Dental erosion in a group of British 14-year-old school children

Part II: Influence of dietary intake

Y. H. Al-Dlaigan,¹ L. Shaw,² and A. Smith,³

Objectives The aims of the present study were first to investigate the dietary intake pattern of UK teenagers and secondly to determine the relationship, if any, between dental erosion and dietary intake in these children.

Methods The study group consisted of a cluster random sample of 14-year-old school children in Birmingham, UK: 418 children were examined from 12 different schools; 209 were male and 209 female. Data on the rate and frequency of consumption of drinks, foods, and fruits were obtained from a self-reported questionnaire supplemented by a structured interview. The data were analysed using SPSS with Chi-square, and Spearman correlation analysis.

Results Over 80% of the teenagers regularly consumed soft drinks but approximately half of these children had a relatively low weekly consumption. However, 13% and 10% respectively had more than 22 intakes per week of cola and other carbonated drinks. Almost a quarter of these 14-year-olds had alcoholic drinks, with significantly more males than females involved (Chi-square $P < 0.05$). Girls had a greater intake of fruits. Statistically significant correlations were found between the prevalence of erosion and the consumption of soft drinks, carbonated beverages, alcohol drinks, fresh fruits, Vitamin-C tablets and foodstuffs (Spearman correlation analysis $P < 0.05$).

Conclusion It was concluded that consumption particularly of soft drinks was high and common in teenage school children in Birmingham, UK. In addition there was a relationship between dental erosion and acidic dietary intake. Further investigation of the erosive potential of these drinks and foods is required.

The first part of this study considered the potentially increasing problem of dental erosion, its multifactorial nature and its possible relationship with socio-economic group. This second part concerns extrinsic factors that may also influence the prevalence of dental erosion.

Extrinsic sources of acid are many and varied but there were very early reports over 100 years ago that related acidic drinks to dental erosion and the 'wasting of tooth tissue'.^{1, 2} Since the 1950s a number of case reports have been published linking clinically observed erosion with acidic food and drinks.³⁻¹³ However, it was not until comparatively recently that any epidemiological investigations were undertaken to show the prevalence of erosion in the general population.

In 1993 the National Child Dental Health Survey reported that dental erosion is common in children and young adolescents and assumed that it was caused mainly by acid drinks.¹⁴ Some *in vitro* experimental studies have clearly shown the potential erosivity of acidic drinks such as orange juice, cola and sport drinks.¹⁵⁻¹⁸

There is growing evidence of a considerable increase in consumption of potentially erosive foodstuffs and drinks. The United States Department of Agriculture (USDA) Continuing Surveys of Food Intake by Individuals (CSFII) have indicated a dramatic increase in the consumption of soft drinks among US children and adolescents.¹⁹ There has been a concurrent reduction in milk consumption. Harnack *et al.* reported that over 82% of 13-18-year-olds consumed soft drinks on a regular basis.²⁰

In the UK, 1,000 million litres of soft drinks were sold annually in the 1950s, which had increased eightfold by 1990 and still continues to escalate.²¹

There have been significant associations shown between soft drink consumption and dental erosion.^{13,22,23} Johansson *et al.* reported a strong correlation between the presence of dental erosion and a high level of consumption of cola-type and other soft drinks.²² Milosevic *et al.* investigated various aetiological risk factors associated with tooth wear in 15-year-old children and concluded that frequent consumption of carbonated beverages is probably related to tooth wear.²³ However, the contribution of other aspects of the diet and their proportional contribution to the development of erosion in the general population is still unclear.

Therefore, the aims of this study were, first to investigate the dietary intake of acidic foods and drinks in a cluster random sample of teenage children, and secondly to determine the relationship, if any, between dental erosion and acidic dietary consumption.

Materials and methods

A cluster random sample of 14-year-olds was drawn from Birmingham UK. This involved 12 secondary schools covering a complete range of social and ethnic mix. The numbers of children examined in each school differed according to the size of the school, but was approximately the same proportion in each one. A total of 418 children were sampled, 209 were males and 209 were females. They, and their parents/carers gave informed consent to participate in this study and ethical approval was given by the Birmingham Research Ethics Committee. Details of the examination, diagnostic index and reproducibility of diagnosis are given in Part I of this 2-part study.

The questionnaire was developed in relation to the main erosive aetiological factors that have been published in the literature. The purpose of these questions was to determine the amount and frequency of consumption of some common drinks such as orange squash, orange juice, cola, other fizzy drinks, milk, tea, coffee, sport drinks and others. Some types of fruit and food consumption were also included in the questionnaire such as apples, oranges, bananas, tomato ketchup, pickles, yoghurt, and Vitamin-C tablets.

The questionnaire was piloted in three studies carried out in the

¹Research Fellow, ²Senior Lecturer/Honorary Consultant in Paediatric Dentistry, ³Professor of Oral Biology, The University of Birmingham, School of Dentistry, St Chads Queensway, Birmingham B4 6NN

*Correspondence to: L. Shaw
email: L.Shaw@bham.ac.uk

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Department of Children's Dentistry at the University of Birmingham Dental School and Hospital. Following modification of both questions and format it was finally re-tested on another group of 35 teenagers.

