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Original articles

Sports drinks hazard to teeth

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Abstract

***Objective*—To determine the dental hazards associated with sports supplement drinks by investigating the chemicophysical properties of eight brands of sports drinks.**

***Methods*—The pH and titratable acidity against 0.1M NaOH was measured. Calcium, phosphate, and fluoride concentrations and viscosities of Carbolode, Gatorade, High Five, Isostar, Lucozade Sport Lemon, Lucozade Sport Orange, Maxim, and PSP22 were determined.**

***Results*—The pH values of the drinks ranged from 4.46 (Maxim) to 2.38 (Isostar) and therefore were below the critical pH value (5.5) for enamel demineralisation. Both Lucozade varieties had high titratable acidities (16.30 ml 0.1M NaOH to neutrality) with Gatorade, High Five, and Isostar displaying intermediate titratable acidity, although Isostar had 74.5 ppm calcium and 63.6 ppm phosphate. The fluoride concentration of all drinks was low, and none of the drinks was particularly viscous (range 3.1–1.4 mPa.s).**

***Conclusions*—The chemicophysical analyses indicate that all the sports drinks in this study have erosive potential. However, drinks with higher pH, lower titratable acidity, and higher concentrations of calcium, phosphate, and fluoride will reduce this erosive potential.**

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The regular and frequent use of sports supplement drinks by sports men and women can potentially lead to increased caries experience (dental decay) and to dental erosion. Dental decay is a disease caused by dental plaque, a bacterial film on the tooth surface, which ferments carbohydrates, thereby producing acidic byproducts of metabolism such as lactate, acetate, propionate, and formate. Major loss of tooth mineral normally occurs below the pH value of 5.5. Dental erosion, on the other hand, does not involve bacteria, since the erosion is caused by the inherently low pH from extrinsic sources within the diet or from intrinsic gastric acid being brought "back up"—for example, gastric reflux, self induced vomiting in bulimia nervosa.[1] Low pH extrinsic dietary sources are fresh citrus fruits or their fruit juices, acidulated carbonated beverages, and sports supplement drinks, many of which contain citric acid. Meurman *et al*[2] reported that nine out of 13 sports drinks contained citric acid, two contained malic acid, and two contained an unknown acid. Furthermore, the citric acid based drinks were more erosive than the malic acid containing drinks, the erosion being inversely related to the pH of the drink. However, the titratable acidity was believed to be a better indicator of erosive potential, because this indicates the total amount of H^+ able to dissociate rather than just the H^+ concentration of the solution.[3 4] The degree of saturation of calcium, phosphate, and fluoride in the drinks with respect to tooth mineral will also influence erosive potential.[5] Furthermore, the more adhesive or "stickier" the drink to the tooth, the greater the propensity for erosion to occur, although Lucozade Sport Orange was reported to exhibit the lowest adhesion to enamel when compared with blackcurrant squashes, Coca Cola, and natural orange juice.[6]

All the monosaccharides (including glucose and fructose) and disaccharides (including sucrose, maltose, and lactose) are highly cariogenic. Therefore, since the sports supplement drinks are mainly carbohydrate (usually glucose, maltose, or dextrose), dental decay may be potentiated in sports men and women who do not maintain a good standard of plaque control with frequent use of fluoride toothpaste. Sports drinks had the same cariogenicity as fruit juice and carbonated beverages.[7] However, levels of decay were not significantly different between a group of Swedish school athletes and a non-athletic control group.[7] The effect that these sugars and organic acids may have on the dental health of sports men and women has received scant attention in the British dental or sports literature. The Medline database did not have one reference with the keywords sports drinks, caries and erosion from 1990 up until the end of 1995.

The clinical presentation of an athlete with dental erosion is described, and the pH and titratable acid, the calcium, phosphate, and

Figure 1 Labial view of upper front teeth. Note the loss of the incisal edges of the central incisors.

