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Effect of xylitol and sugar-free chewing gums on salivary bacterial count of streptococcus mutans and lactobacilli in a group of Egyptian school children of different ages: A randomized clinical trial

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ABSTRACT

Aim: The purpose of this randomized clinical trial was to compare the effect of xylitol containing and sugar free brands of chewing gum on the salivary Colony Forming Unit (CFU) count of streptococcus mutans (SM) and lactobacilli (LB) cariogenic organisms in a group of Egyptian school children of different ages.
Study design: This pragmatic randomized controlled trial (parallel group design) was approved by the Research Ethics Committee of the Faculty of Dentistry, Ain Shams University.
Materials and methods: 42 high caries risk children (DMFT/dmft/deft of 3 or more) were randomly allocated to either the xylitol or polyol group. Each main group was divided into three equal subgroups. Each subgroup comprised a block of seven children of the same age group as follows: Nursery group aging 3–6 years, junior primary school group aging 6–9 years and senior primary school group aging 9–12 years. Salivary analysis was carried out at baseline and after three weeks of daily gum chewing to all participating children by recording his/her stimulated salivary flow and salivary CFU counts of SM and LB bacteria.
Results: Compared to polyol gum, xylitol gum showed lower SM CFU counts. LB CFU counts were not affected by either gum types. However, there was no statistically significant difference between the two chewing gum groups in the different ages and regardless of age.
Conclusion: Xylitol gum is more effective in decreasing SM count in saliva compared to polyol gum wheras both sugarless chewing gums show similar effect on LB species.

1. Introduction

Dental caries is one of the most common diseases of mankind. It is considered the most common oral disease worldwide, as it affects the majority of people of all ages during their lifetime; its incidence is high, particularly during childhood [1]. Untreated caries in deciduous teeth was the 10 t h most prevalent condition, affecting 621 million children worldwide according to a 2015 systematic review and meta-regression [2].

The prevalence of tooth decay has decreased in industrialized countries, but not so in less developed countries [3]. Moreover, the prevalence of dental caries in Egyptian children has remained high with 70% of children with untreated caries experience, mean dmf value of 3.31 ± 3.99, according to the most recent Egyptian epidemiological study in 2014, which was released by the Ministry of Health in collaboration with the WHO. The study highlighted the profound and consequential oral health disparities within the population and that Egypt is still in the process of reducing decay, especially in children [4]. Caries can arise in early childhood as an aggressive tooth decay that affects the primary teeth of infants and toddlers [5]. The etiology of dental caries is multifactorial. Dental caries forms through a complex interaction over time between acid producing bacteria and fermentable carbohydrates, and many host factors including teeth and saliva. Risk for caries includes physical, biological, environmental, behavioral, and lifestyle related factors such as high numbers of cariogenic bacteria, inadequate salivary flow, poor oral hygiene and inappropriate feeding habits [6].

Many types of bacteria have been linked to the cariogenic process, especially large populations of acidogenic and aciduric bacterial species, mainly Streptococcus mutans, Streptococcus sobrinus and Lactobacillus, which are capable of demineralizing hard tooth structure by producing and surviving in an acidic environment [7,8].

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Streptococcus mutans (SM) is the most important microbial factor associated with the prevalence and incidence of caries as it is the most frequently associated microorganism with dental caries. Several studies clarified the tight relationship between caries development and SM scores in plaque and saliva in children [9,10].

Lactobacilli (LB) present in carious lesions represent a major contributor to caries progression rather than caries initiation. There are essential requirements for a sustained colonization of lactobacilli in the oral cavity:

1 a stagnant and retentive niche that is mostly anaerobic;
2 a low pH environment; and
3 access to carbohydrates.

Carious lesions provide these favourable conditions for certain lactobacilli species to thrive. In contrast, these aciduric species are largely absent in caries-free children [11].

