Effect of Xylitol-containing Chewing Gums on Lactic Acid Production in Dental Plaque from Caries Active Pre-school Children

Svante Twetman[a]/Christina Stecksén-Blicks[a]

Purpose: The aim of this study was to evaluate the lactic acid concentration in supragingival plaque from caries-active pre-school children after a short-term use of either xylitol- or sorbitol-containing chewing gums.

Material and Methods: The investigation consisted of a prospective crossover design with 10 healthy children aged 2–4 years each with at least two caries lesions within the dentine (ds ≥ 2). The children were instructed to chew 6 pieces of a test or a control gum every day for a 14-day period. The test gum contained 65% xylitol and the control gum was sweetened with sorbitol. At baseline and after 14 days, salivary mutans streptococci were enumerated with a chair-side test (Strip mutans) and dental plaque was collected from the upper maxillary incisors. After a washout period of 6 weeks, the same procedure was repeated with the corresponding test or control gum. Lactic acid was determined enzymatically in glucose-challenged plaque suspensions.

Results: The lactic acid concentration was significantly reduced ($p<0.05$) by 22% compared with baseline following the xylitol gum regimen but was unaltered after the control gum. The levels of salivary mutans streptococci were mainly unaffected by both chewing gums.

Conclusion: A 14-day use of xylitol-containing chewing gums, corresponding to a daily amount of 5 grams of xylitol, could diminish glucose-initiated lactic acid formation in supragingival plaque in caries-active pre-school children.

Key words: caries, chewing gum, lactic acid, xylitol

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Although it is generally accepted that dental caries is an infectious disease of bacterial origin, its prevention and management through antimicrobial measures is still insufficiently evaluated (Caufield et al, 2001). Xylitol is a natural sugar alcohol that has gained substantial interest as an anti-caries agent over the recent decades (for recent reviews, see Mäkinen, 2000; Peldyak and Mäkinen, 2002). Two key factors have been advanced for its expected mode of action. Firstly, some oral bacteria, like the caries-associated mutans streptococci, are unable to utilize xylitol in their metabolism and thus, less acids are formed in the oral biofilm (reviewed by Trahan, 1995). Secondly, long-term use of xylitol may ecologically select for mutans streptococci strains with an impaired adhesiveness for tooth surfaces (Trahan et al, 1992). Several previous studies have demonstrated that xylitol exposure to human dental plaque could affect oral ecology and reduce plaque acidogenicity (Maki et al, 1983; Söderling et al, 1987; Söderling et al, 1989; Aguirre-Zero et al, 1993; Bradshaw and Marsh, 1994) while other, more recent investigations, have

[a] *Department of Odontology/Paediatric Dentistry, Faculty of Medicine and Odontology, Umeå University, Umeå, Sweden.*

Reprint requests: *Dr Svante Twetman, Paediatric dentistry, Department of Odontology, Umeå University, SE-901 87 Umeå, Sweden. Fax: +46-90-770 330. E-mail: svante.twetman@odont.umu.se*

failed to disclose such an effect (Scheie et al, 1998; Giertsen et al, 1999; Assev et al, 2002). The reason for the contrasting findings is not clear but factors such as xylitol dosage and exposure time, carbohydrate availability, plaque composition and laboratory processing may likely play a role. In the study by Scheie et al (1998), xylitol-containing chewing gums were used in young adults with a low incidence of caries. Since they are not the primary target group for xylitol administration, it was of interest to evaluate the possible inhibitory effect on bacterial glycolysis in plaque samples from caries active patients. The aim of this study was therefore to evaluate the lactic acid concentration in supragingival plaque from pre-school children with ongoing caries activity after a short-term use of either xylitol- or sorbitol-containing chewing gums. The null hypothesis was that the acid production would not differ between the test and the control gum.

MATERIALS AND METHODS

Subjects

The material consisted of 10 selected pre-school children of both sexes, aged 3-4 years, attending a daycare centre in Halmstad, a mid-sized city in the southwest of Sweden. The inclusion criteria were non-compromised general health and at least two caries lesions (ds ≥ 2) according to the WHO-criteria (1987), as diagnosed by the local Public Dental Clinic. The ethical committee at Lund University approved the study design and all parents consented after verbal and written information. All children were inhabitants in a community with low levels of fluoride in the piped water (>0.1 ppm). The parents were instructed to brush the teeth of their children twice daily at home with a pea-sized amount of fluoridated toothpaste (1000 ppm). No dental care was provided during the study period but the decayed teeth were restored after its completion.

