JKAU: Med. Sci., **Vol. 17** No. 4, pp: 41-58 (2010 A.D. / 1431 A.H.)
DOI: 10.4197/Med. 17-4.4

Salivary Characteristics in a Sample of Preschool Children with Severe Early Childhood Caries (S-ECC)

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Abstract. The aim of this study is to investigate the salivary counts of mutans streptococci and lactobacilli, as well as measure the saliva buffering capacity and salivary flow rate in a sample of preschool children with severe early childhood caries in Jeddah, Saudi Arabia. The study was designed as a cross-sectional investigation; sixty children diagnosed to have severe early childhood caries were selected and another thirty caries free children were selected as control. Children were selected according to certain criteria; healthy normal, diagnosed as severe early childhood caries and age range 36-71 months. A clinical examination was done to measure decayed, missing and filled index, salivary tests to measure bacterial counts, buffering capacity and salivary flow rate. There was a highly significant difference in streptococcus count ($p = 0.02$), lactobacillus count ($p = 0.00$), between both groups, but there was no significant difference in the saliva buffering capacity and salivary flow rate. Based on the sample of patient studied, it was concluded that *Streptococcus mutans* and lactobacilli counts are major risk factors. Furthermore, there was no statistically significant difference in the saliva buffering capacity and salivary flow rate between the two groups.

Keywords: Salivary characteristics, Preschool children, Severe early childhood caries.

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Accepted for publication: 19 September 2010. Received: 15May 2010.

Introduction

Dental caries continues to be a major problem in dentistry, and should receive significant attention in every day practice. Bowen *et al.*[1] pointed out that, although, it has been observed a decline in caries prevalence for many years, it is clear that dental caries still remains the most prevalent disease-affecting humans.

Early Childhood Caries (ECC) was a new term adopted in 1994 to denote dental caries in infants and preschool children. Recently, ECC was defined by the presence of one or more decayed (noncavitated or cavitated lesions), missing (due to caries) or filled tooth surfaces in any primary tooth in a child 71 months of age or younger[2].

Severe Early Childhood Caries (S-ECC), refers to children with atypical progressive acute or rampant pattern of dental caries. The diagnosis of S-ECC is based upon the age of the child and the extent of caries experience in the primary dentition (number of decayed, missing and filled (DMF) surfaces)[2].

Streptococcus mutans (*S. mutans*), *Streptococcus sobrinus* (*S. sobrinus*) and Lactobacilli are the main bacterial strains involved in human caries[3-5]. Microbiological tests show a close association between cariogenic bacteria and high caries levels in children. Furthermore, there was an association between a low number or the absence of these bacteria, and few or no carious lesions in children[6].

The acidogenic plaque bacteria, especially mutans streptococci and lactobacilli, are associated with stages in the development of dental caries[7,8]. *S. mutans* has been shown to be strongly associated with dental caries, and levels in the mouth were good indication of risk[9].

Kohler *et al*.[10] found that children with a variety of other bacterial species had higher numbers of total mutans streptococci, and a tendency to higher caries prevalence than those with only *S. mutans*. Inconsistencies were found where heavy colonization of *S. mutans* and *S. sobrinus* did not accompany high caries experience[11,12]. This conflict in findings showed that the cause of caries was influenced by biological factors other than high numbers of mutans streptococci[13].

A strong relationship of caries was observed for *S. mutans* at all lesion depths. Also, the data did not indicate a major role for *S. sobrinus*

in ECC, thus, it was not significantly associated with caries, and it was found at lower levels, compared to *S. mutans* and other caries – associated species. Veillonella utilizing lactic acid may be an important factor in the caries process which provided protection for acid-producing bacteria[14].

Mutans streptococci were the principle bacteria isolated from children with ECC[15]. Mutans streptococci were the main bacteria implicated in ECC, and *S. mutans* and *S. sobrinus* species were the most commonly isolated types in human dental caries[12]. Aciduricity appeared to be the most consistent attributes of *S. mutans* and was associated with its cariogenicity. It was also observed that aciduric species such as *S. sobrinus* may be more important in a smooth-surface decay, and was perhaps associated with rampant caries[7].

