ORIGINAL ARTICLE

International Dental Journal 2011; 61: 247–251

doi: 10.1111/j.1875-595X.2011.00067.x

Patterns in consumption of potentially erosive beverages among adolescent school children in the Netherlands

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Aim: To determine the frequency of intake and patterns in consumption of potentially erosive beverages in school children in the Netherlands. **Methods:** A cross-sectional, single centre study was performed among 502 school children in Rotterdam, in age varying between 12 and 19 years. Data on consumption of soft drinks, energy drinks, sports drinks and alcopops were obtained through a self-reported questionnaire. Gender- and age-related differences in consumption were analysed with Chi-square, Kruskal–Wallis and Mann–Whitney tests. Associations between variables were investigated with Chi-square tests and Spearman's rank order correlation analysis. **Results:** Boys consumed soft drinks, energy drinks and sports drinks more frequently than girls, and on average also consumed higher amounts of these drinks. No gender-related differences were observed in alcopop consumption. Consumption of all drinks was most frequent at 14- or 15-year of age, with the exception of alcopops which was most frequent by 16-year-old school children. Significant positive associations were observed between the consumption of soft drinks, energy drinks and/or sports drinks. Alcopop consumption was only associated with consumption of energy drinks. **Conclusion:** Consumption of soft drinks, energy drinks, sports drinks and alcopops by school children is related to age and gender. The significant positive associations between the consumption of these drinks suggest that a subgroup of school children exists with a high cumulative intake of these potentially erosive drinks.

Key words: *Dental erosion, consumption patterns, soft drink, energy drink, sports drink*

Dental erosion is the loss of dental hard tissue that is chemically etched away from the tooth surface by acid without bacterial involvement.[1] In Europe, the prevalence of dental erosion is high among children and adolescents, and the incidence seems to be increasing.[2–5] Consumption of acidic beverages is considered an important factor involved in the aetiology. Cola-type and other soft drinks contain high levels of phosphoric, citric or other acids, resulting in pH values below 4.0.[6] Similar pH values are frequently observed in sports drinks and energy drinks, due to high levels of citric acid.[7,8]

During the last two decades, *in vitro* experiments have clearly proved the erosive potential of soft drinks, sports drinks and energy drinks.[9–14] Although increasing the length or frequency of exposure to acidic drinks resulted in increased erosion *in vitro*, the effect was not proportional.[15–18] Several observational studies support an association between soft drink consumption and the incidence or severity of dental erosion.[19–27] However, many other studies failed to find a significant relationship.[3,5,28–32] Cross-sectional observational studies and a case control study also failed to show a relationship between sports drinks use and dental erosion.[28,31,33,34] In a case control study, however, a significant increased risk of erosion was found when sports drinks were consumed weekly.[23] Studies investigating the relationship between the consumption of energy drinks and dental erosion seem to be lacking in the scientific literature.

The observation that many studies fail to demonstrate a relationship between dental erosion and consumption of acidic beverages indicate that focussing on a single type of drink may be too simplistic.[7] Studies may have been affected by positive or negative associations between the consumption of soft drinks, sports drinks and energy drinks.[32] Therefore, the aim of the present study was to investigate whether a relationship exists in the amount of these acidic beverages consumed by adolescent school children per week. In addition, age- and gender related differences in consumption of these potentially erosive beverages were investigated.

MATERIALS AND METHODS

A cross-sectional, single centre study was conducted at a public high school in Rotterdam. All children of the school were invited to participate, with the exception of the graduating classes to avoid disturbing them in their preparations for their final examinations. This resulted in a study group of 502 children (12–19-year-olds) with a multi cultural background. This study was performed according to the guidelines of the Medical Ethical Committee of the Vrije Universiteit (Amsterdam, the Netherlands) and approval for the study was obtained from the board of the school.

A questionnaire was developed to determine the consumption of different types of beverages and focused on the consumption of soft drinks, sport drinks, energy drinks and alcopops. To clarify these types of drinks to the participants, three examples of each type of drink were mentioned. The consumption of the beverages was recorded as the number of cans consumed during the previous week. Additional questions asked about the brand(s) used, age and gender. The questionnaire was administered anonymously at school, but the children were supervised whilst completing it to ensure that they did not discuss the questions with each other. Due to the fact that some children did not disclose their age or gender, the total number of respondents differs between analyses.

