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Association between soft drink consumption, oral health and some lifestyle factors in Swedish adolescents

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Abstract

Objective. The aim was to investigate the relationship between soft drink consumption, oral health and some lifestyle factors in Swedish adolescents. ***Materials and methods.*** A clinical dental examination and a questionnaire concerning lifestyle factors, including drinking habits, oral hygiene, dietary consumption, physical activity and screen-viewing habits were completed. Three hundred and ninety-two individuals completed the study (13–14 years, $n = 195$; 18–19 years, $n = 197$). The material was divided into high and low carbonated soft drink consumption groups, corresponding to approximately the highest and the lowest one-third of subjects in each age group. Differences between the groups were tested by the Mann-Whitney U-test and logistic regression. ***Results.*** Intake of certain dietary items, tooth brushing, sports activities, meal patterns, screen-viewing behaviors, BMI and parents born outside Sweden differed significantly between high and low consumers in one or both of the two age groups. Dental erosion (both age groups) and DMFT/DMFS (18–19 years group) were significantly higher in the high consumption groups. Logistic regression showed predictive variables for high consumption of carbonated soft drinks to be mainly gender (male), unhealthy dietary habits, lesser physical activity, higher BMI and longer time spent in front of TV/computer. ***Conclusion.*** High soft drink consumption was related to poorer oral health and an unhealthier lifestyle.

Key Words: *dental caries, lifestyle, oral health, soft drinks, tooth erosion*

Introduction

The global increase in carbonated soft drink consumption (SDC) over the past several years is well-recognized. In this regard, consumption by children and adolescents accounts for much of the rise [1–7]. It has also been found that lifestyle changes, of which SDC can be considered one aspect, have the potential to affect both general and oral health [8].

Some studies have found a positive association between SDC and children and adolescents being overweight, while others have not [9–11]. SDC has also been found to be associated with being overweight in combination with the presence of other lifestyle factors, such as screen-viewing habits, less participation in team sports activities and exercise programs [9,12,13]. Furthermore, while SDC and time spent watching TV are correlated, its correlation with habitual computer usage is stronger [5,12,14–16].

A correlation between SDC and oral health, viz. dental erosion [17–21] and dental caries [22–24] has been found in many studies, although there are exceptions [25]. In one study, a history of dental caries in combination with high SDC was found to be related to the presence of dental erosion [26]. Several studies have reported higher SDC among young males compared to females [2,4–6,17,27], as well as a higher prevalence of erosion [28–30]even though contradictory results also have been presented [31].

SDC in adolescents has also been found to be associated with eating behavior, with it being lower in those who take milk, breakfast and cooked meals, but higher in those consuming fast food [2,3,14]. Children with dental erosion have been found to drink less water than children with lesser severity of erosion [32]. In addition, consumption of beverages is influenced by a number of factors such as availability of drinks at home or at school [4,5].

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To our knowledge, there are only a few studies concerning the relationship between SDC, oral health and lifestyle among Swedish adolescents. One study found overweight/obese adolescents and young adults to have more caries than those of normal weight [33] and another study found that adolescents with irregular intake of breakfast had poorer dietary habits and a higher SDC, amongst other lifestyle factors [34].

The aim of this study was to investigate the association between SDC, oral health and some lifestyle factors in Swedish adolescents.

Materials and methods

Patient selection

During the study period (January 12, 2005–December 7, 2007), a total of 1580 children and adolescents aged 5–6, 13–14 and 18–19 years at the Public Dental Health Service in Nora and Storå, County Council of Örebro, Sweden, were scheduled as recall patients. From the recall list in the computerized recall system at the Public Dental Health Service, 801 patients were selected in consecutive order and invited to participate.