The early acquisition of *S. mutans* was clearly associated with caries development in the primary dentition[10]. The dental plaque concentration of *S. mutans* in children with ECC ranged from an average of 30-40% to over 50% of the total cultivable plaque flora, and 10% of the salivary flora[16]. In breast fed children with rampant decay, it was reported that levels of *S. mutans* in dental plaque samples were 100 times higher than in children without decay[17]. While the majority of studies have shown that most infants harbored only *S. mutans*, a small percentage may show both, *S. mutans* and *S. sobrinus* or *S. sobrinus* alone. Many studies have reported cases of children harboring both *S. mutans* and *S. sobrinus* who had a significantly higher caries incidence than those with *S. mutans* or *S. sobrinus* alone[18-21]. Mixed colonization with multiple *S. mutans* serotypes might be related to the occurrence of caries, especially in the youngest children. There was also a close relationship between mixed mutans streptococci colonization and caries development in the primary dentition; this mixed infection seemed to be related to dietary habits that included sugar consumption. However, this was not confirmed as there was no evidence for a close relationship between mixed infection and variables regarding dietary habits; habitual use of sweet drinks, frequent snacks, and habitual consumption of sweet snacks and non-use of sugar substitutes[22]. In children with ECC, heavy infection by mutans streptococci of more than one clonal type probably reflected high frequency of sugar consumption[15].

Hata *et al.*[23] found that there was a closer association between the presence of *S. mutans* and the prevalence of dental caries in the 3- and 4-years-old age group than those in the 5- and 6-years-old age group. Children colonized with *S. mutans* at an early age were considered to have higher risk of developing caries. The ratios of *S. mutans* to total bacteria in plaque were closely associated with the prevalence of dental caries.

Stimulated saliva played an important role in the oral clearance of fermentable carbohydrates. The large increase in the salivary flow rate that occurred when saliva was stimulated, increased the rate at which fermentable carbohydrates were cleared from the mouth[24]. At rest, salivary clearance occurred at a much slower rate that may fall to almost zero during sleep, thus, the clearance of fermentable carbohydrates is considerably prolonged[25].

Several medical conditions, therapeutic radiation to the head and neck, and pharmacological agents with xerostomia side effects, lowered the salivary flow rate to pathological level that elevated the patient's risk of caries. However, there was no evidence that physiologically low salivary flow rates produced similar outcome. This may reflect the increased importance of other factors, such as dietary and oral hygiene habits as well as microbial load in determining caries susceptibility in subjects with normal but low salivary flow[26].

A review done by Ericsson[27], showed that the buffering capacity had inverse relationship with human caries incidence. Nomura *et al.*[28] in his study showed that the buffering capacity was significantly correlated with the incidence of dental caries. While other studies done by Twetman *et al.*[29] showed that saliva buffering capacity was not affected by presence or absence of caries, as a result compared between before and after treatment. Also, no significant correlation has been found between salivary flow rate, saliva buffering capacity and caries activity, except when the salivary flow rate was below the threshold level[30].

Leone and Oppenheim[26] in their review, found evidence between poor buffering capacity, and caries were weaker than that of low salivary flow. Most of the studies failed to demonstrate an inverse relationship between saliva buffering capacity and caries experience. Also, buffering capacity can be affected by different foods, such as proteins and carbohydrates[31].

Therefore, the aim of this study was to investigate the salivary counts of mutans streptococci and lactobacilli, as well as to measure the saliva buffering capacity and salivary flow rate in a sample of preschool children with S-ECC) in Jeddah, Saudi Arabia.

Materials and Methods

Study Design

Cross sectional study.

Study Sample

The sample used in this study was selected from the screening clinics of Faculty of Dentistry, KAU. Children that came for dental treatment at the Faculty of Dentistry were referred from the screening clinic during a period of 2 months. Sixty children diagnosed to have S-ECC were selected and 30 other caries free children were selected as control.

Sample Selection

Study Group

Children were selected according to the following criteria

- Healthy, normal
- Diagnosed as S-ECC (according to criteria of AAPD 2006-07)[32]
- Age range 36-71 months

Referred children were re-examined by the principle examiner to reconfirm selection criteria.

Control Group

An age matched control group was selected by reviewing dental records and screening files. Children diagnosed to be caries free were called for clinical examination together with their brothers and sisters. It was only possible to collect 30 children, due to difficulty in obtaining caries free children attending the faculty. Children were examined clinically and bitewing X-ray was performed to exclude proximal caries.

