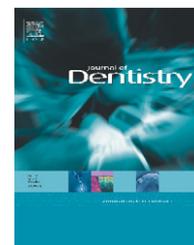


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The association of tooth wear, diet and dietary habits in adults aged 18–30 years old[☆]

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ABSTRACT

Objective: The association of acidic foods and drinks to the development of erosive tooth wear was investigated in a single cohort of adults aged 18–30 years.

Method: A tooth wear index was recorded on 1010 participant's who had a mean age of 21.9 years (SD 0.1) and of which 70% were female and 30% males. Participant's completed a previously validated questionnaire containing 50 questions about current and historical dietary habits. Data were analysed at the tooth level using odds ratio.

Results: Tooth wear was statistically significantly associated to acidic foods and drinks with high titratable acidity and dietary habits, including drinking from a glass and holding drinks, (OR 5 and 6.5 respectively). A history of heartburn was statistically significantly associated to palatal dentine exposure ($p \leq 0.05$ and OR 7.6).

Conclusion: In this sample of adults, tooth wear was associated to a number of acidic dietary products and drinking habits.

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1. Introduction

Data suggest that the prevalence of tooth wear in children and adolescents is common.^{1–5} A previous study, on the prevalence of tooth wear on 1010 adults reported that some degree of tooth wear on enamel was universal and that the percentage of surfaces with dentine exposed was 5.3%.⁶ A systematic review in adults reported that prevalence of tooth wear increases with age but there was insufficient data to indicate whether this increase was a result of specific factors or if it reflected the ageing process.⁷

The role of acidic foods and drinks is probably important to the progression of tooth wear. There is a considerable body of evidence from laboratory studies to indicate that low pH acidic foods and drinks cause erosion of enamel and dentine.^{8–10} However, the clinical evidence is less convincing. Most studies

on children and adolescents support the finding that acidic foods and drinks cause erosive tooth wear^{11,12} but comparatively few have assessed these risk factors in adults.^{12–14} Other recognized risk factors are reported to be gastric acids presenting as regurgitation or vomiting with one small adult study reporting the relationship on 109 adults.¹⁵

There is some disagreement on what term to use for wear on teeth and this varies to some extent upon the interpretation of clinical definitions.¹⁶ In only a few patients a specific causative factor can be identified whereas in most the contribution from erosion, attrition or abrasion is combined to some extent to produce the wear. For this reason the term tooth wear is preferred. The most common method of determining dietary behaviour in large studies is through validated questionnaires. The aim of this study was to investigate known risk factors in tooth wear in a convenience sample of university students in London. The tooth wear data

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has been previously reported. This study presents the results of a questionnaire conducted on each participant and then compared it to the data collected from the tooth wear scores.

2. Methods

A convenience sample of adults, aged 18–30 years old, were recruited by three examiners from a precinct of a University Biomedical campus. Subjects were asked to participate and then taken to a dental chair which was located away from a Dental School to record the prevalence of tooth wear using a modified index (exact tooth wear index). The results of the prevalence and reproducibility of the scoring system have been previously reported⁶ and this paper presents a comparison of the prevalence data to the results from a dietary questionnaire conducted on the same group. Ethical approval was given (CREC/06/07-147 by Kings College London Ethics committee) and written consent obtained from all participants. The new index, based on the Smith and Knight¹⁷ graded wear on the cervical, buccal, incisal/occlusal and palatal/lingual surfaces of each tooth and each tooth was given a score separately for wear on enamel and then on dentine (Table 1). The severity of wear was graded at 5 levels in enamel and 6 in dentine and ranged from zero, less than 10%, less than 1/3rd, 1/3 to 2/3rds, greater than 2/3rds and in dentine only pulpal exposure. Three previously trained and calibrated examiners, using the new index, recorded the tooth wear for all participants under good lighting which followed thorough drying. The data from this study showed that 5.3% of all surfaces had exposed dentine and the reproducibility between the examiners as previously reported was a between K 0.88 and 0.95.⁶

During the same visit as the prevalence study participant's completed a previously validated questionnaire containing 50 questions about current and historical dietary habits.³ Examples of the questions are shown in Table 2. The questions targeted specific dietary acids and targeted the frequency of consumption. The interviewer asked the participant's to answer each question with the appropriate response to each food and drink and the frequency of any medical factors (over 3 times per day, 2–3 times per day, once a day, less than once a day, less than once a week, never). An additional section of questions asked participant's to reflect whether their diet had recently changed over the past 2 months. When the participants expressed doubt or needed further information about a particular question the information was explained in more detail by the researcher. Most questions were based on the Likert's scale¹⁸ with 5 possible responses. In addition, participant's answered questions on frequency and severity of dentine sensitivity measured as an ordinal scale. The questionnaire was designed to be computer readable and all answers from the respondents were collected using this digital system.