The statistical analysis was performed using the statistical software package SPSS version 15.0.1 (SPSS Inc., Chicago, USA). Age and gender-related differences in consumption pattern and number of cans consumed were investigated with Chi-square tests, Kruskal–Wallis tests and Mann–Whitney tests. The association between consumption of different type of drinks was explored with Chi-square tests and Spearman's correlation coefficients. All levels of significance were set at $P < 0.05$.

RESULTS

The data in *Table 1* show that the majority of the school children in the study group consumed soft drinks during the previous week (85.2%). Sports drinks and energy drinks were less frequently used (44.7% and 39.4%, respectively) and only a minority of the school children reported the consumption of alcopops (12.8%). For the total study group, the mean number of drinks consumed showed a similar trend with 4.8 units of soft drinks, 1.7 units of energy drinks, 1.1 units of sports drinks and 0.4 units of alcopops.

Boys and girls were equally represented in the study group (49.5% and 50.5%, respectively). When stratified according to gender, boys reported more frequently the use of soft drinks, energy drinks and sports drinks than girls (*Table 2*). On average, boys also consumed significantly higher amounts of each of these drinks. When the analyses were limited to the school children that reported use of a specific drink ('users'), the amount consumed by boys remained significantly higher for both soft drinks and sports drinks (*Table 2*).

Tables 3 and *4* show the age-related differences in the consumption of the investigated drinks. Consumption of soft drinks, energy drinks and sports drinks was most

Table 1 Percentage of school children reporting consumption of soft drinks, energy drinks, sports drinks and alcopops in the previous week, number of cans consumed by the total study group and number of cans consumed by those children reporting use in the previous week

	Use previous week (%)	Number of cans (mean ± SD)	
		Total	Users
Soft drinks	85.2% (*n* = 500)	4.8 ± 6.3 (*n* = 491)	5.6 ± 6.5 (*n* = 417)
Energy drinks	39.4% (*n* = 500)	1.7 ± 3.7 (*n* = 499)	4.1 ± 4.8 (*n* = 196)
Sports drinks	44.7% (*n* = 499)	1.1 ± 2.0 (*n* = 495)	2.4 ± 2.0 (*n* = 218)
Alcopops	12.8% (*n* = 501)	0.4 ± 1.7 (*n* = 500)	3.3 ± 3.8 (*n* = 63)

Table 2 Percentage of school children reporting consumption of soft drinks, energy drinks, sports drinks and alcopops last week, number of cans consumed by the total study group and number of cans consumed by those children reporting use the previous week, all stratified according to gender

	Use previous Week (%)		Number of cans (mean ± SD)			
	Male	Female	Total group		Users	
			Male	Female	Male	Female
Soft drinks	91.5% (*n* = 185)	80.2%† (*n* = 189)	6.1 ± 7.6 (*n* = 185)	3.5 ± 4.7** (*n* = 189)	6.7 ± 7.7 (*n* = 169)	4.3 ± 4.9** (*n* = 151)
Energy drinks	45.7% (*n* = 188)	32.3%* (*n* = 191)	2.0 ± 3.7 (*n* = 188)	1.0 ± 2.3¶ (*n* = 191)	4.3 ± 4.5 (*n* = 86)	3.2 ± 3.2 (*n* = 61)
Sports drinks	51.8% (*n* = 186)	33.3%† (*n* = 191)	1.4 ± 2.2 (*n* = 186)	0.8 ± 2.0** (*n* = 191)	2.6 ± 2.4 (*n* = 100)	2.3 ± 2.9§ (*n* = 63)
Alcopops	10.1% (*n* = 188)	10.9% (*n* = 192)	0.4 ± 1.8 (*n* = 188)	0.3 ± 1.3 (*n* = 192)	3.7 ± 4.4 (*n* = 19)	2.7 ± 3.0 (*n* = 21)

Chi-square *vs.* male: **P* < 0.01; †*P* < 0.005; ‡*P* < 0.0005. Mann–Whitney *vs.* male: §*P* < 0.05; ¶*P* < 0.005; ***P* < 0.0005.