Consent Form

A verbal informed consent was obtained from the parents before clinical examination of their children. The parents were motivated by offering them full dental treatment for their children and performing preventive procedures for caries free children.

In order to study the salivary characteristics associated with S-ECC, the following parameters have been investigated through:

I Clinical examination to measure DMF index

II Salivary tests to measure saliva bacterial counts, buffering capacity and flow rate

I. Clinical Examination

- *Intra Oral Radiographs*

Bitewing radiographs were taken from children to confirm presence or absence of proximal caries and to confirm the presence of sound proximal contacts to exclude class II caries in the control group.

- *Intra Oral Examination*

Clinical examination and recording of observations were carried out by one dentist using mouth mirror and blunt explorer on the dental chair using dental light.

DMFs Score

Caries were recorded in terms of DMFs[2], and were diagnosed when there was a:

- Cavity or white spot apparent on visual and tactile inspection.
- Tooth with history of extraction due to pain and presence of cavity prior to extraction.
- Presence of dental restoration.
- Radiolucency as seen in bitewing radiographs.

Teeth missing because of trauma, congenital absence or normal shedding (exfoliated) were not counted as caries.

The criteria of the American Academy of Pediatric Dentistry was used which defined ECC as the presence of one or more decayed (noncavitated lesions, white lesions, or cavitated lesions), missing due to caries or filled tooth surfaces in any primary tooth in a child 71 months of age or younger. From age 3 through 5, one or more cavitated, missing (due to caries), or filled smooth surfaces in primary maxillary anterior teeth, or decayed, missing, or filled score of ≥ 4 at age 3, ≥ 5 at age 4 or ≥ 6 at age 5 constituted S-ECC[32].

II. Saliva Testing

The CRT saliva testing kit (Ivoclar Vivadent AG, Principality of Liechtenstein) was used to measure salivary characteristics. Before

collecting saliva, the child was asked to abstain from eating for at least one hour, and it was confirmed that they were not receiving any antibiotic treatment for 2 weeks. The following characteristics were identified:

1. Bacterial counts of both
   a. Mutans streptococci
   b. Lactobacilli
2. Buffering capacity of saliva
3. Salivary flow rate

1) Bacterial Counts

CRT bacteria kit (Ivoclar Vivadent AG, Principality of Liechtenstein) was used to determine the mutans streptococci and lactobacilli counts in saliva by means of selective culture media.

The CRT tube contained two-agar surfaces; the bright green agar surface for determination of lactobacilli count in saliva and plaque, and the blue agar surface for determination of mutans streptococci count in saliva, or plaque.

Application

The test was professionally conducted by the dentist and trained personnel.

The following steps were taken as to perform the test according to manufacturer's instructions:

1. Using the same saliva that was collected for saliva flow rate and buffering capacity.

2. The agar carrier was removed from the test vial.

3. The $NaHCO_3$- tablet was placed at the bottom of the vial; it was activated by placing two drops of water.

4. The protective foils were carefully removed from the two agar surfaces without touching the agar medium.

5. Then, both agar surfaces were wetted carefully with saliva using a pipette; avoiding scratching the agar surface.

6. The agar carrier was slide back into the vial and the vial was closed tightly.

7. White adhesive paper was cut into small pieces and was placed on the test vial to note the name of the patient and the date.

8. The test vial was placed in an upright position in the incubator of the same company (Cultura, Ivoclar Vivadent); the temperature of the incubator was set at 37°C/99°F.

9. After 48 h the vial was removed from the incubator. The agar carrier was held slightly oblique under a light source to facilitate the evaluation.

10. The density of the mutans streptococci and lactobacilli colonies was compared to corresponding evaluation pictures in the enclosed model chart in the kit.

The child was considered having high bacteria count when it was $\geq 10^5$ CFU/ml saliva, and was considered having low bacterial count when it was $\leq 10^5$ CFU/ml. These measures were recorded separately for Lactobacilli and streptococci.