The amount of consumption of drinks, food and fruits per week were categorised into the following groups:

- No consumption at all
- Low consumption (1 to 7 times per/week)
- Medium consumption (8 to 21 times per/week)
- High consumption (22 or more times per/week).

The data was collected through a self-reported questionnaire completed by the children at the schools. As there was a wide range of educational attainment, some children required help to undertake this through a structured interview with standardised prompts.

All data were analysed using SPSS with Chi-square and Spearman's rho correlation analysis. Significance was accepted at the $P < 0.05$ level.

Results

A total of 418 children, 209 males and 209 females, were examined clinically and completed the questionnaire. Examiner reproducibility was reported in the first article and showed a very high level of agreement. The prevalence of erosion was also high and is shown in Table 3 and Figures 1 to 3 in Part I.

When the data from the questionnaire were analysed they too showed a high level of intake of acidic dietary components, particu-

Fig. 1 a), b) The rate of consumption of drinks by children per week

Fig. 2 a), b) The rate of consumption of fruits and foods by children per week

larly soft drinks. Figures 1a and 1b give the rate of consumption of drinks per week. The most common drinks were orange squash, cola and other carbonated drinks with 81%, 80% and 76% respectively of the teenagers consuming them at some stage during the week. However, approximately half of the children had a relatively low consumption with between 1 and 7 intakes per week. At the other end of the range, 13% of the children had a high consumption of cola, with more than 22 intakes per week, and 10% had a high intake of other carbonated drinks. Although sport drinks are relatively expensive, 34% of the teenagers did consume them occasionally and 10% of these had a medium to high intake.

Drinks such as milk, tea, coffee and chocolate were less frequently consumed but those children that had milk and tea tended to have appreciable consumption.

All of these teenagers were 14 years old when examined and completing their questionnaire. Although the majority of them (almost 80%) did not consume alcohol-based drinks at all, a significant proportion did and a small minority (3%) consumed beer and cider between 8 and over 21 times per week; 21% and 15% respectively drank some wine or spirits.

Other acidic dietary components are given in Figures 2a and 2b. The most common type of fruit intake was apples, although 14% of these teenagers never consumed fruit at all. Oranges, bananas and grapes were eaten regularly by over two-thirds of the children. Approximately 10% of the children had a medium to high intake of

Fig. 3 Differences between males and females in the consumption of drinks

Table 1. The significant difference between males and females in the consumption of drinks, fruit and foods using Chi-square.

Variable	Significance (Sig)
Cola: Frequency of consumption	P < 0.001
Fizzy drinks: Frequency of consumption	P < 0.01
Cider: Consumption and frequency	P < 0.05
Beer: Consumption and frequency	P < 0.001
Sport drinks: Consumption and frequency	P < 0.001
Apples: Consumption and frequency	P < 0.001
Oranges: Consumption and frequency	P < 0.05
Bananas: Frequency of consumption	P < 0.01
Grapes: Consumption frequency	P < 0.01
Salad dressing: Consumption and frequency	P < 0.01
Vinegar: Consumption and frequency	P < 0.01
Children taking Vitamin-C Tablets	P < 0.02

fruits and regularly consumed over 8 intakes per week, with 2% of the teenagers having more than 22 separate fruit intakes in a week.

Other acidic foodstuffs such as tomato ketchup, salad dressings, pickles and yoghurt formed a regular but low component of most teenager's diets. However, once again a small but important 2% of the teenagers had a very high intake of these acid based products. Analysis showed that those teenagers who had high fruit intake also had a significantly acidic diet from other sources.

The data were also analysed by gender and this is shown pictorially in the histogram of Figure 3 and Table 1. Only the statistically significant differences between males and females in relation to food and drink consumption are shown (Chi-square analysis).

As far as the majority of soft drinks were concerned there were few differences between the genders in total consumption, but more boys had a medium to high level of cola ingestion than girls. It is apparent that the main differences lie in total consumption of sport drinks with 67% of boys and only 33% of girls consuming these regularly. A similar distribution was observed for beer drinking, and of those who drank cider regularly, 59% were boys and 41% were girls. Conversely, significantly more females ate apples, oranges and grapes than boys. They were also more likely to take Vitamin C tablets. The P values of the significant differences between genders in the consumption of drinks, fruits and foods are shown in Table 1.

The relationship between the prevalence of erosion and the dietary intake variables was assessed using Spearman's correlation statistical method. The buccal/labial and palatal/lingual surfaces of teeth were used as dependent variables and questionnaire replies as independent variables. The incisal and occlusal surfaces were

excluded from the analysis to minimise the influence of any tooth surface loss caused by attrition. The results are shown in Table 2a and b. There were highly significant correlations between dental erosion and the frequency of consumption of cola drinks, other carbonated drinks, apple juice, sport drinks and beer. Milk and tea were also found to show some correlation, but this may have reflected a high overall fluid consumption by some individuals. As far as other potentially erosive foods were concerned, it was found that the range and amount of fruit intake were correlated to erosion; apples, oranges, bananas, and grapes were all significant.