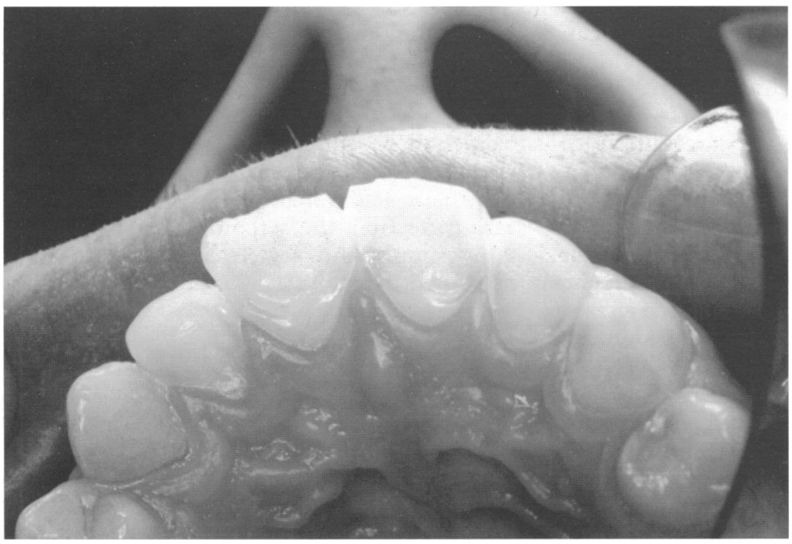

Figure 2 The palatal view of the upper front teeth. A ridge is present between the relatively intact enamel near to the gum margin and the thinned eroded body of the crown.

fluoride concentrations, and the viscosity (as a measure of adhesiveness) of several popular varieties of sports supplement drinks were determined. Advice regarding "safer" drinks and caries/erosion-reducing behaviour is also given.

Case report

A 23 year old man was referred to the author by a local dental practitioner. The patient complained of the poor appearance of the incisal edge of his top front teeth which were also slightly sensitive (fig 1). The medical history was clear, the subject being a marathon and cross-country runner. Dental examination revealed minor erosion of the upper teeth on many surfaces, but extensive erosion through to the dentine on the palatal (inside) surfaces of the upper central incisors (fig 2). These teeth are ridged at the point where enamel meets the eroded and thinned dentine body of the crown. This ridge was bothersome to the subject. Oral hygiene was good, with few filled teeth indicating a moderate level of past caries experience. Questioning the athlete revealed regular consumption of sports supplements for over one year, and he also drank carbonated mineral water in order to quench his thirst. A five day fluid intake record showed that hot beverages were rarely consumed, the subject preferring fresh fruit juice and carbonated beverages. Although the subject did not compete during the five days, he did drink a popular brand of still isotonic sport drink from a pouch after three training sessions.

Table 1 Chemicophysical properties of 10% concentrations of sports supplement drinks at 20° C

Sports drink	*pH*	*Titratable acid (ml 0.1M NaOH to pH 7)*	*Calcium (ppm)*	*Phosphate (ppm)*	*Fluoride (ppm)*	*Viscosity (mPa.s)*
Carbolode	3.74	1.80	0.22	0.00	0.01	2.5
Gatorade	3.05	10.70	0.98	104.00	0.01	1.4
High 5	2.52	7.85	3.00	1.10	0.01	1.7
Isostar	2.38	8.50	74.50	63.60	0.05	1.4
Lucozade Sport Lemon	3.05	16.30	21.00	3.45	0.04	3.1
Lucozade Sport Orange	3.05	16.30	25.00	12.65	0.03	2.2
Maxim	4.46	0.30	0.11	0.00	0.01	2.1
PSP 22	2.60	2.10	0.04	0.00	0.01	2.2

Methods

The chemicophysical properties of six varieties of freshly made sports supplement drinks at 10% concentration were analysed. A further two sports drinks, Lucozade Sport Orange and Lemon were analysed directly from the pouch. The titratable acidity was determined against 0.1 M NaOH to the neutral end point with phenolphthalein as indicator. The pH was measured with a calibrated pH meter and fluoride concentration with the fluoride specific ion electrode (Orion Research Inc). A Perkin-Elmer atomic absorption spectrophotometer with a nitrous oxide/acetylene flame was used to measure calcium concentration, and phosphate was measured by the standard chemical technique of Murphy and Riley.[8]

Viscosity analyses on 8 ml drink samples were made with the model DV-1 Brookfield digital viscometer (Brookfield Engineering Labs Inc., Stroughton, MA, USA). Spindle rational speed was set at 60 rpm as per manufacturer's instructions at a shear rate of 1.32 N. Constant viscometer readings were obtained after a few minutes, and this value was multiplied by the recommended factor for speed/spindle combination. All analyses were made at the ambient room temperature.

Results

Table 1 shows the chemicophysical properties of eight varieties of sports supplement drink.

Discussion

All the sport drinks had pH values lower than the value of 5.5, below which enamel demineralisation mainly occurs. The titratable acidity varied from 16.30 ml of 0.1M NaOH for Lucozade Sport to 0.30 ml 0.1M NaOH for Maxim. Lucozade Sport is ready to drink from a pouch, whereas all the other drinks were in powdered form and subsequently mixed with water. Although Lucozade did not exhibit the lowest pH, the high titratable acidity makes it potentially the most erosive. However, the presence of calcium and phosphate in the aqueous oral fluid will influence the extent of the demineralisation. Undersaturation of this aqueous phase with respect to hydroxyapatite and fluorapatite in vitro resulted in dental erosion and not dental decay.[9] Therefore the presence of calcium at 21–25 ppm in Lucozade would tend to mitigate against demineralisation, but whether or not this concentration of calcium is significant and able to reduce erosion is not known. Isostar, with the lowest pH and a mid-range titratable acid, may not be particularly erosive because of the high concentration of calcium and phosphate present in the drink.