2) Saliva Buffering Capacity

The saliva buffering capacity was measured using CRT kit (Ivoclar Vivadent AG) following the manufacturer's instructions:

- The CRT buffer test strip was removed carefully from the packaging without touching the yellow test field.
- Then, the test strip was placed on a stable; absorbent paper with the yellow test field facing upwards.
- The entire yellow test field was wetted with saliva using the provided pipette. It was very important to avoid scratching the test field with the pipette. The saliva should be allowed to drop off and prevent the formation of bubbles in the saliva.
- The buffering capacity of saliva was determined by comparing the color of the test field with the color samples provided in the kit after exactly 5 min of reaction time. The blue color indicated a high buffering capacity, while the green color indicated medium buffering capacity of saliva, and the yellow color indicated low buffering capacity. The values were given scores 3, 2 and 1, respectively.

If the test field was blotchy, the buffer capacity was rated according to the most unfavorable color present; in case of doubt the test was repeated.

3) Salivary Flow Rate

A stimulated saliva sample was collected from every child, by asking the child to chew a standardized piece of paraffin wax for 5 min and sitting in a relaxed upright position. Then, the saliva was collected in a graduated container to measure the flow rate in ml/min. The same salivary sample was used to measure the other saliva characteristics.

Statistical Analysis

All the data were collected tabulated and statistically analyzed using Statistical Package for Social Sciences (SPSS) version 10. Odds ratio and unpaired *t*-test were used according to the need. The level of significance used was 5%.

Results

The sample was composed of 90 children (60 study and 30 controls), 39 of them were males while 51 were females. The mean age of children in the study group was 4 years and 8 months, compared to 4 years and 5 months in the control; the study and the control groups did not differ significantly in the age.

The mean of decayed teeth (d) was 16.5, missing (m) 2, filled (f) 4.8 and DMFs was 23.3, while the mean number of teeth was 19.6.

Saliva bacterial counts, buffering capacity and flow rate were measured through laboratory methods.

Saliva Bacterial Counts

Mutans Streptococci

Table 1 shows that there was a high significant difference in Streptococcus count between both groups ($p = 0.022$). The value of the odds ratio indicates that the child who has a high Streptococcus count, may have a 2.82 times more chance to be at risk of caries more than the child who has a low Streptococcus count (Fig. 1).

Table 1. Streptococci count in study and control groups.

Streptococcus Count	Study		Control		Odds Ratio	*p*
	Count	%	Count	%		
Low	19	31.7	17	56.7	1	
High	41	68.3	13	43.3	2.82	0.022
Total	60	100.0	30	100.0		

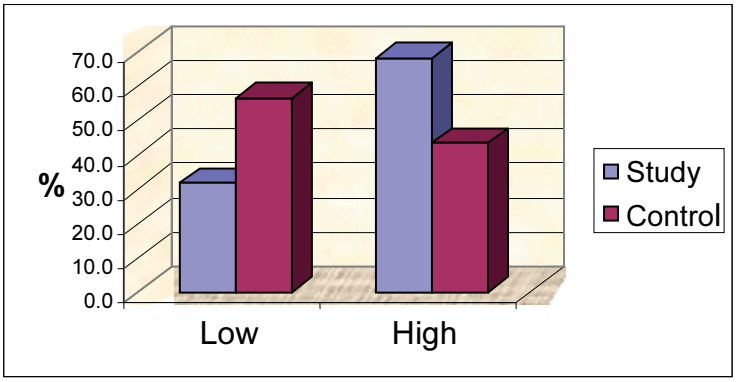

Fig. 1. Percentage of children with high or low Streptococcus count in the study and control groups.

Lactobacilli

A highly significant difference in Lactobacillus count between study and control group (p = 0.000) was observed in Table 2. The value of the odds ratio indicates that the child who has a high Lactobacillus count may have a chance about 24 times to be at risk of caries more than the child who has a low Lactobacillus count (Fig. 2).

Table 2. Lactobacilli count and percentage in study and control groups.

Lactobacillus Count	Study		Control		Odds Ratio	p
	Count	%	Count	%		
Low	22	36.7	28	93.3	1	
High	38	63.3	2	6.7	24.18	0.000
Total	60	100.0	30	100.0		

Saliva Buffering Capacity and Flow Rate

The mean salivary buffering capacity was 2.7 ± 2.5 for the study group compared to 2.5 ± 0.8 for the control. The difference was not statistically significant (t = 0.320) p = 0.750. The mean salivary flow rate was 1 ml/min ± 1 for the study group compared to 1.5 ml/min ± 1.3

for the control. Again the difference was not statistically significant (t = 1.851) p = 0.067 (Table 3).

