A Pilot Study into the Effect of Whisky, Wine and Beer Consumption on Tooth Surface Dissolution

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Abstract

Aim: To assess the potential of acute alcohol consumption to dissolve tooth surfaces and to evaluate the difference in the dissolution potential of whisky, beer and wine.

Methods: The study sample comprised 36 healthy male volunteers with mean age of 26.27 (SD-1.96) years (range 25-30 years). The study design involved randomly allocating the 36 individuals into three groups of alcohol consumption (whisky, beer, wine) with 12 subjects in each group. Two samples of paraffin stimulated whole saliva were collected, at baseline and immediately after consumption of alcohol. Saliva was subjected to chemical analysis for pH, ionic calcium and inorganic phosphate.

Results: There was a significant difference for mean change in salivary pH, calcium and inorganic phosphate between the three alcohol groups. A significant reduction in the mean pH was observed after consumption of any form of alcoholic drink (mean change=-1.34, p=0.0001). Beer consumers had highest reduction in mean pH (1.75) followed by the wine (1.13) and whisky consumers (1.12) (p=0.045 and p=0.087 respectively). Mean calcium (mean change=5.75, p=0.0001) and inorganic phosphate (mean change=8.42, p=0.003) concentration significantly increased in the whole study sample. Mean inorganic phosphate and calcium concentrations increased after consumption of whisky and wine while a drop in their concentrations was observed in beer consumers.

Conclusions: Salivary pH decreased significantly in subjects belonging to all the three groups. In both whisky and wine groups, there was a rise in salivary inorganic phosphate concentration while only whisky was able to dissolve calcium from the tooth surfaces.

Key Words: Alcohol, Salivary pH, Salivary Calcium, Salivary Inorganic Phosphate

Introduction

Alcoholic beverages have been used in human societies at least since the beginning of recorded history and it has deep roots in the culture and customs of many of the societies. In association with ubiquitous availability, the social and health problems associated with alcohol have become wide spread. A wide range of health disorders have been attributed to alcohol abuse [1]. Ingestion of a large amount of alcohol on a single occasion can even lead to intoxication. Clinical manifestations are heterogeneous and involve different organs with behavioural, cardiac, gastrointestinal, pulmonary, neurological, and metabolic effects [2].

A range of oral manifestations have been ascribed to chronic alcohol usage. Alcoholics have been found to present higher numbers of decayed, missing, and filled teeth in comparison to non-alcoholics [3]. Moreover, alcoholics have an increased rate of chronic, advanced generalized periodontitis [4] with inflamed gingivae and deep pocketing with associated bone loss [5].

In 2001, a Finnish study compared dental health status among Finnish alcohol dependent subjects with social drinkers as controls using panoramic radiographs [6]. It was observed that alcohol dependent individuals experienced more caries, horizontal bone loss and vertical infrabony pockets than social drinkers [6]. Apart from these oral manifestations chronic alcoholics are at particular risk of dental erosion and tooth wear [7]. Another study reported significantly more tooth wear in alcoholic patients than in age and sex matched controls [8]. The erosive potential of alcoholic beverages might be due to the acidic content of the drink or it could be due to the frequent vomiting associated with excessive alcohol consumption. Moreover, salivary flow rate and composition is significantly altered after alcohol consumption and a study observed that acute alcohol consumption caused a decrease in flow rate of stimulated whole saliva along with decrease in the output of electrolytes [9]. The critical point at which enamel dissolves is reported to lie between pH of 5.0 to 5.7 [10,11] and hence alcohol can play a major role in tooth erosion owing to its acid content. The salivary concentration of calcium and phosphate normally is supersaturated in relation to enamel hydroxyapatite. An acid challenge results in under saturation of these salivary salts, and tooth demineralization with softening of dental enamel occurs [12]. The dissolution of enamel in acid occurs as a result of reaction between the hydrogen ion and the inorganic material (hydroxyapatite) which forms the principal part of enamel. The reaction results in dissolution of enamel leading to liberation of calcium and phosphate ions along with water molecules [13]. With this background information, we hypothesized that consumption of alcohol on a single occasion can lead to a fall in salivary pH below the critical level due to its acidic content which would eventually cause dissolution of enamel liberating ionic calcium and inorganic phosphate into saliva.