All the fluoride concentrations were low and probably unable to prevent demineralisation or promote remineralisation. It is likely that the fluoride levels in the powdered drinks would be higher in areas where the public water supplies are optimally fluoridated at 1 ppm F or have naturally occurring fluoride. Table 1 presents all drinks at 10% concentration, which is the recommended concentration for most sporting activities. However, at a concentration of 20%, the properties would be different. The low viscosities reflect the concentration of sugars diluted in the water, but Carbolode and Lucozade Sport Orange are likely to be "stickier" to teeth than the other drinks.

Ranking the erosive potential of the sports drinks is thus difficult, and furthermore individual drinking habits would also influence the pattern and severity of dental erosion. Theoretically at least, Maxim displayed the lowest acid content.

Too frequent an intake of sports drinks and consequent exposure to acidic challenges, both from the drink and the bacterial fermentation of sugars, could lead to erosion and decay respectively. Sipping is therefore more deleterious. Chilled drinks are potentially less erosive because the acid dissociation constant is temperature dependent and the use of a straw will reduce the contact with teeth. Habits such as holding or swishing the drink around the mouth are to be avoided. The dental management for eroded teeth ranges from the non-interventionist to advanced restorative dentistry. The erosive wear can be monitored with the use of study casts, tooth wear indices, and photographs. The subject reported in this paper requested treatment to improve appearance and reduce sensitivity. This was achieved by the provision of palatal composite veneers which were bonded to the tooth with modern dental adhesive resins. This is favoured by the author because "adhesive dentistry" is reversible and non-destructive of further tooth substance since tooth preparation is minimal.

However, the erosion cannot be attributed unequivocally to the sports drinks since the subject also drank fresh fruit juice and carbonated beverages. Such drinks are potentially erosive and highlights the difficulty in ascertaining aetiological significance in individual cases. The risk of erosion from a variety of suspected causes may be determined by two types of epidemiological investigation: the case control study or the cohort study. Risk of erosion from daily sports drink consumption in a Finnish case control study resulted in an odds ratio of 4 and a population attributable risk of 26.[10] Whether such an association exists in the UK is not known.

In conclusion, all eight sports drinks analysed in this study exhibited dental erosive potential. However, some drinks are probably "safer" than others, and individual patterns of intake can further reduce the potential damaging effects to the dentitions of sports men and women. Frequent users of sports drinks should have regular dental check ups and ask their dentists to look for the signs of erosion. With early detection, the symptoms can be treated fairly simply and severe erosive destruction prevented.

1 Milosevic A. Tooth wear: an aetiological and diagnostic problem. *European Journal of Prosthodontics and Restorative Dentistry* 1994; **1**: 173–8.
2 Meurman JH, Harkonen, M, Naveri H, Koskinen J, Torkko, H, Rytommaa, I, *et al.* Experimental sports drinks with minimal dental erosion effect. *Scand J Dent Res* 1990; **98**: 120–8.
3 Holloway PJ, Mellanby M, Stewart RJC. Fruit drinks and tooth erosion. *Br Dent J* 1958; **104**: 305–9.
4 Grenby TH, Mistry M, Desai T. Potential dental effects of infant's fruit drinks studied *in vitro*. *Br J Nutr* 1990; **64**: 273–83.
5 Lussi A, Jäggi T, Schärer S. The influence of different factors on *in vitro* enamel erosion. *Caries Res* 1993; **27**: 387–93.
6 Ireland AJ, McGuiness N, Sherriff M. An investigation into the ability of soft drinks to adhere to enamel. *Caries Res* 1995; **29**: 470–6.
7 Borg A, Birkhed D. Dental caries and related factors in a group of young Swedish atheletes. *Int J Sports Med* 1987; **8**: 234–5.
8 Murphy J, Riley JP. A modified single solution method for the determination of phosphate in natural water. *Analytica Chimica Acta* 1962; **27**: 31–6.
9 Larsen MJ. Chemical events during tooth dissolution. *J Dent Res* 1990; **69** (special issue): 575–80.
10 Järvinen VK, Rytömaa II, Heinonen OP. Risk factors in dental erosion. *J Dent Res* 1991; **70**: 942–7.