Acta Odontologica Scandinavica, 2007; 65: 162–166

informa
healthcare

ORIGINAL ARTICLE

Stimulated salivary flow rate and buffer effect in schoolchildren from Greenland and Sweden: A comparative study

LILLEMOR BJÖRNSTAD[1] & CLAES-GÖRAN CROSSNER[2]

[1]*Department of Hospital Dentistry, Västerås Central Hospital, Västerås, Sweden and* [2]*Institute of Clinical Dentistry, Faculty of Medicine, University of Tromsø, Tromsø, Norway*

Abstract

Objective. To compare food habits and stimulated salivary flow rate and buffer effect between schoolchildren from Greenland and Sweden and to evaluate whether the change in lifestyle concerning eating habits in Sweden during recent decades has resulted in any obvious alteration in these salivary properties. ***Material and methods.*** Fifty healthy schoolchildren from Greenland were included and compared with 50 age-matched and gender-matched Swedish children. Whole saliva stimulated by chewing was collected, and prior to sampling each participant filled in a simple questionnaire regarding their food habits. ***Results.*** Salivary flow rate and buffer effect were significantly ($p < 0.001$) higher for the Greenlandic children. The difference in flow rate was on average 0.71 ml/min. Milk, fish/meat and fruit/vegetables were more frequently consumed by the Swedish children, while snacks, soft drinks and sweets had a higher consumption frequency on Greenland. No obvious correlation could be found between consumption frequency of the tested food products and flow rate or buffer effect of saliva. Twenty-nine Swedish children were within the age range ± 6 months of an age with earlier documented values of stimulated salivary flow rate. Twenty-six of these 29 Swedish children were within the 25–75 percentile range of the old values, while 22 of their Greenlandic "twins" were in or above percentile 75. ***Conclusions.*** Obvious differences in salivary flow rate and buffer effect between schoolchildren from Greenland and Sweden illustrated the importance of being cautious when exchanging reference data between different cultures/ethnic groups.

Key Words: *Consumption frequency, food habits, salivary properties*

Introduction

Dental caries is the most common dental disease in children and adolescents. It is a typical so-called "lifestyle disease" mainly depending on food habits and daily oral hygiene procedures. Today, we have a fairly good knowledge of the origin as well as the pathogenesis of the disease. In consequence, during the second half of the 20th century, through more preventive oriented dental care, there are numerous reports of a continuous improvement in the incidence as well as the increment of dental caries in Western industrialized countries [1–4]. By the end of the 20th century, however, a well-documented stagnation in this improvement had taken place [5,6], and there is recent evidence for a reversal in the decline of dental caries among children [7]. At the same time, there is also recent documentation of an increase of dental erosion in children and teenagers [8,9]. This is another food-related dental disease caused by the frequent intake of sour products, and in this age group most probably mainly due to the high consumption of soft drinks [6]. A change in lifestyle during recent decades has resulted in an increased frequency of in-between-meal-eating of "fast food", snacks, soft drinks and sweets at the expense of regular meals [6,10]. Besides alarming medical reports of over weight/obesity problems in children [11], this change in food habits might also be a contributing factor to the recently reported impairment of children's dental health.

Many food products are good mechanical and/or gustatory stimulants of saliva production, and it is a well-known fact that, world-wide, there are large variations in diet and food pattern. There are also reports supporting that a change in dietary pattern in the long term will influence the flow rate and buffer

Correspondence: Claes-Göran Crossner, Institute of Clinical Dentistry, Faculty of Medicine, University of Tromsø, NO-9037 Tromsø, Norway. Tel: +47 77 64 91 21. Fax: +47 77 64 91 01. E-mail: claes.crossner@fagmed.uit.no

(Received 24 October 2006; accepted 27 December 2006)