Aims

Thus the present study aimed to assess the dissolution potential of acute alcohol consumption on the tooth surfaces and to evaluate the difference in erosive potential of whisky, beer and wine.

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Material and Methods

The study sample comprised 36 healthy male volunteers who were post graduate students of Darshan Dental College and Hospital, Udaipur, India. The mean age of the study population was 26.27 (SD-1.96) years (range 25–30 years).

Exclusion criteria comprised of unhealthy individuals on any regular medication, those with substance related addiction, smokers, subjects with psychiatric disorders or any enamel lesions While only social drinkers (individuals scoring ≤ 8 on the AUDIT scale [14]) with a sound dentition were included in the study [14].

The study design constituted randomly allocating the 36 individuals into three groups for the consumption of different types of alcohol (whisky, beer, wine) with 12 subjects in each group.

Body weight of each volunteer was registered and the amount of alcohol to be consumed was calculated to be equivalent to 0.7 g alcohol/kilogram of body weight [9]. Whisky and wine had an alcohol concentration of 42.2% and 13% respectively whereas beer had the lowest alcohol concentration of 6%.

Whisky was consumed with distilled water (1 part: 2 parts) while beer and wine were consumed without any dilution.

Ethical approval for conducting the study was obtained from ethical committee of Darshan Dental College and Hospital and the study methodology conformed to the guidelines issued in the Declaration of Helsinki. Written informed consent was obtained from each volunteer.

Two samples of paraffin stimulated whole saliva were collected; first sample at baseline (S0) and the second sample immediately after consumption of alcohol (S1). The time frame to consume alcohol was set at 15 minutes during which the participants refrained from eating or drinking other beverages. In addition, all the volunteers were refrained from eating and drinking for 3 hours before the start of the study.

Ten ml of paraffin stimulated saliva was collected in ice chilled tubes by the draining method and all the saliva samples were analyzed immediately after collection. Saliva was subjected to chemical analysis for pH, ionic calcium and inorganic phosphate. pH was analyzed using pH meter (Elco LI 160) while ionic calcium assessment was performed using the Orion SS-20 ionized calcium meter. Inorganic phosphate level in saliva was evaluated by using a phosphomolybdate/ UV method [15].

SPSS 15.0, Chicago., IL was used for statistical analysis. For descriptive purposes, salivary pH, ionic calcium and inorganic phosphate concentrations are presented as mean and standard deviation. Parametric tests were used to compare the salivary concentrations. Paired 't' test was used to compare the difference in mean saliva concentration of salivary parameters at baseline and after alcohol consumption for each type of alcohol. Two-way repeated measure ANOVA was executed to compare the mean changes in salivary pH, calcium and phosphate concentrations between the three alcohol groups. A Bonnferroni multiple comparison test was performed to compare the groups against each other. Furthermore, overall changes in each factor over time were estimated using the same repeated measure ANOVA model. The assumption of normality and equality of variance in paired t-test and repeated measures ANOVA were checked and all these assumptions were satisfied. A p value of <0.05 was considered as statistically significant.

Results

Descriptive statistics for salivary pH concentration at baseline and after consumption of alcohol in various forms is presented in *Table 1*.

Two-way repeated measure ANOVA revealed significant reduction in the mean pH of saliva in the whole sample after consumption of all three types of alcoholic drink (mean change=-1.34, p=0.0001). Furthermore, there was a significant difference between the groups for the mean change in pH. On multiple comparison between the groups by Bonferroni, beer consumers had highest reduction in mean pH (1.75) followed by the wine (1.13) and whisky (1.12) groups (p=0.045 and