The health field has always aimed to use natural products as an alternative to conventional formulations. Xylitol is a naturally occurring non-cariogenic sugar substitute that cannot be metabolized by oral bacteria even if administered for years [12]. Short-term consumption of xylitol was associated with decreased Streptococcus mutans levels in saliva and plaque [13]. Xylitol was found to act by starving Streptococcus mutans, the most challenging cariogenic organism which are cheated by xylitol instead of sucrose and consequently cannot ferment it to produce acid to cause demineralization of hard tooth structure [9]. Lately commercial sugar free -whether xylitol or polyol gum-have gained popularity among consumers for a variety of reasons, for instance decreasing dietary and sugar intake and for their good taste [14].

The act of chewing has been proven to stimulate salivary flow and therefore could be a beneficial caries preventive method, especially if used in conjunction with caries preventive agents such as xylitol as an additional contribution to good oral health [15]. Thus, xylitol and other polyol gum consumption may be an effective and attractive way in decreasing decay in Egyptian children.

Few studies have examined the influence of xylitol gum consumption on the control of risk factors, including mutans streptococci and lactobacilli infection as well as salivary factors, in preschool and school children in Egypt. Although the minimum intervention to achieve some effectiveness is useful from a public health viewpoint, most of the xylitol intervention periods were over six months [16–19]. Moreover, to our knowledge, no previous report has addressed its effects in Egyptian children with deciduous teeth and in the mixed dentition stage.

Thus, the aim of this randomized clinical trial was to compare the effect of xylitol containing and sugar free brands of chewing gum on the salivary CFU count of streptococcus mutans (SM) and lactobacilli (LB) cariogenic organisms in a group of Egyptian school children of different ages.

2. Materials and methods

At the start of investigation, 93 preschool and school age Egyptian children, aging 3–12 years, were examined and given an interactive oral health education session by the primary investigator.

To detect a statistically significant difference with a two-sided 5% significance level and a power of 80%, a sample size of 22 patients per group was necessary, given an estimated dropout rate of 10%. A 4-month inclusion period was anticipated to recruit this number of patients. The Research Ethics Committee of the Faculty of Dentistry, Ain Shams University (FDASU-REC) approved this research.

Forty-two children were selected according to the inclusion and exclusion criteria.

Inclusion criteria included high caries risk group Egyptian children of DMFT/dmft/deft of 3 or more, those who complied to research instructions and belong to the age groups of the investigation; while the exclusion criteria included children with systemic and allergic diseases or mental disorders. Those who report taking antibiotics three weeks prior or during the three weeks period of undergoing the research were excluded. Children with dental prosthesis or orthodontic appliances were also excluded [12].

The volunteer children and their caregivers were informed about the overall aim of the research. A written consent was signed by the caregivers and the participating children before starting the investigation. All materials and instructions required were assured to the participants. All participating children were given the opportunity to be treated at the pediatric clinic of Ain Shams University after the completion of the study.

The included 42 children were assigned codes randomly by a second non-dental investigator. Codes were written with permanent marker on the concealed chewing gum containers so that each code denoted the chewing gum type a participant was going to receive. The 42 children were randomly allocated to either the xylitol gum (Mentos® White Chewing Gum) or sugar-free polyol gum (Mentos® Juice Blast Chewing Gum) group. Each main group was divided into three equal subgroups. Each subgroup comprised a block of seven children of the same age group as follows: Nursery group aging 3–6 years, junior primary school group aging 6–9 years and senior primary school group aging 9–12 years.

2.1. Salivary analysis was carried out at baseline for all participating children as follows:

2.1.1. Collection of stimulated salivary flow

The stimulated salivary flow rate was performed by collecting salivary secretion of each child by letting the child chew on a tablet of paraffin wax for 5 min. For accurate readings the saliva was collected in a graduated sterile saliva jar and the volume of collected saliva was drawn up carefully in 5 ml plastic syringes after air bubbles have resolved.