2.1. Statistical analysis

Data were analysed at the surface level on enamel and dentine. Each level analysed wear greater than one in enamel since all subjects presented with at least score 1 and 2 in

Table 1 – The exact tooth wear index.

(A) ETW index for enamel:

0	No tooth wear: no loss of enamel characteristics or change in contour
1	Loss of enamel affecting less than 10% of the scored surface
2	Enamel loss affecting between 10% and 1/3 of the scored surface
3	Enamel loss affecting at least 1/3 but less than 2/3 of the scored surface
4	Enamel loss affecting 2/3 or more of the scored surface

(B) ETW index for dentine:

0	No dentinal tooth wear: no loss of dentine
1	Loss of dentine affecting less than 10% of the scored surface
2	Dentine loss affecting between 10% and 1/3 of the scored surface
3	Dentine loss affecting at least 1/3 but less than 2/3 of the scored surface
4	Dentine loss affecting 2/3 or more of the scored surface, no pulpal exposure
5	Exposure of secondary dentine formation or pulpal exposure.

dentine. Data were analysed using Stata version 11.2. For all hypothesis tests significance was pre-determined at $\alpha = 0.05$. Data were analysed using ordered logistic regression (OLR). OLR estimates relationships between an ordinal dependent variable and one or more categorical or continuous explanatory variables. In addition, the odds ratio of the relationships was calculated.

3. Results

The data on the outcome of the prevalence study showed that the 1010 participants had a mean age of 21.9 years (SD 0.1) and of which 70% were female and 30% males.⁶ In brief, the data

Table 2 – Dietary questions (each question was set to record frequency of intake (e.g. over 3 times per day, 2–3 times per day, once a day, less than once a day, less than once a week, never).

Current dietary habits

Fruits (lemons, apples, oranges, grapes, grapefruit, other fruit); Drinks (cola, lemonade, orangeade, orange juice, lemon juice, fruit juice); Other acids (vinegar, pickles, curried food, salad dressing)

Recent change in diet (question asked if drinking or eating specific foods and drinks had changed recently within two months)

Fruits (lemons, apples, oranges, grapes, grapefruit, other fruit); Drinks (cola, lemonade, orangeade, orange juice, lemon juice, fruit juice); Other acids (vinegar, pickles, curried food, salad dressing)

Do you hold or swirl your drinks (yes, no); Do you use a straw? (yes, no)

Medical factors (symptoms of heartburn, vomiting, chest pain, regurgitation)

Clenching or grinding teeth (yes, no); How many times a day do you brush your teeth? Do you have tooth sensitivity yes/no and how frequently?

Table 3 – The associations of wear in enamel and those explanatory factors with *p* values less than 0.05. All other factors were not significantly related.

	Cervical		Buccal		Occlusal/Incisal		Palatal/lingual	
	<i>p</i>	OR	<i>p</i>	OR	<i>p</i>	OR	<i>p</i>	OR
Carbonated drinks	0.2	0.48	0.7	0.9	0.02	0.3	0.01	0.3
Apples	0.9	1.2	0.6	1.2	0.6	0.8	0.6	0.9
Orange juice	0.1	0.2	0.7	0.8	0.8	0.7	0.8	0.9
Grapefruit	0.03	0.07	0.04	0.07	0.8	0.7	1.4	0.5
Lemon juice	0.7	0.6	0.6	1.2	0.01	0.7	0.8	1
Lemons	0.3	0.2	0.2	1.5	0.08	2.3	0.02	0.7
Fruit juice	0.2	0.4	0.7	1.1	0.2	0.6	0.4	1.1
Recent change in orange juice frequency	0.8	0.2	0.001	0.06	0.06	0.2	0.6	0.8
Recent change in orangeade	0.7	0.6	0.3	0.4	0.3	2.5	0.1	1.6
Pickles	0.04	0.05	0.05	0.05	0.05	0.05	0.1	0.1
Heartburn	0.2	0.3	0.02	0.5	0.003	1.0	0.003	0.6
Beer	0.7	0.8	0.5	0.6	0.02	3.4	0.5	0.8
Wine	0.9	0.9	0.03	0.5	0.005	4.1	0.00	0.6
Spirits	0.08	0.9	0.3	0.7	0.3	1.6	0.003	0.6
Drinking from a glass	0.5	1.8	0.004	5	0.9	0.9	0.001	5
Swilling	0.2	0.2	0.1	0.6	0.02	0.2	0.6	0.9

showed a total of 96,960 surfaces were examined, of these 2033 (2.1%) surfaces had more than 25% of the surface restored, with a mean of two surfaces restored per subject. These data showed all subjects had evidence of wear on enamel grade 1 and 20.1% showing a scores >2. Dentine was exposed at score of <grade 1, on 5.3% of surfaces and 7.9% of participant's had at least one tooth surface with dentine exposed. Enamel wear was generalized occurring mostly on the anterior teeth and the first molars. Dentine wear was most frequently observed on the incisal surfaces of the upper and lower incisors.