Table 1. *Mean and standard deviation for salivary pH concentration at baseline and after consumption of alcohol (whisky, beer and wine).*

pH	Whisky (n=12)	Beer (n=12)	Wine (n=12)	Total (n=36)
S0 Mean (SD)	6.58 (0.24)	6.44 (0.98)	6.53 (0.22)	6.51 (0.58)
S1 Mean (SD)	5.45 (0.24)	4.68 (0.54)	5.39 (0.22)	5.18 (0.50)
Mean difference† Mean (95% CI)	-1.12 (-1.16–-1.09)	-1.75 (-2.30–-1.19)	-1.13 (-1.17–-1.09)	-1.34 (-1.51–-1.16)
p=	0.0001*	0.0001*	0.0001*	0.0001∞

*Paired't' test
Two way repeated measures ANOVA (F=6.008, p=0.006) for the mean change in salivary pH between the three alcohol groups
†p=0.045 (Beer vs Whisky), ‡p=0.087 (Beer vs Wine); adjusted for multiple comparisons by Bonferroni method
∞ Two way repeated measures ANOVA (F= 252.667) for overall change in pH over time

Table 2. *Mean and standard deviation of salivary Ca^{2+} concentration at baseline and after consumption of whisky, beer or wine.*

Ca^{2+} concentration	Whisky (n=12)	Beer (n=12)	Wine (n=12)	Total (n=36)
S0 Mean (SD)	47.77 (6.57)	57.28 (10.54)	47.64 (8.61)	50.90 (9.63)
S1 Mean (SD)	62.91 (5.55)	56.91 (6.45)	50.14 (12.19)	56.65 (9.87)
Mean difference†‡ Mean (95% CI)	15.13 (11.73–18.53)	-0.36 (-7.50 - 6.76)	2.49 (-2.83–7.81)	5.75 (-2.08–9.41)
p=	0.0001*	0.911*	0.325*	0.0001∞

*Paired't' test
Two way repeated measures ANOVA (F=10.892, p=0.006) for the mean change in salivary calcium between the three alcohol groups
†p=0.034 (Beer vs Wine); adjusted for multiple comparisons by Bonferroni method
∞Two way repeated measures ANOVA (F=15.888) for overall change in salivary calcium over time

p=0.087 respectively).

Table 2 shows mean salivary calcium concentration in the three groups at baseline and after alcohol consumption. Mean calcium concentration increased significantly after alcohol consumption in the whisky (mean change = 15.13, p=0.0001) group only while this factor had modest decrease in beer consumers. Although the three groups differed significantly for the mean change in calcium concentration (p=0.006), multiple comparisons by Bonferroni multiple revealed that a significant difference for the mean calcium concentration existed only between wine and beer consumers (p=0.034). According to two way repeated measure ANOVA, mean calcium concentration significantly increased in the whole study sample (mean change=5.75, p=0.0001).

Table 3 shows mean salivary inorganic phosphate concentration in the three groups at baseline and after alcohol consumption. Overall, mean inorganic phosphate concentration had a significant increase in whole study sample (mean change=8.42, P=0.0001). Mean inorganic phosphate concentration like calcium concentration also had an increment among whisky (22.69 µg/ml) and wine (5.65 µg/ml) groups but a drop was observed in beer consumers (-3.14 µg/ml). The mean increase in salivary calcium concentration in whisky group was significantly greater than the beer and wine groups (p=0.0001 and p=0.0001 respectively).

Discussion

The dissolution of enamel in acid occurs as a result of reaction between the hydrogen ion and the inorganic material which forms the principal part of enamel. In simple terms the reaction of tooth enamel with acid results in dissolution of enamel and the release of calcium ions, phosphate ions and water molecules [13]. The critical point at which enamel dissolves is reported to be a pH of 5.0 to 5.7 [11,16,17]. Thus it can be hypothesized that at a critical pH, the acidity of alcohol would dissolute the enamel hydroxyapatite releasing ionic calcium and inorganic phosphate.

Although the methodology used for quantifying mineral loss by erosion used in the present study is not technologically advanced, it was found in a study that all the methods (longitudinal microradiography, profilometry, and analysis of calcium and phosphorus in the erosion solution) of quantitative mineral loss showed a good linear correlation [18]. However, the process of erosion is complex and depends on various factors like pH value, mineral content, titratable acidity ('the buffering capacity') and the calcium-chelation properties of the drinks [7].