2.1.2. SM and LB CFU count measurement

The CFU count for both streptococcus mutans and lactobacilli was carried out using CRT® kit by Ivoclar-Vivadent, Lichenstein [20]. The disposable dropper was used to transfer saliva to the vial of the CRT® kit. The vials were coded to prevent investigator bias. The plastic strip covering the two sides of the vial was removed to expose the culture media and the saliva was swabbed by the dropper to each of the sides of the vial assigned for SM and LB. The blue culture medium is for culturing SM while the green culture medium is for culturing LB. Both culture media were thoroughly swabbed with saliva without leaving air bubbles as directed in manufacturer's instructions. The white pellet containing sodium hydrogen carbonate was inserted in the vial and excess saliva from the culture media was allowed to drip off to soak the sodium hydrogen carbonate pellet. The vial was stoppered with its cap and incubated at 37 °C for 48 h. After incubation, the two culture media sides were matched with the supplied index of the CRT® kit to determine the CFU for both cariogenic organisms.

2.1.3. Determination of effect of gum

Children within each age group block were randomly allocated to either xylitol gum group or other polyol gum group. The designated type of chewing gum was supplied to each participant according to the assigned random grouping and coding in a different container than the original chewing gum bottle. The amount delivered to each child was enough for consuming for a period of three weeks taking one gum pellet twice daily [21]. Each child in the xylitol group consumed two chewing gum pellets per day which accounts for a total daily dose of 0.28 g xylitol per day for each child. The participants were instructed to chew the gum after lunch and after dinner for 10 min each, supervised by their caregivers. They were followed up at home by phone calls.

After three weeks, all participants were subjected to bacterial count and salivary analysis once more to determine the effect of consumption

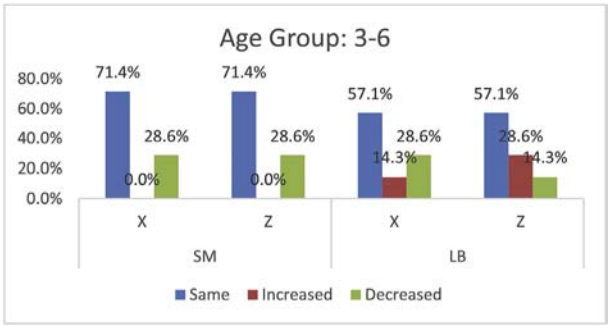

Fig. 1. Bar charts showing the effect of xylitol gum (X) and polyol gum (Z) on SM and LB CFU count in age group from 3 to 6 years.

of both types of chewing gum on the salivary CFU count of both cariogenic organisms.

Outcomes were assessed blindly by the primary investigator and data were recorded, tabulated and statistically analyzed by a blinded statistician using Statistical Package for Social Science (SPSS 20) to determine the effect of xylitol chewing gum in comparison to sugar-free polyol gum.

3. Results

3.1. Data analysis revealed the following results

3.1.1. Comparison between pre and post SM and LB CFU counts for xylitol gum (X) and polyol gum (Z) in different age groups

Fig. 1 shows that after administration of xylitol gum (X) in 3–6 year old children, the SM CFU count of all seven children was less than 100000 colonies. Thus, McNemar test was not applicable. Among children aging 3–6 years and assigned to the polyol gum (Z) group, there was no statistically significant difference at 95% confidence level for the effect of administration of polyol gum (Z) on the SM CFU in age group 3 to 6. (p-value > 0.05).

In age group from 6 to 9 years, McNemar test indicated that there was no statistically significant difference at 95% confidence level for the effect of xylitol gum on the SM CFU count. (p-value > 0.05) **N**one of the 6–9 year old children recorded an SM CFU count below 100000 colonies at baseline and on administration of the polyol gum (Z), the values did not change(Fig. 2).

Regarding the age group from 9 to 12 years, the percentages of SM CFU values and number of individuals remained the same. Statistical analysis revealed no significant difference at 95% confidence level for the effect of xylitol gum (X) on the SM CFU count in this age group. (p-value > 0.05) In the same age group, there was no statistically significant difference at 95% confidence level for the effect of polyol gum (Z) on the SM CFU count. (p-value > 0.05) (Fig. 3).