At their scheduled recall appointment, a total of 609 children (76%) agreed to participate: 135 were aged 5–6 years, 227 were 13–14 years and 247 were 18–19 years; 51% were males. The 5–6 years group was excluded from the present analysis, while 82 individuals in the 13–14 years and 18–19 years groups were excluded from the analysis because of incomplete responses to the questionnaire. From the 13–14 years ($n = 195$) and 18–19 years ($n = 197$) groups, high and low SCD sub-groups were extracted. The selection of high and low SDC groups were based on a calculated average of the reported present and past carbonated soft drink consumption. The approximate 1/3 highest consumers of the participants were allocated to 'high' and the 1/3 lowest consumers became the 'low' group. This was done for both the 13–14 and 18–19 years groups (13–14 years, $n = 58_{\text{High}}$ and $n = 60_{\text{Low}}$; 18–19 years, $n = 57_{\text{High}}$ and $n = 57_{\text{Low}}$). The 'middle' group as regards amount of SDC consumption was excluded from further analyses.

Methods

The study was based on two parts, a clinical examination and a questionnaire investigation regarding drinking and dietary habits and some lifestyle factors. The questionnaire was divided into two parts, where the first enquiry was filled in by the patient and the second enquiry was supervised and completed at the clinic visit.

Questionnaire

The first part of the questionnaire (self-administered) included questions related to oral hygiene and lifestyle (e.g. diet, general health such as gastroesophageal reflux, physical activity, screen-viewing habits). They were asked to state their body height/weight, whether they had tried to increase or reduce their weight, and if either of their parents were born outside Sweden. As to dietary habits, intake of water, soft drinks, milk, yoghurt, sour milk, cheese, sweets, sour sweets, ice cream, popsicle, biscuits, snacks, dried and fresh fruits, were recorded.

The second part of the questionnaire (examiner supervised) included a detailed examination of beverage consumption and was completed during an interview by a specially-trained dental assistant. All present (within the last 1 year) and past (more than 1 year ago) average weekly consumption of beverages was recorded in detail and re-calculated to yearly intake. Carbonated soft drinks were recorded separately from all soft drinks, which also included juice, still drinks and sport drinks in addition to water, milk, tea and coffee. To facilitate the participants' remembrance of their amount of drink intake, different-sized glasses/cups were shown and they could tell which they used and the amount could be more easily calculated.

Clinical examination

The regular oral health examination followed a routine protocol and was complemented by recording of dental erosion on all buccal and palatal surfaces

Table I. Ordinal scale used for grading severity of dental erosion on buccal and palatal surfaces of maxillary anterior teeth [35].

Grade	Criteria
0	No visible changes, developmental structures remain, macro-morphology intact.
1	Smoothened enamel, developmental structures have totally or partially vanished. Enamel surface is shiny, matt, irregular, 'melted', rounded or flat, macro-morphology generally intact.
2	Enamel surface as described in grade 1. Macro-morphology clearly changed, facetting or concavity formation within the enamel, no dentinal exposure.
3	Enamel surface as described in grades 1 and 2. Macro-morphology greatly changed (close to dentinal exposure of large surfaces) or dentin surface exposed by ≤ 1/3.
4	Enamel surface as described in grades 1, 2 and 3. Dentin surface exposed by > 1/3 or pulp visible through the dentin.

Note: Approximal erosion and presence of 'shoulder' should be recorded.

Table II. Ordinal scale used for grading cuppings on occlusal surfaces of first permanent molars [30].

Grade	Criteria
0	No cupping/intact cusp tip
1	Rounded cusp tip*
2	Cupping ≤1 mm
3	Cupping >1 mm
4	Fused cuppings: at least two cuppings are fused together on the same tooth

*Changed morphology compared to the assumed original anatomy at time of eruption.

Table III. Dichotomization of the independent variables included in the regression analysis for the 13–14 years and 18–19 years group.