ISSN 0001-6357 print/ISSN 1502-3850 online
DOI: 10.1080/00016350601187132

effect of saliva [12,13]. Consequently, it is possible that the recent change towards an increased consumption of "junk food", easily chewable and rich in energy, has had a negative impact on salivary properties, and the available data on flow rate and buffer effect of stimulated whole saliva in healthy Swedish schoolchildren are rather old [14,15]. Besides a reduction in quantity due to poor mechanical stimulation, the change in quality of saliva will not only affect salivary bicarbonate and buffering ability, but also electrolytes such as calcium, phosphate and fluoride [16]. Any factor influencing secretion or composition of saliva might ultimately influence susceptibility to dental caries and dental erosion through changes in oral clearance, buffering of acids, demineralization and remineralization.

The research hypotheses for this study were that dietary differences between children from Greenland and Sweden had an impact on salivary flow rate and buffer effect and that the changes in food habits in Sweden during recent decades might have influenced these salivary properties. Therefore, the aim was to compare food habits and stimulated salivary flow rate and buffer effect between schoolchildren from Greenland and Sweden and at the same time try to evaluate whether the change in lifestyle concerning eating habits in Sweden had resulted in any obvious alteration in these salivary properties.

Material and methods

In 2004, 50 consecutive healthy schoolchildren (20 boys and 30 girls) visiting the public dental health clinic in Maniitsoq, Greenland, were included in this study. Their mean age was 12.5 years (12.3 for the boys and 13.2 for the girls), with an age range from 9.0 to 14.6 years. For comparison, 1 year later, 50 healthy Swedish schoolchildren attending the public dental health clinic in Laxå, Sweden were selected to participate. They were chosen by sex and age to match each child from Greenland as closely as possible. However, administrative problems caused some delay in the investigation of the Swedish children, and they ended up being on average 0.4 year (5 months) older than their Greenlandic "twins".

Prior to saliva sampling, each participant was asked to fill in a simple questionnaire regarding their food habits. Consumption frequency (several times daily; once daily; several times weekly; once weekly; seldom/never) was checked for milk, fish/meat, fruit/vegetables, snacks (potato chips, pop corn, cheese doodles, corn chips, etc.), soft drinks and sweets. When the results were analyzed, these six different groups of food products were also dichotomized into daily intake or not.

Stimulated mixed whole saliva was collected using a standardized sampling procedure. Every sample was taken between 0830 and 1030 h, and the child was asked not to eat or drink anything within 1 h prior to the visit. While sitting comfortably and relaxed, saliva stimulated by chewing a piece of paraffin wax was collected by spitting into a graduated disposable cup for 5 min. After collection, the cup was shaken in order to reduce froth. The amount of saliva was read off and the flow rate was expressed in ml/min. The buffer effect was determined immediately after sampling using the commercial Dentobuff Strip® test (Orion Diagnostica, Espoo, Finland) [17] and was expressed as low (final pH $\leq$4.0), medium (final pH 4.1–5.9) or high (final pH $\geq$6.0) depending on the color indicated.

The study design has been ethically approved in both Denmark and Sweden. Participation has been voluntary and, after being properly informed, all participants as well as their parents have given their written consent. Information gathering, sampling and recording, both on Greenland and in Sweden, were done by the same person, one of the authors (L.B.).

Statistics

All statistical analyses were performed with SPSS 13.0 for Windows using Student's t-test and the χ^2-test, Wilcoxon signed ranks test or sign test. Statistical significance was set at $p < 0.05$.

Results

The flow rate, as well as the buffer effect of mixed whole saliva stimulated by chewing, was significantly ($p < 0.001$) higher for the children from Greenland than for the Swedish children (Tables I and II). The results from both Greenland and Sweden showed no significant gender difference (Table I). Milk, fish/meat and fruit/vegetables were more frequently consumed by the Swedish children, while snacks, soft drinks and sweets had a higher consumption frequency on Greenland (Table III). The dichotomized food variables together with salivary flow rate and buffer effect were tested using rank and sign tests by comparing the 50 age-matched and gender-matched pairs of children. The results confirmed the variation in the dietary pattern between the two populations, as well as the highly significant differences in the salivary properties (Table IV). In this