Foods such as tomato ketchup and yoghurt showed a correlation with erosion, but others such as salad dressing and pickles failed to reach significance. Even though the numbers were relatively small, children who consistently took Vitamin-C tablets also had significantly more erosion.

Discussion

The current investigation has shown a high intake of acidic dietary components, particularly drinks, in a cluster random sample of 14-year-olds. The most commonly consumed soft drinks were orange squash, cola and other carbonated beverages. Of the 80% of children who drank cola and other fizzy drinks, only 13% and 10% of them respectively had a high consumption rate of over 22 intakes per week for these beverages. An increasing number of teenagers are now having sport drinks (44%) but relatively few in this random sample had a high intake (2%). Many of these soft drinks are regarded as 'empty calories' and concern has been expressed about their high and increasing consumption as far as general nutrition is concerned. However, nutritionalists in general feel that more emphasis should be placed on ingestion of fresh fruit and vegetables. The current study also found that most teenagers did have some intake of fresh fruit, but this was generally low with only approximately 10 to 13% having a medium to high consumption of over 8 times weekly.

Neumark-Sztainer *et al.*²⁴ (1996) analysed dietary data from 36,284 Minnesota adolescents and found that there was a need for

Table 2a The significance values for correlation of erosion (buccal and lingual surfaces) to the questionnaire data using the Spearman correlation analysis

Variable	Significance (Sig)
Orange squash drinks: (consumption)	P < 0.05
Apple juice: (consumption and frequency)	P < 0.001
Orange juice: (consumption)	P < 0.05
Cola drinks: (consumption and frequency)	P < 0.001
Fizzy drinks: (consumption and frequency)	P < 0.001
Milk: (consumption and frequency)	P < 0.05
Tea: (consumption and frequency)	P < 0.001
Coffee: (frequency)	P < 0.05
Spirits: (consumption and frequency)	P < 0.001
Wine: (frequency)	P < 0.05
Beer: (consumption and frequency)	P < 0.05
Sport drinks: (consumption and frequency)	P < 0.001

Table 2b The significance values for correlation of erosion (buccal and lingual surfaces) to the questionnaire data using the Spearman correlation analysis

Variable	Significance (Sig)
Apples: (consumption and frequency)	P < 0.001
Oranges: (consumption and frequency)	P < 0.01
Bananas: (consumption and frequency)	P < 0.001
Grapes: (consumption)	P < 0.05
Vinegar: (consumption frequency)	P < 0.001
Tomato ketchup: (consumption and frequency)	P < 0.001
Yoghurt: (consumption and frequency)	P < 0.001
Vitamin-C Tablets: (consumption and frequency)	P < 0.01

intervention programmes aimed at increasing the consumption of fruits and vegetable among US adolescents. Nicklas *et al.* (1998)²⁵ described an intervention programme involving a media campaign, classroom workshops, school meal modification, and parental support. This was implemented in 12 high schools with a total of 2,213 students. They concluded that dietary habits could be influenced by media messages as long as they were related to the specific age group. It was also noted in another study undertaken in the USA that fruit and vegetable consumption was greater in girls than in boys.²⁶

Alcohol consumption was significantly greater in male teenagers than females, in this Birmingham UK sample; this is in agreement with a USA study of 12–17-year-olds.²⁷ However, the current study showed a higher general consumption rate at 23%, in contrast to the US investigation which reported that 7.7% had already 'binged' on alcohol and 2.7% were heavy drinkers.

Other differences between the genders were noted in higher consumption of cola, fizzy drinks and sport drinks in boys, but in girls there was a higher Vitamin-C tablet and fruit intake.

When correlating the results of the dietary questionnaire with erosion of the bucco-labial and palato-lingual tooth surfaces, there were significant relationships with orange squash, apple and orange juices, cola, other fizzy drinks, beer, wine, and spirits as well as with sport drinks. Direct comparison of these data with other published studies is difficult as they are relatively few in number, some have used different diagnostic indices and most are not random samples. However, Johansson *et al.* reported a strong correlation between the presence of dental erosion and a high level of consumption of cola-type and other soft drinks.²² Milosevic *et al.*^{23,28} in two separate studies, found that frequent consumption of carbonated beverages and sport drinks was associated with tooth wear.

It is not only drink consumption, which was shown to be related to dental erosion in the present investigation. Other acidic dietary components such as fruits and pickles and ketchups were also associated, as was a vegetarian diet in general. This has been noted in subjects living on a raw food diet.²⁹

Thus, the results from this study have indicated that a high consumption of acidic soft drinks is common in teenagers and that there is an association with dental erosion. However, there are also other factors that may be implicated in erosion. Not all teenagers that developed dental erosion had a very high acidic intake and conversely, not all teenagers with highly acidic diets developed extensive tooth surface loss. There may be other modifying factors, for example saliva or intrinsic acid production that may be involved.

Erosion is clearly a 'multi-factorial' disease and further investigation of the relative importance of these factors is required. Nevertheless the clear correlations between diet and erosion observed in the present study provide strong evidence for dietary intervention in developing preventive strategies for dental erosion.

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