13–14 years	
Gender	1 = girl 2 = boy
Sweets	1 = <2 times/week 2 = ≥2 times/week
Chips/cheese doodles	1 = <1 times/week 2 = ≥1 times/week
Soured milk	1 = <1 times/week 2 = ≥1 times/week
Sweetened milk (e.g. O'boy)	1 = <1 times/week 2 = ≥1 times/week
Juice/fruit drinks	1 = <50 L/year 2 = ≥50 L/year
Time in front of TV/computer	1 = 0–5 hours/day 2 = >5 hours/day
Physical activity (game playing)	1 = ≥1 game playing/week 2 = No game playing
Tooth brushing	1 = ≥2 times/day 2 = <2 times/day
Parents birth place (one or both)	1 = Sweden 2 = Outside Sweden
18–19 years	
Gender	1 = girl 2 = boy
Fresh fruit	1 = ≥2 times/week 2 = <2 times/week
Chips/cheese doodles	1 = Seldom or never 2 = ≥1 once/month
Syrup–regular	1 = <once/week 2 = ≥once/week
Soured milk	1 = <1 times/week 2 = ≥1 times/week
Juice/fruit drinks	1 = <50 L/year 2 = ≥50 L/year
Breakfast meals	1 = Every morning 2 = Not every morning
Tooth brushing	1 = ≥2 times/day 2 = <2 times/day
Mouth breathing	1 = No 2 = Yes
Gastroesophageal reflux	1 = Seldom or never 2 = ≥1 once/month
Time in front of TV/computer	1 = 0–5 hours/day 2 = >5 hours/day
BMI	1 = <22.5 2 = ≥22.5

on all six maxillary anterior teeth, grading of occlusal wear/cupping on first permanent molars and plaque accumulation and gingival bleeding.

The grading of dental erosion on maxillary anterior teeth was performed according to Johansson et al. [35] (Table I). A separate scale was constructed and used for recording molar occlusal wear/cupping [30] (Table II). The highest scores from the recordings of maxillary anterior tooth erosion (Table I) and cupping on first molars (Table II) were used to determine the prevalence of erosion according to the Simplified Erosion Partial Recording System (SEPRS) [30]. Intra-examiner concordance in the use of the scales for grading erosion and occlusal wear/cupping was tested by the examiner (AH) performing two successive blind assessments after an interval of 2–6 weeks in 24 patients aged 13–19 years. Intra-examiner concordance in grading of dental erosion, dropout rate and reasons for not attending the examination has been reported elsewhere [30].

Gingival bleeding index (GBI) and visible plaque index (VPI) was recorded dichotomously as 'yes' or 'no', according to Ainamo and Bay [36], for the maxillary anterior teeth. Bitewing radiographs taken within the last 2 years were considered acceptable. Caries visible into dentine was assessed and calculated as decayed, missing and filled teeth (DMFT) and decayed, missing and filled surfaces (DMFS). One examiner (AH) performed all the clinical examinations. Details of the complementary clinical examination performed for the present purposes are described elsewhere [30]. The additional time needed for the extended examination and interview was estimated to be 15 min. The clinical examiner was blinded to all information obtained from the questionnaire.

Ethical considerations

An informed consent form was signed by the participants or by a parent in cases of under-aged children. Approval from the Regional Ethical Review Board in Uppsala, Sweden, was obtained prior to the start of the study. If a diagnosis of erosion was made, the patient was informed about the condition and preventive and/or restorative measures were carried out. Dental treatments for children and adolescents in Sweden are free of charge.

Table IV. Differences in variables related to self-reported dietary habits and other lifestyle factors and clinical findings in high and low consumers of carbonated soft drinks in 13–14 and 18–19 year-old adolescents. *p* denotes the difference between the high and the low consumption groups.

	p	
Variables	13–14 years	18–19 years
Dietary habits		
Higher intake of:		
Sweets	0.002	NS
Chips/cheese doodles	0.001	0.007
Sweetened milk (e.g. O'boy)	0.006	0.001
Syrup–diet	0.020	NS
Syrup–regular	NS	0.033
Coffee–with sugar	NS	0.025
Juice/fruit drinks	0.025	0.003
Lower intake of:		
Fresh fruit	NS	0.001
Soured milk	0.015	0.019
Number of breakfast meals	NS	0.008
Number of school lunch meals	0.044	NS
Other lifestyle factors		
Lower frequency of tooth brushing	0.022	0.005
Longer time in front of TV/computer	0.001	0.001
Lower physical activity	0.029	0.002
Higher BMI	NS	0.003
More mouth breathing	NS	0.018
More gastroesophageal reflux	NS	0.059*
One or both parents borne outside Sweden	0.016	NS
Clinical findings		
Higher GBI	NS	0.018
Higher DMFT	NS	0.015
Higher DMFS	NS	0.008
Higher severity of dental erosion (SEPRS)	0.001	0.013

*Tendency for statistical significance.