Table 3 Percentage of school children reporting consumption of soft drinks, energy drinks, sports drinks and alcopops in the previous week, stratified according to age

	≤13 (*n* = 102)	14 (*n* = 86)	15 (*n* = 93–95)	16 (*n* = 89–90)	≥17 years (*n* = 72–76)
Soft drinks*	80.4%	91.9%‡	88.4%	87.8%	77.3%¶
Energy drinks	34.3%	44.2%	41.5%	38.9%	36.8%
Sports drinks†	44.1%	53.5%	53.2%	47.2%	27.6%‡**††‡‡
Alcopops*	4.9%	9.3%	13.7%‡	20.0%§¶	10.5%

Chi-square for age-related differences: $^{*}P < 0.05$; $^{\dagger}P < 0.01$. Chi-square *vs.* 13-year: $^{\ddagger}P < 0.05$, $^{\S}P < 0.005$; *vs.* 14-year: $^{\P}P < 0.05$, $^{**}P < 0.005$; *vs.* 15-year: $^{\dagger\dagger}P < 0.005$; *vs.* 16-year‡‡: $P < 0.05$.

Table 4 Number of cans of soft drinks, energy drinks, sports drinks and alcopops consumed by the total study group and number of cans consumed by those children reporting use in the previous week, stratified according to age

	≤13	14	15	16	≥17 years
Soft drinks					
Total‡	3.3 ± 5.0 (*n* = 102)	5.5 ± 6.1** (*n* = 86)	6.1 ± 6.9** (*n* = 94)	4.5 ± 4.6¶ (*n* = 89)	5.1 ± 9.3§§ (*n* = 72)
Users‡	4.1 ± 5.3 (*n* = 82)	6.0 ± 6.2¶ (*n* = 76)	6.9 ± 7.0** (*n* = 94)	5.1 ± 4.5§ (*n* = 90)	6.6 ± 10.1§ (*n* = 55)
Energy drinks					
Total	1.2 ± 2.5 (*n* = 102)	1.5 ± 2.6 (*n* = 86)	1.4 ± 2.7 (*n* = 94)	1.8 ± 4.0 (*n* = 90)	1.8 ± 4.9 (*n* = 75)
Users	3.4 ± 3.3 (*n* = 35)	3.5 ± 3.4 (*n* = 38)	3.5 ± 3.3 (*n* = 39)	4.7 ± 5.2 (*n* = 35)	4.9 ± 7.3 (*n* = 27)
Sports drinks					
Total†	1.1 ± 2.7 (*n* = 102)	1.4 ± 2.1 (*n* = 86)	1.2 ± 1.7 (*n* = 93)	1.0 ± 1.5 (*n* = 89)	0.7 ± 2.0§‡‡¶¶*** (*n* = 74)
Users	2.6 ± 3.6 (*n* = 45)	2.6 ± 2.2 (*n* = 46)	2.2 ± 1.8 (*n* = 48)	2.1 ± 1.5 (*n* = 42)	2.6 ± 3.4 (*n* = 19)
Alcopops					
Total*	0.4 ± 2.3 (*n* = 102)	0.2 ± 0.6 (*n* = 86)	0.4 ± 1.4§ (*n* = 95)	0.5 ± 1.4¶†† (*n* = 90)	0.4 ± 1.2 (*n* = 76)
Users	7.2 ± 8.7 (*n* = 5)	1.9 ± 1.1 (*n* = 8)	3.0 ± 2.4 (*n* = 13)	2.4 ± 2.4 (*n* = 18)	3.4 ± 1.8 (*n* = 8)

Kruskal–Wallis for age-related differences: $^{*}P < 0.05$; $^{\dagger}P < 0.001$; $^{\ddagger}P < 0.0005$. Chi-square for differences *vs.* 13-year: $^{\S}P < 0.05$, $^{\P}P < 0.005$, $^{**}P < 0.0005$; *vs.* 14-year: $^{\dagger\dagger}P < 0.05$, $^{\ddagger\ddagger}P < 0.0005$; *vs.* 15-year: $^{\S\S}P < 0.05$, $^{\P\P}P < 0.0005$; *vs.* 16-year: $^{***}P < 0.005$.

Table 5 Associations between consumption of soft drinks, energy drinks, sports drinks and, alcopops last week (Chi-square tests)

	Energy drinks	Sports drinks	Alcopops
Soft drinks	*P* < 0.0005 (*n* = 499)	*P* = 0.011 (*n* = 498)	*P* = 0.191 (*n* = 500)
Energy drinks		*P* < 0.0005 (*n* = 498)	*P* < 0.0005 (*n* = 500)
Sports drinks			*P* = 0.113 (*n* = 499)

frequent and the mean consumption was the highest at 14 or 15 years of age, after which it declined. Alcopop consumption was most frequent and highest by 16-year-old school children. The age-related differences in the consumed number of soft drinks remained significantly when the analyses were limited to 'users'. For sports drinks and alcopops, the number of consumptions by 'users' did not show age-related differences (*Table 4*).