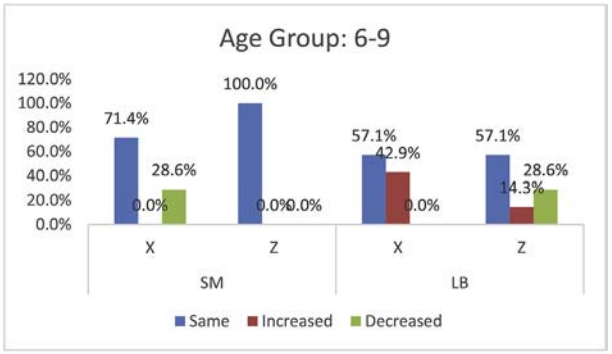

Fig. 2. Bar charts showing the effect of xylitol gum (X) and polyol gum (Z) on SM and LB CFU count in age group from 6 to 9 years.

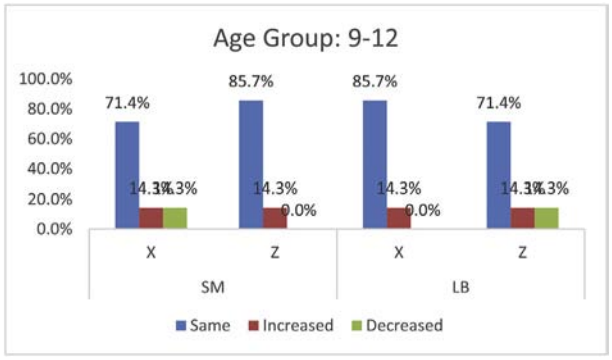

Fig. 3. Bar charts showing the effect of xylitol gum (X) and polyol gum (Z) on SM and LB CFU count in age group from 9 to 12 years.

The maximum effect in decreasing the SM CFU count was seen in the xylitol gum (X) group particularly in children aging 3–6 years, followed by children of age group 6–9 years after taking the xylitol gum (X). On the other hand, the worst effect was recorded in children 9–12 years old receiving polyol gum (Z). There was no statistically significant difference between both gums in their effect on the SM CFU count in the different age groups (Figs. 1–3) and regardless of age group (Fig. 4).

The maximum effect in decreasing the LB CFU count was recorded in case of administration of xylitol gum (X) in the 3–6 year old age group, followed by children of 6–9 years receiving polyol gum (Z). On the other hand the worst effect was recorded in 6–9 year old children taking xylitol gum (X). There was no statistically significant difference at 95% confidence level for the effect of administration of xylitol gum (X) or polyol gum (Z) on LB CFU counts in any of the age groups (Figs. 1–3) and regardless of age group. (p-value > 0.05) (Fig. 4).

Comparison between pre and post SM and LB CFU counts for xylitol gum (X) and polyol gum (Z) regardless of age group.

4. Discussion

The main objective of this clinical trial was to compare the effect of xylitol containing and sugar free brands of chewing gum on the salivary bacterial count of streptococcus mutans (SM) and lactobacilli (LB) cariogenic organisms in Egyptian school children of different ages.

There is a consensus that the main causative organism that plays the most important role in dental caries is the streptococcus mutans due to its acidogenic and proteolytic activities, in addition to its ability to adhere to the tooth surface and the release of extracellular polysaccharides [8,10]. Consequently, the SM CFU count in saliva is considered crucial in determining the patient caries risk [22]. On the other hand, Lactobacilli play a rather very important role in the production of acid and regression of the salivary pH and buffering capacity due to its acidogenic and aciduric characteristics [6,11]. The CRT® kit is a well

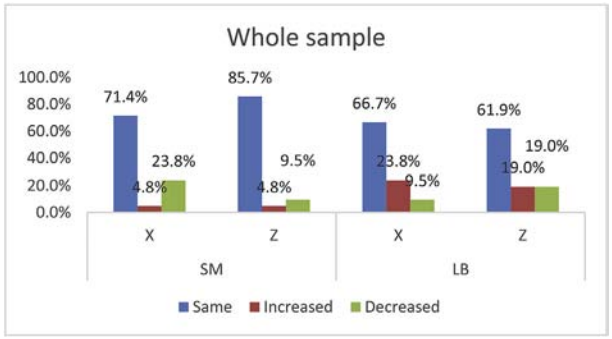

Fig. 4. Bar charts showing the effect of xylitol gum (X) and polyol gum (Z) on SM and LB CFU counts regardless of age group.

known reliable and simple method to calculate the CFU counts of both types of microorganisms and proved success as a simple, rapid chair-side method for precise determination of CFU counts in saliva [20,23].