Statistical analysis

The yearly SDC (based on the average present and past consumption) was estimated per individual and the material was divided into high and low SDC groups, corresponding to approximately the highest and the lowest one-third of subjects in each age group (13–14 years, $n = 58_{High}$ and $n = 60_{Low}$; 18–19 years, $n = 57_{High}$ and $n = 57_{Low}$). Differences between the groups were tested by the Mann-Whitney U-test; $p < 0.05$ was considered statistically significant.

Logistic regression analyses were performed with high and low SDC as dependent variables. Separate analyses were performed for the 13–14 years and 18–19 years groups, respectively. The following criteria were used for the selection of independent variables: (1) Theoretical relevance; and (2) A selection of variables that differed statistically significantly between groups according to the Mann-Whitney U-test. All independent variables were dichotomized before being entered into the logistic regression models (Table III). Odds ratios (OR) with confidence interval (95%) were calculated for each independent variable. All analyses were performed using IBM SPSS Statistics 21 (IBM Corporation, Armonk, NY).

Results

In the 13–14 years group, the high consumers reported a mean SDC (based on the average present and past consumption) of 72 L/year and the low consumers 8 L/year. Corresponding figures for the 18–19 years group were 167 L/years and 9 L/year, respectively. In both 13–14 years and 18–19 years groups there were significantly more boys than girls in the high SDC groups ($p < 0.01$ and $p < 0.001$, respectively).

Significant differences between the high and low SDC group and in both the 13–14 and 18–19 years olds were found as regards certain dietary items, meal patterns, lifestyle factors and clinical variables (Table IV). No significant difference in VPI was found between the groups.

In the regression analysis, the independent factors gender, higher frequency of consumption of chips and cheese doodles, juice and other still drinks, more time spent in front of TV/computer (screen-viewing habits) and lesser physical activity were significantly associated with high SDC in the 13–14 years group and Nagelkerke's pseudo *R*-squared coefficient of

Table V. Significant independent variables according to logistic regression (Forward Stepwise Conditional Method) in 13–14 year olds. Dependent variable was low (1) or high (2) consumption of carbonated soft drinks. Independent reported variables were dichotomized before being entered in the model.

				95% CI for OR	
	B	*p*	OR	Lower	Upper
Gender (male)	1.3	0.027	3.5	1.2	10.7
Chips/cheese doodles (higher intake)	2.7	0.000	15.2	3.4	69.4
Juice/fruit drinks (higher intake)	1.2	0.043	3.4	1.0	11.2
TV/computer time (longer)	2.2	0.009	8.6	1.7	43.4
Physical activity (lesser)	2.9	0.001	17.6	3.0	102.3

Nagelkerke $R^2 = 0.48$; −2 Log likelihood = 85.129.
B, Regression coefficient; *p*, Significant level; OR, Odds ratios; CI, Confidence interval.

determination was 0.48. The sensitivity and specificity for the five variables were 84% and 71%, respectively, for correct classification into the low or high SDC group. Variables included in the analysis but not entered in the final model were frequency of consumption of sweets, sour milk, sweetened milk drinks, tooth brushing and having parents born abroad (Table V).

Among 18–19 year olds, Nagelkerke's pseudo *R*-squared was 0.59 for the variables gender, higher frequency of consumption of sweetened milk drinks, juice and still drinks, lesser physical activity and higher BMI. The sensitivity and specificity for the five variables were 91% and 73%, respectively, for correct classification into low or high SDC group. The variables consumption of fresh fruit, chips and cheese doodles, soured milk, sugared syrup, frequency of tooth brushing, breakfast habits, existence of reflux or mouth breathing and TV or computer habits were included in the analysis, but were excluded in the final model (Table VI).