All participants completed the questionnaire. Table 3 shows the results of analysis at the surface level of teeth in enamel and Table 4 in dentine. The most notable factors for enamel were drinking from a glass on the buccal surface (odd ratio = 5) and beer (od = 3.4) and wine consumption (od = 4.1)

on the occlusal/incisal surfaces. No other associations were detected. For dentine the risk associations, predicted by odds ratios above 1, were observed with dentine with apples (od = 7 and 3.7), orange drinks (od = 1.3), fruit juice and a recent change in orange containing drinks (od = 1.7). In addition, swilling (1.3 and 6.5) and heartburn (od = 7.6) also had statistically significant relationships and odds ratios above 5.

Dentine sensitivity was reported by 586 (58%) of respondents, and of these 115 (11.3%) reported symptoms at least once a day.

4. Discussion

This study reports the results of a questionnaire conducted on a convenience sample of King's College London University

Table 4 – The associations of wear in dentine and those explanatory factors with *p* values less than 0.05. All other factors were not significantly related.

	Cervical		Buccal		Occlusal/Incisal		Palatal/lingual	
	<i>p</i>	OR	<i>p</i>	OR	<i>p</i>	OR	<i>p</i>	OR
Carbonated drinks	0.4	1.7	0.1	0.6	0.2	1.8	0.6	0.9
Apples	0.4	0.8	0.03	7	0.4	1	0.04	3.7
Orange juice	0.8	1.1	0.8	0.9	0.002	1.3	0.9	1
Grapefruit	0.3	0.7	0.9	1	0.7	0.8	0.9	1
Lemon juice	0.5	0.7	0.3	0.7	0.3	0.4	0.9	0.8
Lemons	0.04	0.5	1.9	0.3	0.05	0.8	0.9	0.8
Fruit juice	0.5	0.6	0.1	2.5	0.05	1.3	0.9	0.9
Recent change in orange juice frequency	0.1	1.2	0.2	0.3	0.005	1.7	0.1	0.2
Recent change in orangeade	1	1.4	0.7	0.8	0.04	1.4	1	0.05
Pickles	0.2	2	0.3	0.7	0.6	0.9	0.6	0.7
Heartburn	0.2	0.5	0.9	1	0.6	0.9	0.05	7.6
Beer	0.9	1	0.1	0.7	0.8	1	0.09	0.8
Wine	0.1	0.2	0.4	0.8	0.02	0.8	0.02	0.8
Spirits	0.7	0.8	0.6	1.1	0.007	0.8	0.4	1.5
Drinking from a glass	0.9	0.3	0.4	1.2	0.001	0.3	0.1	0.4
Swilling	0.4	0.6	0.3	1.3	0.001	1.3	0.04	6.5

Legend: *p* = probability associated with the regression and OR = odds ratio.

students aged 18–30 years-old. We specifically did not recruit dental students but if they passed the recruiter who was presented in an open campus location they were included. Therefore this data presents results from a generalised University group of adult subjects. So whilst this group is unlikely to be representative of all adults it provides an estimate of the impact within this age group. Epidemiological studies in children are simpler to conduct particularly when undertaken at schools. The situation is much more difficult in adults.

The data were very complex considering the number of subjects and the questions asked. When the data were analysed there were different patterns of wear observed in enamel and dentine and this complicated the statistical analysis. For enamel, most data were positive and above 1 whereas for dentine most data were zero. Although wear of enamel was universal at grade 1 comparatively few had more severe levels (score $>2 = 20.1\%$).⁶ Most of the associations, using the odds ratio's were site-specific, particularly involving those foods and drinks with a high titratable acidity. These relationships also give some indication of the association between the dietary intake and the surface at which the tooth wear developed. The intake of both apples and other fruit showed high odds ratio's indicating a strong association with tooth wear in dentine and as such the results support the clinical suspicion and laboratory findings that dietary foods and drinks with a higher titratable acidity cause tooth wear.¹⁹ Interestingly, the drinks most often associated with dietary erosion, particularly the carbonated drinks such as cola, showed no odds ratios or statistical relationships. Other studies, in younger age groups, have also reported this finding¹² and emphasises that dietary advice should be targeted to strong acids rather than some of the commonly consumed beverages.