Significant associations were observed between the consumption of soft drinks, energy drinks and sports drinks (*Table 5*). Alcopop consumption was associated with consumption of energy drinks but not with the consumption of soft drinks or sports drinks. Significant correlations were also observed between the number of soft drinks, energy drinks and sports drinks consumed in the previous week (*Table 6*). The number of alcopops consumed showed only a significant relation with the consumption of energy drinks.

Table 6 Non-parametric correlations between number of cans of soft drinks, energy drinks, sports drinks and alcopops consumed the previous week (Spearman's rank order correlation coefficients)

	Energy drinks	Sports drinks	Alcopops
Soft drinks	0.344 *P* < 0.0005 (*n* = 489)	0.248 *P* < 0.0005 (*n* = 489)	0.076 *P* = 0.095 (*n* = 491)
Energy drinks		0.189 *P* < 0.0005 (*n* = 493)	0.155 *P* = 0.001 (*n* = 498)
Sports drinks			0.080 *P* = 0.076 (*n* = 494)

DISCUSSION

The results from this study indicate that adolescent school children in the Netherlands have a high level of intake of acidic drinks, particularly soft drinks. Eighty-five percent of the children consumed soft drinks, which is in agreement with other recent surveys among teenagers in Europe and the USA.[19,22,35] The proportion of school children consuming soft drinks was the highest at the age of 14 (*Table 3*). Previously, Dugmore and Rock[22] also reported an increase between the age of 12 and 14 (from 77% to 92%). Compared with soft drinks, the percentages of adolescents reporting consumption of sports drinks and energy drinks are much lower, and similar to previous reports (*Table 1*).[19,36]

Only a minority of school children reported the use of alcopops (*Table 1*). These alcoholic beverages are known to cause erosion.[37] Dutch law prohibits the sale of alcoholic beverages to individuals under the age of 16. This probably explains the increase in consumption of alcopops at the age of 16 (*Table 3*). Although the proportion of children with underage consumption is relatively low, the number of alcopops consumed by underage users is not statistically significant from children of 16 or older (*Table 4*).

Boys more frequently consume soft drinks, energy drinks and sports drinks than do girls, and consume on average higher quantities of these drinks (*Table 2*).[19,24] This higher intake of acidic drinks could explain the significantly higher prevalence of dental erosion in boys than in girls in the Netherlands.[30,38]

Several studies indicate that a minority exists within the population with a disproportionally high intake of soft drinks. Such subgroups have been identified among (pre)schoolchildren in Britain, Norway, Brazil and Kuwait (see[17]). The significant positive associations between consumption of soft drinks, energy drinks and sports drinks in our study (*Tables 5* and *6*) indicate that these subgroups of school children not only have a high intake of soft drinks, but consume other types of acidic beverages more frequent as well. Consequently their teeth are very frequently subjected to attacks by acid.

The present cross-sectional study has some limitations. In the first place, it was a single centre study performed at a high school which may not be representative of the national population. It is also important to consider the reliability of self-reporting dietary habits with the possibility of under- or over-reporting. Furthermore, due to the cross-sectional nature of the study, seasonal changes in consumption pattern may have affected the results.[39]

The erosive potential of acidic beverages *in vivo* will also depend on the way in which they are consumed. For example it has been suggested that drinking through a straw may reduce the risk of developing erosion.[40] The method of drinking was not explored in the present study, neither did we distinguish between the consumption of regular and diet drinks. *In vitro*, diet cola beverages were less erosive than the sugar-containing versions.[13,41] Consumption of sugar-containing versions would have a higher risk of dental erosion, but also increase the risk of developing caries and obesity. Taken together, these limitations indicate the need for longitudinal studies on the consumption of potentially erosive beverages by school children.

In summary, the data from this study indicate that a subgroup of school children exists with a high cumulative intake of potentially erosive drinks. The consumption pattern of erosive beverages is also related to age and gender. This information may be useful when developing dietary advice for the prevention of dental erosion, which is considered a priority area for future research.[42]

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