The 82 individuals who were excluded from the analysis due to incomplete responses to the self-administered questionnaire did not differ significantly to the responders as regards group belonging (13–14 or 18–19 years group), gender, DMFT/S, severity of dental erosion and GBI. However, both the 13–14 and 18–19 years old non-responders reported significantly higher intake of present and past consumption of carbonated soft drinks ($p = 0.034$ and $p = 0.021$, respectively). The non-responders in the 18–19 years group had significantly higher VPI ($p = 0.016$).

Discussion

In a broader-aged sample of Swedish children and adolescents, it was previously reported that a positive correlation existed between high SDC and increased severity of dental erosion [30] in agreement with other studies [29,37]. The same study also showed gender differences in prevalence of dental erosion and SDC, both being higher in males.

The choice of the two age groups for the present study was made in consideration of their different social and dental developmental stages. Thus, the 5–6 years group was excluded from the analysis because it was deemed more interesting to investigate the lifestyle of adolescents as they move from parental influence into adult life. Statistical analyses were performed separately in the 13–14 years and the 18–19 years groups, since the amount of SDC as well as the clinical parameters such as dental caries and erosion are influenced by age and, therefore, precluded pooled analyses of the two age groups [29,38]. Eighty-two individuals were excluded from the analyses due to incomplete responses to the self-administered questionnaire. The non-responders did not differ from the responders with respect to gender, age and oral health parameters (except for VPI in the 18–19 years group). However, the non-responders were included in the examiner-supervised questionnaire in which the details of SDC were recorded and they reported a significantly higher intake of SDC compared to the responders. This is in agreement with an earlier study of risk behavior regarding soft drink consumption and dental caries [39]. A responder bias can, therefore, not be excluded in regard to the variables retrieved from the self-administered questionnaire, but most likely not in regard to the clinical variables. We applied logistic regression in which only the highest and lowest SDC consumers was included which reduces the risk for bias.

Unhealthier lifestyle, impaired oral health, being male and/or having an immigrant background were predictive of high SDC. Plausible explanations for the higher SDC among male adolescents could be that teenage boys in general have higher food consumption than girls [40] and that boys favor foods of sweet taste more than similarly-aged girls [41]. In addition, it has been reported that teenage girls spend more of their money on items other than food, such as clothing and personal care, compared to boys [42,43].

It was interesting that teenagers with high SDC showed a tendency towards other unhealthy dietary behaviors, such as less frequently having breakfast, school lunch, fruit and yoghurt/sour milk, but more frequently having sweetened milk drinks, salty snacks and sweets, a tendency that is supported by other reports [2,3,34]. Consequently, it can be suggested that when high SDC is detected in an adolescent one should be alerted to the possibility of other generally unhealthy lifestyle behaviors being present.

The clinical variables GBI, DMFT, DMFS and dental erosion were all significantly higher in

Table VI. Significant independent variables according to logistic regression (Forward Stepwise Conditional method) in 18–19 year olds. Dependent variable was low (1) or high (2) consumption of carbonated soft drinks. Independent reported variables were dichotomized before being entered in the model.

				95% CI for OR	
	B	*p*	OR	Lower	Upper
Gender (male)	1.8	0.005	6.2	1.7	22.2
Sweetened milk drinks (higher intake)	2.0	0.003	7.6	2.0	28.7
Juice/fruit drinks (higher intake)	2.4	0.003	11.1	2.3	53.0
Physical activity (lesser)	2.4	0.002	11.4	2.4	54.2
BMI (higher)	2.1	0.002	8.5	2.1	33.5

Nagelkerke $R^2 = 0.59$; −2 Log likelihood = 69.397.
B, Regression coefficient; *p*, Significant level; OR, Odds ratios; CI, Confidence interval.