Table I. Mean values and standard deviations (SD) of stimulated salivary flow rate (ml/min) and level of statistical significance between the 50 participants from Greenland and the 50 age-matched and gender-matched Swedish children

	Boys ($n=20$) Mean (SD)	Girls ($n=30$) Mean (SD)	Total ($n=50$) Mean (SD)
Greenland	2.55 (1.04)	2.56 (0.79)	2.55 (0.93)
Sweden	1.93 (0.65)	1.71 (0.53)	1.84 (0.61)
p-value*	<0.01	<0.001	<0.001

*Student's t-test.

Table II. Number of children with low (final pH $\leq$4.0), medium and high (final pH $\geq$6.0) values of salivary buffer effect, and the level of statistical significance between the participants from Greenland and Sweden

	Low	Medium	High	
Greenland	1	18	31	p-value*
Sweden	10	30	10	<0.001

*χ^2-test.

material, no obvious correlation could be found between the consumption frequency of the tested food products and the flow rate or buffer effect of stimulated whole saliva.

Of the 50 Swedish children, 29 were within the age range $\pm$6 months of an age with earlier documented values of salivary flow rate stimulated by chewing and expressed in percentiles [14,15]. Twenty-six of these 29 children were found to be within the 25–75 percentile range of the old Swedish values, while 22 of their Greenlandic "twins" were in or above percentile 75.

Discussion

Despite being slightly younger, the children from Greenland had a significantly higher flow rate (on average 0.71 ml/min) of stimulated mixed whole saliva in comparison with the age-matched and gender-matched Swedish children. According to earlier published so-called "normal values" for Swedish children in the investigated age group, the stimulated flow rate will increase by around 0.2 ml/min yearly for both boys and girls, while the gender difference is roughly 0.3 ml/min, the boys having the higher value [14,15]. These are facts explaining the similarity in flow rate between the boys and the girls in the present study, as the girls were almost 1 year older than the boys. The flow rate is the main factor affecting the composition of saliva and the bicarbonate ion is one of several constituents that will rise in concentration with increased flow rate [18]. This electrolyte is known to be responsible for the most important buffering system in stimulated saliva, and in agreement with a documented positive correlation between salivary flow rate and buffer effect in children [14] the saliva of the Greenlandic children had a significantly better buffer effect as well.

Even the very simple anamnestic data recorded in the present study revealed obvious differences in food habits between the children from Greenland and the children from Sweden. In order to avoid being statistically misled by less important variations in consumption frequency – such as whether the intake of milk and fish/meat was once or several times a day, or whether sweets and soft drinks were consumed once weekly or seldom/never – the six different groups of food products were also dichotomized into daily intake or otherwise. From a general health aspect as well as from a dental caries promoting point of view, the Swedish children seemed to eat a better composed diet with less in-between-meal consumption of refined carbohydrates. On the other hand, no indication of a correlation between variations in consumption frequency of the different food products and salivary properties could be found. For example, a suggested positive relationship between fruits/vegetables and buffer effect [12] could not be verified in the present study when daily or more frequent intake was compared to once a week or less. At the same time, it has to be stressed that in the present material, when point of origin, age and sex had been taken into proper account, the comparable groups became rather small. In general, however, there seems to be little evidence supporting the fact that differences in diet will exert systemic effects on salivary flow rate and composition [19].