Experimental Design

The study had a prospective crossover design. At baseline (day 0), the subjects were randomly allocated to chew 6 pieces each day of either a xylitol- (test) or a sorbitol-containing gum (control) for a period of two weeks (days 0 – 14). Salivary mutans streptococci were enumerated with a chair-side method (Dentocult SM-Strip mutans, Orion Diagnostica, Helsinki, Finland) according to Jensen and Bratthall (1989). Samples of dental plaque were gently collected from the buccal surfaces of the upper maxillary teeth with the aid of sterile curette on day 0 and day 14. The parents were asked to omit tooth brushing one day before each sampling in order to allow plaque to accumulate. After a washout period of 6 weeks with regular tooth brushing, the experimental procedure was repeated with the corresponding test or control gum. The test gums weighed 1.2–1.3 g each and contained 65% xylitol (Xylifresh, Leaf, Turku, Finland), which means that the daily dose of xylitol was approximately 5.0 g. The control gums (Sorbitol Real Fruit, Vejle, Denmark) contained no xylitol and were sweetened with sorbitol, maltitolsyrup, aspartame and acesulfame-K (total carbohydrate content 63%). The test and the control gums were purchased from a dental depot and a grocery store, respectively. The day-centre staff administrated and supervised the chewing and the children were asked to chew two gums for 5 minutes on three different occasions during the day. The gums were packed in plastic boxes marked A or B and neither the staff nor the children were informed of the sugar content. However, the test and control gums differed somewhat from each other concerning shape, taste and chewing resistance. The operator was aware of the regimen but not the staff performing the laboratory analyses.

Lactic Acid Assay

The plaque samples were transferred and pooled in a micro-tube and immediately brought to the laboratory. The samples were weighed on a microbalance suspended in a 0.05 M sodium phosphate buffer (pH 7.0) to a final concentration of 5 mg wet weight/mL. The suspensions were mixed and homogenized with the aid of a Teflon homogenizer. Acid production was initiated by adding D-glucose (BDH Chemicals Ltd, Poole, UK) to a final concentration of 0.01M and the suspensions were thereafter mixed and incubated at 37°C for 30 minutes under constant agitation. The fermentation was disrupted by centrifugation for 5 min at 8,700 x g (Beckman Microfuge B, Beckman Instruments Inc., USA) and the supernatant was withdrawn and kept frozen at –70°C until further analysis. The L(+)-lactic acid concentration was determined enzymatically using the Boehringer monotest in a microcentrifu-

Table 1 Distribution of children (n=10) with different Strip mutans scores at baseline and after a 14-day chewing period of either xylitol- or sorbitol-containing chewing gums

Time	Strip mutans score		
	≤10^4 CFU/mL	10^5 CFU/mL	10^6 CFU/mL
Test gum			
Day 0	–	6	4
Day 14	1	6	3
Control gum			
Day 0	–	5	5
Day 14	–	6	4

Table 2 Mean values of L(+)-lactic acid concentration (μg/mL) in glucose-challenged suspensions of supragingival plaque collected before and after a 14-day consumption of either xylitol- (test) or sorbitol-containing (control) chewing gums in caries-active pre-school children (n=10)

Time	Test gum Mean ± SD	Control gum mean ± SD
Day 0	0.63 ± 0.26	0.68 ± 0.25
Day 14	0.49* ± 0.28	0.65 ± 0.24

* statistically significant difference from day 0, Student's paired t-test, $p<0.05$ ($t = 2.43$).

gal analyzer (Cobas-Fara, Roche Diagnostica, USA). All determinations were performed in duplicate and the precision of the method was ±6% in the range of 0.5–10 μg/mL.

Statistical Method

The 14-day values were compared with baseline with the aid of Student's paired t-test after checking of normal distribution with the Tukey method in SPSS, version 11.0. The level of significance was set at 5%.

RESULTS

The mean caries prevalence in the study group was 3.6 decayed surfaces (range 2–11). No fillings were present. All children harbored salivary mutans streptococci and the majority exhibited high counts at baseline (median 10^5 CFU/mL saliva). The levels were not significantly affected by the two chewing regimes (Table 1). The lactic acid concentration in glucose-challenged suspensions of dental plaque collected at baseline and after two weeks use of xylitol- or sorbitol-containing chewing gums is presented in Table 2. The mean lactic acid concentration was significantly reduced ($p<0.05$) by 22% compared with baseline following the xylitol gum regimen while it was unaltered after the control gum. The individual values are shown in figure 1. Following the 14-day use of the test gum, 8 of the participants exhibited a lower lactic acid concentration compared with 4 of the subjects when using the control gum.