The SM CFU results show the effect of xylitol chewing gum in decreasing the SM CFU count as reported by Assev et al. who reported that in the presence of xylitol SM bacterial growth was inhibited, which was apparent at 4 h after SM inoculation of glucose-xylitol culture medium. However, the initial growth rate of SM was regained after a short lag period when the xylitol-containing medium was replaced with xylitol-free medium during growth. The role of xylitol in the inhibition of SM growth is probably a consequence of xylitol's ability to starve SM bacteria and consequently the bacteria cannot act on xylitol to produce acids. Thus xylitol should be available to bacteria continuously and at low levels of glucose to have an inhibitory function in vivo as well [24].

Soderling et al. suggested another mechanism of action not associated with growth inhibition but rather with inhibition of adherence of polysaccharide forming streptococci which contributes to plaque accumulation [25].

The results of SM CFU counts after the intake of polyol gum in the different age groups indicate the general role of chewing sugar free gum in decreasing bacterial colonization by the cleaning effect and the increase of salivation with its consequent washing, chemical and mechanical cleaning, in addition to the increase of pH of saliva and its neutralizing effect. This finding supports the idea that polyol gum possesses a less effective mechanism in reducing dental caries compared to xylitol gum. A finding that is in accordance with the results of Campus et al. stating that the long-term use of non-sucrose chewing gums had beneficial effects both on plaque pH and SM salivary concentration, especially xylitol sweetened varieties [18]. It was also in agreement with Mäkinen et al. who hypothesized that pentatols such as xylitol are more effective than hexatols as polyols as gum sweeteners in reducing SM counts and in preventing caries. Burt et al. as well as Mäkinen et al. concluded that the habitual use of small daily quantities of polyol sweetened chewing gum by children is an important additional caries preventive measure in a day care center and home setting [26,27].

As for the effect of both types of gum on the CFU counts of Lactobacilli, results of the intake of xylitol gum and polyol gum in different age groups show that LB count was not affected in the majority of children. This result supports the idea that xylitol has a classical sugar substitute effect on LB unlike its specific effect on SM. A relatively similar effect for the polyol gum and xylitol gum could be seen on LB CFU count, evidenced also by the insignificant difference in statistical analysis of results of LB CFU counts after the intake of gum in both chewing gum groups. This finding goes in parallel with the conclusion of Çaglar et al. and Thabius et al. who found no alterations of salivary LB CFU count in any of their chewing gum groups [28,29].

The result of our study goes in line with Biria et al., who found that the amount of LB bacteria increased after chewing pure mastic gum and xylitol gum but not significantly, whereas probiotic gum decreased LB count significantly [21]. These findings may support the hypothesis of xylitol's unique target which is SM bacteria and that LB count is rather affected by probiotics.

The results of CFU counts of both SM and LB for both types of gums showed no statistically significant difference at 95% confidence level for the effect of age grouping on the CFU counts. This may be attributed to the unification of selection criteria among children in different age groups.

5. Conclusions

Under the conditions of this clinical trial and with respect to the materials and techniques employed, the following conclusions could be detected:

1. Xylitol gum is more effective in decreasing SM count in saliva compared to polyol gum.
2. Xylitol and polyol sugar free gums are comparable in decreasing the LB CFU count in saliva.

Caregivers and their children should be encouraged to consume sugar free chewing gum particularly xylitol containing brands due to its favourable effect on the anti-cariogenic potential of saliva.

More research is needed to investigate the dose dependent effect of xylitol gum on the anti-cariogenic potential of saliva and determine the minimum effective dose and its possible sustained effect.

Declarations of interest

None.

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