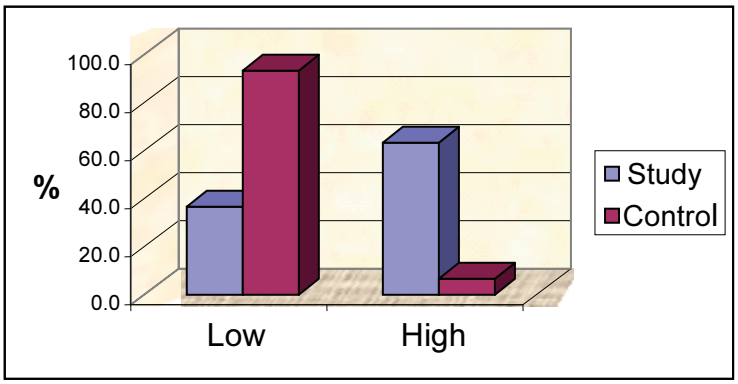

Fig. 2. Percentage of children with high or low Lactobacilli count in the study and control groups.

Table 3. The mean saliva buffering capacity and flow rate (ml/min) in study and control groups.

	Group	Mean	SD	*t*	p
Salivary Flow	Study	1.0	1.0	-1.851	0.067
	Control	1.5	1.3		
Salivary buffer capacity	Study	2.7	2.5	0.320	0.750

Discussion

The present study assesses the relationship between dental caries experience and several risk factors; namely Streptococcus and Lactobacillus counts in saliva, salivary buffering capacity and flow rate.

Streptococcus and Lactobacillus Counts in Saliva

In this study, there were significantly higher streptococcus and lactobacillus counts in children with S-ECC (study group). This indicates that children with high streptococcus and lactobacillus counts are at higher risk of developing caries. This finding agrees with Campus *et al*.[33] who found that high caries incidence was related to salivary mutans streptococcus and lactobacillus count in children with primary teeth, while the higher score of lactobacilli was more related to the presence or absence of caries in the permanent teeth.

Our result again agree with Nomura *et al*.[28] and Twetman *et al.*[29], in that *S. mutans* are considered the strongest risk factor for dental caries. Moreover, their high count reflects the severity of the disease as there was a strong association between the levels of mutans streptococci with dental decay in the primary dentition of preschool children as proven by Vachirarojpsan *et al.*[34] Also, Ohlund *et al*.[35] found that caries was strongly and positively associated with the salivary level of mutans streptococci (OR = 1.57).

It was proven that streptococcus count is more related to the number of teeth present as they need non-shedding surfaces in order to colonize the oral cavity. Whereas, Lactobacilli are highly dependent on the presence of retentive sites and are less frequently detected in the saliva of young children[29,36,37].

Our study showed that the odds ratio for lactobacilli was higher than the odds ratio for Streptococci. This could be explained by the fact that our study included children with S-ECC characterized by severely progressive cavitated lesions, which acted as retentive sites for the lactobacillus. It was also reported by many authors, that the high level of Lactobacilli in saliva reflects the total consumption of carbohydrate, and it lies in the progression of the disease rather than in the initiation of the disease[29,37,38].

Lactobacillus is considered to play a secondary or opportunistic role in the development of dental caries by producing lactic acid and extracellular polysaccharides[7]. In our work, presence of mutant streptococcus in the study group was implicated as the main bacteria causing caries. And, that mutans streptococci were the principle bacteria isolated from children with ECC, which again agrees with the work of several authors[15,39,40]. There was strong relationship of *S. mutans* to dental caries at all lesion depths. As the role of lactic acid production by *S. mutans* in caries pathogenesis was well documented, and numerous clinical investigations have shown a strong association between caries and the presence of *S. mutans*[14,41].

In another study, mixed mutans streptococcus (*S. mutans*, *S. sobrinus*) colonization was found to be a novel measure correlated with caries development in the primary dentition [22].

