscuits and heavily iced buns.
† Sandwiches with sweet dressing.
‡ Including sugar-based chewing gum.

among 13-year-olds: 91% of the girls reported eating sweets daily, compared with 67% of the boys. The percentage of daily sweet consumers among 12-year-olds was equal for both sexes (86%).

Fig. 2 shows the distribution of children in accordance with intake frequency for each food category.

Apart from confectionery the most popular products both with and between meals were buns, cakes, and soft drinks (Table 1). On the average boys appeared to consume nearly all items more often than girls; the difference reached statistical significance with regard to sweet sandwiches with meals and buns, cakes, and soft drinks between meals ($p < 0.05$). The mean frequency of intake was similar in the two age groups. When the sexes were examined separately, 12-year-old boys proved to be more frequent consumers than 13-year-old boys of confectionery ($p < 0.05$), buns, and cakes with meals ($p < 0.05$) and sweet sandwiches between meals ($p = 0.01$). No differences were observed among the girls.

Fig. 3 shows the contribution from each food category to the total daily intake of high-sugar products. The highest contributors, buns and cakes together with soft drinks, constituted 53% of all intake during mealtimes and 68% between meals.

The total DFS score was higher among girls by 1.3 surfaces at the base-line examination. The incidence of manifest caries lesions (DFS) was similar in both sexes. However, boys showed a tendency to develop more new initial lesions (DS_i) (Table 2). The variation within the groups was considerable, and none of the differences achieved statistical significance.

The higher incidence of DS_i and DFS_{tot} was associated with frequent intakes of buns and cakes with meals ($p < 0.01$ and < 0.05, respectively) and of confectionery ($p < 0.05$). The boys who had lunch developed fewer new DS_i and DFS than boys who missed lunch ($p < 0.05$). No such associations were observed among girls. No other significant relationships were found between the dietary variables and the caries incidence.

Discussion

Detailed knowledge about the caries-promoting dietary habits and the main sources of sugar in the target population is necessary to formulate meaningful dietary advice. Collaboration with study participants in the development of questionnaires afforded the advantage of concentrating on the most popular products. Thus, while the true sugar intake cannot be calculated, the present study provides gross but relevant infor-

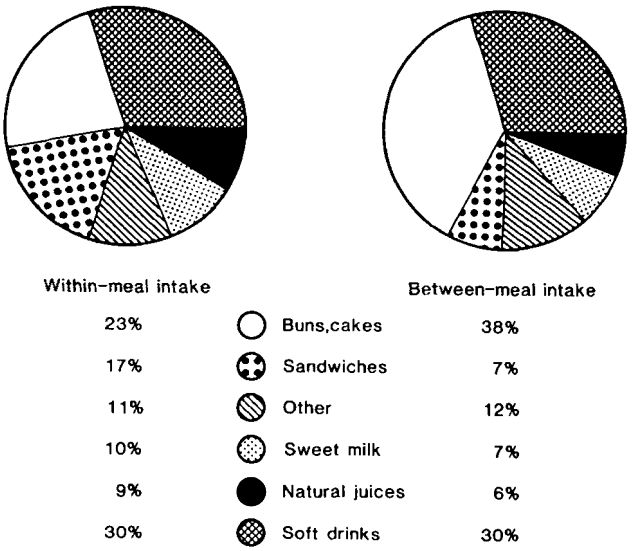

Fig. 3. Percentage of daily intake of various sugar-containing products with and between meals.

mation about the dietary practices with regard to sugar consumption in Icelandic children.

As can be seen from the results, 25% of the children did not have all three main meals daily, 13% of them starting their school day without breakfast. In addition, the relatively large proportion of children having buns, cakes, and soft drinks at mealtimes suggests that snacks to some extent have been substituted for regular meals. Sweet drinks appear to be used routinely with regular meals by the majority (Fig. 1). These observations indicate that the generally recognized pattern of sugar consumption being mostly confined to between-meal snacks (7, 8) is not necessarily valid for Icelandic children. The positive relationship found between mealtime intake of sweet products and caries rate further supports this assumption. A striking finding was the frequent consumption of sweets by a much larger proportion of children than reported from similar investigations in other Nordic countries (9–11).

Buns, cakes, and soft drinks contributed most to the daily intake of high-sugar products and together with confectionery should be considered a major source of excessive

Table 2. Mean number of DS_i*, DFS and DFS_{tot}† at the base-line examination and 1-year caries incidence

	Base line						1-year incidence					
	DS_i		DFS		DFS_{tot}		DS_i		DFS		DFS_{tot}	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Boys	13.1	10.8	9.3	7.3	22.5	16.5	2.4	7.7	2.4	4.4	4.8	8.6
Girls	13.5	9.9	10.3	6.3	23.8	15.0	1.7	6.8	2.4	3.3	4.0	7.4

* DS_i = initial lesions.
† DFS_{tot} = the sum of initial and manifest lesions.

sugar in the diets of children in Iceland, where up to 25% of the total caloric intake is derived from manufactured sugar, mainly sucrose (12).

The tendency towards more frequent ingestion of sugar by boys is in accordance with reports from The Nutrition Survey (Ref. 5), which showed that the considerably higher energy consumption by 11- to 14-year-old boys (2700 kcal) in comparison with girls (2190 kcal) was mostly due to their higher carbohydrate, specifically sugar, intake. This dietary pattern appears to be reflected in the caries development. The boys, having lower caries prevalence at the start of the study, showed similar incidence of DFS and surpassed the girls concerning new initial lesions.

The association between caries-promoting dietary factors and caries has been established in numerous investigations using case-control methods in which only high- and low-caries individuals were studied (13–17). The relationship was less evident or absent in studies in which the material was representative of the normal population (7, 8, 18–22). It is therefore particularly noteworthy that the high overall sugar consumption and great inter-individual variability of sugar intake frequency did not obscure the assocations between several dietary factors and the caries rate among Icelandic children.

This study was performed with emphasis on the intake of a rather limited range of sucrose-containing products. The exposure to other sugars known to be implicated in caries etiology and the intake of products containing 'hidden' sugars were not recorded. Although the ability of 12- and 13-year-old children to recall their previous day's food consumption is fairly accurate (23, 24), short questionnaires appear to underestimate sugar intake (25). The fact that dietary information was obtained in connection with dental examination might have further biased the validity of the dietary data, as the relation between dental caries and sugar consumption is common knowledge. However, while assessment of the magnitude of the bias is not possible, its direction is certainly towards less frequent and lower intakes. Thus the collected data presumably represent only a fraction of the true exposure to sugars.

Notwithstanding these limitations, this study supports the findings of The Nutrition Survey about refined carbohydrates being overrepresented in the diets of Icelandic schoolchildren. Furthermore, the intake of highly adhesive products, such as sweets and iced buns, is most frequent and associated with an increased caries rate. Whereas sugar consumption alone cannot account for the continually high caries experience, the present study shows that dietary habits of Icelandic urban children are detrimental to their dental health and should be considered a major contributing factor to the rapid caries development in a large fraction of the population.

Acknowledgements.—This study was supported by grants from The Icelandic Science Foundation, The Faculty of Odontology, University of Göteborg and The Swedish Dental Society.

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Received for publication 24 February 1988