DISCUSSION

The novel approach of this study was to evaluate the possible beneficial effect of xylitol-containing chewing gums on plaque acidogenicity in caries-active pre-school children. Having lesions in the dentine at an early age, as in the present patient selection, indicate a true and ongoing caries activity. The short-term regimen was chosen mainly for practical reasons but also because studies indicate that oral bacteriae exposed to xylitol over extended periods might lose their sensitivity to the polyol (Assev et al, 2002). Under the existing experimental conditions, our results were clear-cut and the null hypothesis could be rejected. Consumption of xylitol chewing gums for a period of two weeks resulted in a limited but significant decrease in lactic acid production in glucose-challenged supragingival plaque suspensions from the majority of the caries active pre-school children. The results were mainly in agreement with previous findings from older patients (Maki et al, 1983; Söderling et al, 1989; Aguirre-Zero et al, 1993) but still, the findings should be interpreted with caution. Firstly, our results are based on an extraoral acid assay with glucose as the main energy source, which may not be fully representative of the intraoral event when a diversity of various sugars may be available. Second-

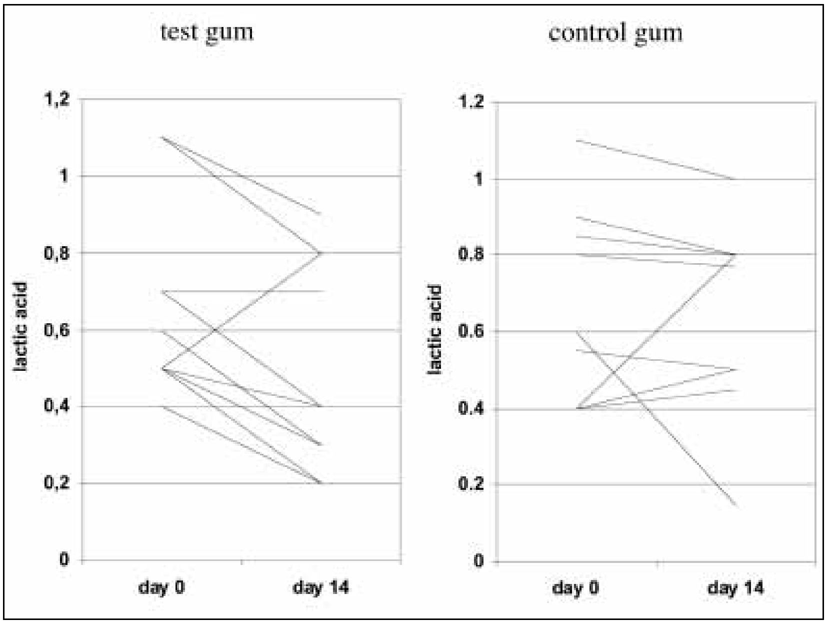

Fig 1 L(+)-lactic acid concentration (µg/mL) in glucose-challenged suspensions of supragingival plaque collected before and after a 14-day consumption of either xylitol- (test) or sorbitol-containing (control) chewing gums in 10 caries-active pre-school children.

ly, a true placebo gum without xylitol or any other sweetener was not used and thus, the subjects may have perceived and preferred the gums differently. Also, one should bear in mind that the sorbitol-containing control gum could initially act as an inhibiting factor on the acidogenic potential of the plaque suspensions. Thirdly, if the present intervention may have a long-term effect on the oral biology this may be obscured in part by the crossover study design. Other factors that could influence the results were varying compliance with the gums, and the fact that a regular diet was not standardized in respect of carbohydrates during the experimental periods.

The present results, obtained with a daily dose of approximately 5 g xylitol/day, may add some information to the dose-response issue. Most clinical studies with a significant caries reduction have utilized chewing gums or pastilles in a daily dose of 8–10 grams, irrespective of age (Hayes, 2001; Peldyak and Mäkinen, 2002). However, there are a few previous studies that have tested a lower dose, similar to this, and with a positive outcome (Kandelman et al, 1988; Alanen et al, 2000). It is of course likely that a higher dose and frequent intakes may be more effective than a low but on the other hand, one should not consume more xylitol than needed. Besides, in pure but important economical aspects, high doses and/or frequent intake may flaw compliance and increase the risk of side effects, such as gastric upsets. It should be underlined that no side or adverse effects were noted during these experimental periods with any of the gums. In contrast, we experienced good acceptance for the chewing regimes in agreement with the earlier report of Autio and Courts (2001). However, the present results indicate that even a relatively limited daily xylitol dose can affect the acid production, but a systematic evaluation for the lowest therapeutic dose is urgently required.

Arguments have been raised concerning the ethical question of performing caries prevention by introducing candy and gums at an early age and possibly enhancing their preference for sweet items (SBU, 2002). We definitely agree on the population level in low-caries societies, but in this study, only caries active pre-schoolers were selected and invited to participate. They disclosed already frequent snacking between meals, and an almost daily consumption of sweets and soft drinks. Thus, chewing gums were not new to them but nevertheless, it should be underlined that xylitol as a preventive method for young children should be recommended only after a comprehensive caries risk assessment and as an adjunct to topical fluorides and other evidence-based preventive measures.

In conclusion, the use of xylitol-containing chewing gums diminished lactic acid production in glucose-challenged supragingival plaque from caries active pre-school children. The clinical significance of this finding is not clear but the results support the commonly accepted mode of anti-caries action of this sugar substitute. However, the minimum amount of xylitol that is needed to obtain a beneficial effect remains open to further elucidation.

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