A more likely explanation for the differences in recorded salivary properties as far as food habits are concerned was the masticatory effect. Despite the strong influence from Western industrialized countries, Greenlandic society retains much of its traditional diet of dried and tough meat from fish, seal, whale and musk-ox, and it is a well-known fact that a diet requiring much chewing and substantial bite force has a very strong positive correlation with flow rate [12,19–21]. Other possible explanations could be differences in interest in participating in salivary sampling between the two groups of children, differences in climate, and/or that the Greenlandic children were physically more active and mature compared to the age-matched and gender-matched

Table III. Differences in consumption frequency of different food products between the 50 schoolchildren from Greenland (G) and Sweden (S)

	Milk G/S	Fish/meat G/S	Fruit/veg. G/S	Snacks* G/S	Soft drinks G/S	Sweets G/S
Several times/day	3/27	6/9	14/17	2/0	5/1	8/0
Once a day	22/13	25/18	7/15	5/1	11/1	6/0
Several times/week	1/2	7/19	6/11	0/5	4/18	7/14
Once a week	17/4	12/3	19/6	38/40	27/25	21/32
Seldom/never	7/4	0/1	4/1	5/4	3/5	8/4
p-value	<0.001	<0.01	<0.05	<0.05	<0.001	<0.001

*Snacks = potato chips, pop corn, cheese doodles, corn chips, etc.

Table IV. Comparison of stimulated salivary flow rate (ml/min), buffer effect (high, medium, low) and consumption of different food products (dichotomized into daily intake or not) between the 50 age-matched and gender-matched schoolchildren from Greenland (G) and Sweden (S)

	Flow rate	Buffer effect	Milk	Fish/ meat	Fruit/vegetables	Snacks	Soft drinks	Sweets
G positive rank	34	29	6	12	7	7	16	14
G and S tied	4	18	24	30	25	42	32	36
S positive rank	12	3	20	8	18	1	2	0
p-value*	<0.001	<0.001	<0.01	NS	<0.05	NS	<0.001	<0.001

*Wilcoxon signed ranks test was used for the flow rate and the ordinary sign test for the remaining variables.

Swedish children. The first factor can never be ignored, of course, but was kept under control by keeping participation entirely voluntary and by having the same investigator gather all the individual information and monitor every sampling procedure. When it comes to the influence of climate on stimulated salivary flow rate in children, there is little available information. Unstimulated flow rate has been reported to be inversely associated with ambient temperature [22], and it is likely that a very hot climate has a negative impact on stimulated flow due to dehydration. The present study was performed on Greenland during September and October and in Sweden during January and February, facts not conducive to the Swedish children being more dehydrated. Physical differences, however, are documented and quite recently Krause et al. [23] reported that in the age range of the present material, compared with Danes, Greenlandic Inuits have a significantly better lung capacity. A difference that according to the authors could have clinical implications is that Greenlandic children with subnormal lung volumes could falsely be classified as healthy if Danish children and adolescents are used as reference material. In other words, it is quite possible that at least some of the salivary differences between the Greenlandic and Swedish children might be of genetic origin.

The salivary flow rate of the Swedish children in the present study expressed as distribution within different percentiles was in good agreement with the old so-called "normal values", and did not indicate any obvious alterations in salivary flow due to a change in lifestyle concerning food habits. At the same time, distribution of the age-matched and gender-matched "twins" from Greenland within the different percentiles of the Swedish normal variation of stimulated flow rate, in agreement with the report on lung volume by Krause et al. [22], clearly showed the importance of being cautious when using reference data from one culture or ethnic group to another.

It can be concluded from this study that the schoolchildren from Greenland had a significantly higher flow rate and better buffer effect of saliva than the age-matched and gender-matched Swedish children. There were also obvious differences in food habits between the children from Greenland and Sweden. However, the study design did not allow any firm conclusions concerning whether and how specific nutrient effects might influence the variation in salivary properties. Furthermore, no difference of any clinical importance could be verified between stimulated flow rate of mixed whole saliva registered in 13 to 15 year-old Swedish children in 2005 compared to results reported 20–30 years earlier [14,15].

References

[1] Hugoson A, Koch G, Göthberg C, Nydell Helkimo A, Lundin S-Å, Norderyd O, et al. Oral health of individuals aged 3–80 years in Jönköping, Sweden during 30 years (1973–2003). II. Review of clinical and radiographic findings. Swed Dent J 2005;29:139–55.