Failure to correlate Lactobacillus and other bacterial species to decayed surfaces and decayed missing filled surfaces means that individually. These bacteria do not cause dental caries, but they help to initiate caries together with mutans streptococci by participating symbiotically, utilizing dietary carbohydrate and producing acids by heterolactic fermentation[13]. A diet comprising caries–conductive carbohydrates can influence levels of mutans streptococci and lactobacilli due to high plaque acidity, which provides these organisms with growth advantage over other less aciduric bacteria[5]. Also, the exposure to intermittent exogenous nutrients in the form of foodstuff, increases the availability of nutrients to the microflora, yet its growth limits to some bacteria, causing shifts in the microbial population[13].

The ability of oral bacteria to integrate within a biofilm is pivotal to their survival. Biofilm formation by lactobacilli in mono-culture was poor, and not necessarily an indicator of their survival and pathogenic potential in complex multispecies plaque biofilm communities. However, co-culture with *S. mutans* promoted substantial biofilm growth of lactobacilli. The role of lactobacilli in plaque ecology and disease may differ, and interspecies modifications of their prevalence in plaque biofilm may prove important [42].

Salivary Buffering Capacity and Salivary Flow Rate

This study shows no significant difference in the saliva buffering capacity and the flow rate between the two groups. This coincide with what have been found in other studies, which showed that saliva buffering capacity is not affected by presence or absence of caries, as a result of comparison between before and after treatment[29]. No significant correlation has been found between salivary flow rate, saliva buffering capacity and caries activity, except when the salivary flow rate was below the threshold level[30]. Our work disagrees with one study, which showed that the buffering capacity was significantly correlated with the incidence of dental caries[28].

Lower salivary flow rate due to pathological condition, therapeutic radiation therapy to head and neck, and pharmacological agents with xerostomia side effects elevates the patient's risk of caries. However, there was no evidence that physiologically low salivary flow rates produce a similar outcome. Also, many studies on the salivary buffering

capacity/or pH failed to demonstrate an inverse relationship between these two parameters and caries experience[26].

The interpretation of salivary buffering test in isolation is questionable, in most investigation; there is little or no correlation with variables measuring different aspects of dental caries. One important explanation is that the decisive events in a carious attack take place in the plaque and below the enamel surface in these loci; the buffering mechanism are very different from those found in saliva[43].

Conclusions

Based on the sample of patient studied, the following was concluded: 1.) *S. mutans* and lactobacilli counts are major risk factors; 2.) There was no statistically significant difference in the saliva buffering capacity and salivary flow rate between the two groups.

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خصائص اللعاب في عينة أطفال ما قبل المدرسة ذوي تسوس شديد في الطفولة المبكرة (S-ECC)

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المستخلص. هدف الدراسة هو التحقيق في العدد اللعابي لإنزيمات الكور السبحية والعصبة اللبنية، وقياس قدرة تحقيق اللعاب ومعدل تدفق اللعاب في عينة من أطفال ما قبل الدراسة ذوي تسوس شديد في الطفولة المبكرة في مدينة جدة بالمملكة العربية السعودية، وكان التصميم عبارة عن دراسة ضبط حالات لعدد ستين طفلاً ذوي تشخيص تسوس شديد في الطفولة المبكرة تم اختيارهم، وعدد آخر من ثلاثين طفل خالين من التسوس كمجموعة ضابطة. وقد تم اختيار الأطفال طبقًا لمعايير معينة : أصحاء- عاديين وذوي تشخيص تسوس شديد في الطفولة المبكرة، ويتراوح العمر ما بين ٣٦-٧١ شهرًا، وقد تم إجراء فحص إكلينيكي لقياس مؤشر التسوس و المفقود والمحشو واختبارات لعاب لقياس مرات البكيتريا والقدرة التخفيفية ومعدل تدفق اللعاب. كان هناك فرق

ملحوظ بدرجة عالية في عدد الكرات السبحية (p = ٠,٠٢) وعـــدد العصبات اللبنية (p = ٠,٠٠) بين المجموعتين، لكن لم يكن هنـــاك فرق ملحوظ في قدرة التخفيف اللعابي ومعدل تدفق اللعاب. وبنـــاءً على دراسة عينة من المرضى كان الاستنتاج أن إنزيمات الكـــرات السبحية ومرات العصبة اللبنية عوامل مخاطرة أساسية، كذلك لـــم يكن هناك فرق ملحوظ إحصائيًا في مقدرة التخفيف اللعابي، ومعدل تدفق اللعاب بين المجموعتين.