Stimulated saliva was collected both at baseline and after alcohol consumption and was assessed for pH, ionic calcium and inorganic phosphate. The reason for not considering unstimulated saliva was that collection of 10 ml of unstimulated saliva would take more than 50 minutes within which the systemic effect of alcohol consumption would take over and influence the constitution of saliva. Although, efforts were made to limit deficiencies, the present study was not free of limitations, which included:

- Limited sample size and no power analysis to calculate the sample size.
- The study population was not representative of the general population.
- There were no women as none of the women postgraduates volunteered to participate and consumption of alcohol among women is not a common practice in India.
- There was no control group who did not consume alcohol.

Subjects in all the groups were homogeneous with regard to salivary concentrations at baseline. Ionic calcium and inorganic phosphate concentrations increased in the saliva after consumption of alcohol. A previous study [19] observed that enamel specimens immersed in citric acid had erosive demineralization by loss of calcium and phosphate ions. In contrast, another study observed that an ingested high single dose of ethanol causes a decrease in the stimulated whole saliva flow rate, calcium concentrations and no change in PO_4^3 concentration [9]. The possible reason for this difference between the present study's findings and the past study could be attributed to the time frame for collection of samples after alcohol consumption which was done after 45 minutes (by this time blood alcohol concentration was estimated to reach maximum level and thus exert its systemic effect on salivary secretion).

There was a significant fall in salivary pH after alcohol consumption which is in agreement with a past study which observed a significant decrease in plaque and salivary pH after the consumption of fruit juices [19]. There was significant increase in calcium concentration in whisky group only while rise in inorganic phosphate concentration was observed among both whisky and wine groups. It has been proposed that pH value, calcium, phosphate and fluoride content of a drink or foodstuff determines the degree of saturation with respect to the tooth mineral, which is the driving force for dissolution [7,20].

Conclusions

Alcohol consumption led on average to fall in salivary pH

Table 3. *Mean and standard deviation for salivary inorganic phosphate concentration at baseline and after consumption of alcohol (whisky, beer and wine).*

Inorganic PO_4^3- concentration†	Whisky (n=12)	Beer (n=12)	Wine (n=12)	Total (n=36)
S0 Mean (SD)	85.99 (6.67)	78.94 (4.78)	72.31 (6.04)	79.08 (8.04)
S1 Mean (SD)	108.68 (7.92)	75.80 (11.83)	77.96 (6.38)	87.51 (17.55)
Mean difference†‡ Mean (95% CI)	22.69 (19.59–25.78)	-3.14 (-8.72–2.44)	5.65 (2.90–8.40)	8.42 (4.20–12.64)
p =	0.0001*	0.241*	0.001*	0.003∞

*Paired't' test

Two way repeated measures ANOVA (F= 51.831, p=0.0001) for the mean change in salivary inorganic phosphate between the three alcohol groups

†p=0.0001 (Whisky vs Beer), ‡ p=0.0001 (Whisky vs Wine); adjusted for multiple comparisons by Bonferroni method

∞ Two way repeated measures ANOVA (F= 64.046) for overall change in salivary inorganic phosphate over time

below the critical pH, increase in salivary ionic calcium and inorganic phosphate concentrations. Mean salivary pH decreased significantly in subjects belonging to all the three groups. In both whisky and wine groups, there was a rise in mean salivary inorganic phosphate concentration while only whisky was able to dissolute calcium from the tooth surfaces. Further studies are recommended with high-quality study design and methods and a larger sample.

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Conflicts of Interest
Nil

Contributions of Each Author
SK conceived the experiment and co-worked with HT in conducting the study. JT and HT have conducted the quantitative analysis of the salivary parameters. SK and JT took part in drafting the paper. PD and Kulkarni S have made substantial contributions to conceptualising, designing and carrying out the study. All the authors have read and approved the final manuscript.

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