[2] Marthaler TM. Changes in dental caries 1953–2003. Caries Res 2004;38:173–81.

[3] Petersson GH, Bratthall D. The caries decline: a review of reviews. Eur J Oral Sci 1996;104:436–43.

[4] Mejáre I, Källestål C, Stenlund H. Incidence and progression of approximal caries from 11 to 22 years of age in Sweden: a retrospective radiographic study. Caries Res 1999; 33:93–100.

[5] Poulsen S, Malling Pedersen M. Dental caries in Danish children 1988–2001. Eur J Paediatr Dent 2002;12:306–15.

[6] Stecksen-Blicks C, Borssén E. Dental caries, sugar-eating habits and toothbrushing in groups of 4-year-old children 1967–1997 in the city of Umeå, Sweden. Caries Res 1999; 33:409–14.

[7] Haugejorden O, Birkeland JM. Evidence for reversal of caries decline among Norwegian children. Int J Paediatr Dent 2002;12:306–15.

[8] Johansson A-K. On dental erosion and associated factors [Thesis]. Swed Dent J 2002;Suppl 156.

[9] Larsen MJ, Poulsen S, Hansen I. Erosion of the teeth: prevalence and distribution in a group of Danish school children. Eur J Paediatr Dent 2005;6:44–7.

[10] Bruno-Ambrosius K, Swanholm G, Twetman S. Eating habits, smoking and toothbrushing in relation to dental caries: a 3-year study in Swedish female teenagers. Int J Paediatr Dent 2005;15:190–6.

[11] Magnusson MB, Hulthén L, Kjellgren KI. Obesity, dietary pattern and physical activity among children in a suburb with high proportion of immigrants. J Human Nutr Diet 2005;18: 187–94.

[12] Johansson G, Birkhed D. Effect of long-term change from a mixed to a lactovegetarian diet on human saliva. Arch Oral Biol 1994;39:283–8.

[13] Johansson I, Saellström AK, Rajan BP, Parameswaran A. Salivary flow and dental caries in Indian children suffering from chronic malnutrition. Caries Res 1992;26:38–42.

[14] Andersson R, Arvidsson E, Crossner C-G, Holm A-K, Månsson B, Grahnén H. The flow rate, pH and buffer effect of mixed saliva in children. J Int Assoc Dent Child 1974;5:5–12.
[15] Crossner C-G. Salivary flow rate in children and adolescents. Swed Dent J 1984;8:271–6.
[16] Lingström P, Moynihan P. Nutrition, saliva and oral health. Nutrition 2003;19:567–9.
[17] Ericson D, Bratthall D. Simplified method to estimate salivary buffering capacity. Scand J Dent Res 1989;97: 405–7.
[18] Nauntofte B, Tenovuo JO, Lagerlöf F. Secretion and composition of saliva. In: Fejerskov O, Kidd E, editors. Dental caries: the disease and its clinical management. Oxford: Blackwell Munksgaard; 2003. p. 7–27.
[19] Pedersen AM, Bardow A, Beier Jensen S, Nauntofte B. Saliva and gastrointestinal function of taste, mastication, swallowing and digestion. Oral Dis 2002;8:117–29.
[20] Yeh CK, Johnson DA, Dodds MWJ, Sakai S, Rugh JD, Hatch JP. Association of salivary flow rates with maximal bite force. J Dent Res 2000;79:1560–5.
[21] Mioche L, Bourdiol P, Monier S. Chewing behaviour and bolus formation during mastication of meat with different textures. Arch Oral Biol 2003;48:193–200.
[22] Kavanagh DA, O'Mullane DM, Smeeton N. Variation of salivary flow rate in adolescents. Arch Oral Biol 1998;43: 347–52.
[23] Krause TG, Pedersen BV, Thomsen SF, Koch A, Wohlfahrt J, Backer V, et al. Lung function in Greenlandic and Danish children and adolescents. Respir Med 2005;99:363–71.