Questionnaires provide an estimate of dietary behaviour. No method is ideal nor is absolutely accurate but asking subjects to record their diet against objective criteria gives reasonably accurate data. The questionnaire had been used in another study³ and had been tested on a pilot group to ensure understanding and ease of reading. Therefore, the questionnaire was felt to be reasonably reliable. The present study unlike previous ones questioned in more detail the type of acidic food and drink intake and attempted to investigate any effect on a recent change to their dietary behaviour. A clinical suspicion is that diets change over time. This study attempted to include any changes that had occurred over a 2 month period. It would have been preferable to extend this period but the validity of relying on memories for longer than a few months cannot be considered to be reliable. The data showed that there were no correlations between recent changes in the diet and the tooth wear scores. This might reflect that the interval was too short to have any real influence but if the time period had been extended the accuracy of the data would have been questionable. Based on this evidence there was no effect from recent changes in diet on the tooth wear.

The odds ratio's reported in our study support the finding of other studies in adults and children.¹³ Milosevic et al.¹² reported that the odds ratio for the consumption of pickles (OR = 1.86) and various sauces (OR = 1.16–1.57) had the strongest association with tooth wear in dentine in their

cohort of children. They suggested that there may be interactions between acidic foods and drinks resulting in a cumulative effect on dental erosion. However, the data were very complex with all enamel surfaces recording above 1 and only a relatively small percentage registered above one in dentine. The data from the questionnaires remained the same. Therefore when analysing the enamel and dentine different results emerged and is partly explained by differences of the tissues to susceptibility to acid erosion. But some of the odds ratio's were below one. This is more difficult to explain and is probably a reflection of the data and its complexity. We have emphasised the value of the odds ratio's with those well above one and so the confidence in this is much higher. Those data around 1 must be less assured and is likely to be a reflection of the complexity of the process.

There is mounting evidence that although the underlying acidic nature of a food or drink is important it is the frequency of consumption that is the most important aspect in the development of tooth wear.^{20,21} The method used in this study, which assessed erosive potential by using frequency of consumption, adds considerable support to this finding. In addition, drinking habits, in particular an admission of swilling drinks prior to swallowing, had particularly high odds ratio and were associated with occlusal and palatal dentine exposure. Drinking from a glass produced an OR in enamel. So drinking methods appeared to influence the development of wear in dentine and enamel and support data from other clinical studies and clinical experience.²²

The other major known cause of erosive tooth wear is acid derived from the stomach. Although heartburn is relatively uncommon in young adults it can occur and was the only source of gastric acid seen to have an increased odd ratio.²³ However, in common with other conditions it was reliant upon self-reporting. There is robust evidence to suggest that gastric acids can cause erosion and the finding in this group that there were high odds ratio's adds further evidence that it is an important factor in tooth wear.^{24,25}

Higher odds ratio's were observed with beer and wine on enamel and fruit based drinks on dentine. The finding that wine might be associated with tooth wear is not entirely surprising, particularly in this sample because of their age range, but finding that beer was too is slightly surprising. Within this age group and student population consumption of beer may be high, although we did not record absolute levels it is not possible to define. Lager beers are acidic and have the potential to cause erosion and so might explain the significance. A curious finding was the association of wear on dentine to consumption of apples, fruit based drinks and heartburn but not to enamel. These foods are strongly acidic which might lead to early dentine exposure and is consistent with clinical experience.

The data from the sensitivity indicates that in this cohort it was a common experience with nearly 60% claiming to have experienced the condition. However, only just over 10% claimed it happened on a daily basis. This apparent contradiction seems to confirm clinical findings and other prevalence studies in which the quoted figures range from 3 to 58%.^{26,27} The perception of pain varies between patients so people will respond differently when asked in a questionnaire to one that clinically investigates the presence of the

condition. However, the distinction used here with daily events limiting the response is a useful one and shows that in this cohort with a number of risks factors showing associations with tooth wear that sensitivity is prevalent.²⁸

In time the reliance on indices to estimate the prevalence of tooth wear in a given community will reduce as scanning techniques become faster and more patient-friendly. Until that happens, the only convenience method to assess tooth wear in large populations is using an index. Although the coding of these indices are challenging most have produced reasonable reproducibility but as new method evolve more quantitative measuring systems using scanner or profilers will supersede index's.^{29–32}

This sample of King's College students cannot be considered to be representative of young adults. University students tend to be better educated and more dentally aware and so their tooth wear experience may differ from other social groups. Whether some of the associations observed in this group would be found in a more representative one is not possible to predict but the finding that strong acids, either from the diet or the stomach, have stronger associations with tooth wear is consistent with current clinical thinking. Despite these challenges the numbers of subjects, their selection from an open University campus provided a reasonably representative cohort of young adults. The results confirm previous clinical observations and add to our understanding of tooth wear and provide further evidence that drinking behaviour and the consumption of foods with strong acidity are important factors in the development of tooth wear. The next phase in the development is to monitor progression using this index.

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