the 18–19 years high- compared to the low-SDC group, although only dental erosion was so in the 13–14 years group. In addition, both high SDC groups showed a lower frequency of tooth brushing than the low SDC groups. Apart from the well-recognized association between dental erosion/cupping and SDC [17–21,26,30], there have been divergent results regarding caries and SDC. Whereas studies in younger children (4–10 year olds) have shown an association between SDC and caries [24], studies in older children showed no such association [25,44,45]. In this study, the higher GBI, DMFT and DMFS found in the 18–19 years high SDC group may be related to the detrimental behaviors regarding poor diet and oral hygiene.

SDC and sedentary behavior were clearly associated, with the higher SDC groups showing lower physical activity and higher screen-viewing activity than the lower SDC groups. This finding is in accordance with other reports [5,9,12,14–16]. In this regard, the issue of obesity in children and adolescents has been widely studied during recent years, but its association with SDC is still somewhat unclear. In this study, however, there was an association between SDC and Body Mass Index (BMI), with 18–19 year olds with high BMI having 8.5 increased risk (OR) of being a high soft drink consumer. High SDC was, in addition, associated with some other unhealthy habits (Tables IV and V) and the present results are supported by other studies showing an association between higher BMI and/or lower physical activity and more screen-viewing activity and between a combination of higher BMI, screen-viewing and higher SDC [9,12,13]. It is well known that gastric reflux is an etiological factor of importance for the development of dental erosion [19]. In this study, only self-reported symptomatic gastric reflux was investigated and non-symptomatic reflux was, therefore, not taken into consideration. The influence from physical activity on gastroesophageal reflux has been discussed with contradictory opinions [46,47], but this was not investigated in this study. Several authors have reported that parental attitude and habits towards SDC and availability of soft drinks in school and at home affect consumption [3–5,14–16]. Similarly, family attitude towards TV viewing and computer habits also affects SDC, as shown in several studies [5,12,14–16].

On the basis of the above findings, it is not possible to link SDC as the single cause of the growing health problem of obesity in young people. The results from this study should instead be seen as one piece of a larger picture of unhealthy lifestyle behavior. This is demonstrated by the findings in the regression analyses (Tables IV and V), in which a number of different lifestyle factors, as well as BMI, were significantly associated with high SDC. These findings seem to be in line with the tendency of some young people to develop a lifestyle in which high SDC is part of a complex behavioral pattern that includes several interdependent unhealthy factors, which, in turn, is influenced by changing life circumstances that have occurred over the past few decades. One example is the association between more frequent use of fast food restaurants and increasing intake of soft drinks [2,14]. In this regard, the results from this study suggest that recording the amount of SDC could be a tool for detection of a more general unhealthy lifestyle behavior.

In the regression analyses, only reported variables, but none of the clinical findings, were included. The reason was that the clinical parameters could not be considered to be independent of SDC. Specifically, the development of both dental erosion and caries are likely to be positively influenced by high SDC, since most of the drinks seem to include acid and regular sugar and are, therefore, not truly independent. However, the results from the multivariate regression analyses strongly corroborated the findings of the bivariate relationships, while additionally supporting the relationship between high SDC and many different lifestyle-related factors. The explanation factor, measured by Nagelkerke R^2 coefficient of determination based on the significant variables included in the model, was 0.48 and 0.59 for the 13–14 years and 18–19 years group, respectively, which is quite striking. It can also be noted that generally odds ratios were high for the different significant variables in the two models and that the strongest was for physical activity (17.6 and 11.4 for the 13–14 years and 18–19 years groups, respectively). These findings substantiate the foregoing discussion of the broad range of inter-relationships of high soft drink consumption and unhealthy lifestyle that needs to be considered when addressing preventive measures.

Conclusion

High consumption of soft drinks among both younger and older adolescents was related to poorer oral health and an unhealthier lifestyle compared to those with lower consumption. In order to promote a healthier pattern of behavior among adolescents, further investigations on their choice of lifestyle and influencing factors need to be performed.

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