Interrelation Between Salivary *p*H, Buffer Capacity and Dental Caries in Underweight, Normal Weight and Overweight Children

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The prevalence of dental caries in Romania remains high. The objective of this study is to analyse the link between dental caries, salivary pH and buffer capacity and the nutritional status in children. This cross-sectional study used a sample of 162 children, between the ages of 6 and 12 years, from Mures County, Romania. The prevalence of caries was measured using the decayed, missing, and filled teeth index for deciduous teeth (dmft index) and for permanent teeth (DMFT index). In addition, height and weight were assessed for each subject, and their body mass index (BMI) was calculated. The buffer capacity and the pH was determined after collecting stimulated saliva. Undernourished children presented a higher caries incidence and a lower salivary pH value compared with the normal weight and overweight children. Further longitudinal studies should be conducted in order to study the relationship between BMI, pH, dental caries and salivary buffer capacity. Future preventive programs should include nutrition control in order to prevent both the apparition of dental caries and of malnutrition.

Keywords: BMI, dental caries, children, saliva, pH, buffer capacity

Actually, the dental medicine is focused on the preventive approach, on early diagnosis of the incipient carious lesions and customized dental treatments of the carious disease [1].

The growth and development of a child are highly influenced by nutrition. Dental caries, a disease affecting both adults and children worldwide, is the main cause of dental pain [2]. The pain caused by dental caries can affect mastication, reducing food intake or even causing growth disruption [3,4]. Its high morbidity potential makes it a primary research subject for dental health professionals. An emerging and fast growing trend is the study of associations between dental caries and systemic diseases [3]. Because caries represent a multifactorial condition, salivary properties and nutritional status of patients should be recorded and analysed in order to clarify their role as risk factors in the devolvement of this condition.

Children with a nutritional imbalance can present delayed dental eruption, altered buffering capacity of saliva, enamel hypoplasia and a higher incidence of caries [5]. Saliva, an easy to collect biological fluid, provides a host of important data which can help with diagnosis, prognosis and patient management. Saliva plays a critical role in the homeostasis of the oral cavity through its multiple functions: protection against viral, bacterial and fungal infections, repairing oral mucosa, buffering capacity and remineralising teeth by providing Ca^+ and phosphate ions [6,7]. The buffer capacity of saliva involves three major systems: bicarbonate, phosphate and protein systems. Buffer capacity is the mmoles of NaOH or HCl per ml of buffer solution needed to produce a unit change [6]. The most important buffer system in saliva is the bicarbonate system produced from CO_2. In saliva exists the equilibrium between $CO_2 + H_20$, H_2CO_3, respectively $HCO_3^- + H^+$.

Bicarbonate determines salivary *p*H, the higher of the bicarbonate concentration, the higher of the salivary *p*H: $pH = 6.1 + \log[HCO_3]/\ H_2CO_3$

The high concentrations of the carbonic acid/ bicarbonate in the saliva allow it to act as an effective determinant of the salivary *p*H. A high bicarbonate concentration would keep saliva *p*H above 6.3 so that the risk of erosion of tooth structure is low. When *p*H reaches the critical value of 5.5, calcium phosphate salts dissolve from the enamel, leading to cavities. In conclusion the buffering capacity of saliva is a dental caries prevention factor [8].

The decrease of salivary flow and salivary calcium concentration can be associated with the initiation and the progress of carious lesions [9].

This cross-sectional study was undertaken to detect the possible effect between nutritional status, in our case defined by BMI, oral health by DMFT/dmft index and salivary buffer capacity in children from Mures County, Romania. We aimed to determine whether a low BMI for age is associated with reduced salivary capacity and higher caries risk.

Experimental part

The studied population involved 162 children the ages of 6 and 12 years, from Mures County. All parents or tutors have accepted and signed the informed consent for entry into the study, after receiving information referring the purpose and objective of the study.

Exclusion criteria were in reference to the children wearing orthodontic appliances, children taking medication at the timing of the study, children with general disease, and difficulties in opening the mouth.

Anthropometric measurements included the BMI index (weight in kg divided by square of height in cm). The weight was measured with a calibrated digital scale, barefoot and the height was measured in cm with a ruler. BMI for age percentiles were used and the sample was divided accordingly as follows:

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BMI percentile for age <5: underweight; BMI percentile for age ≥ 5 or <85 healthy weight; BMI percentile for age ≥85 or <95 overweight; BMI percentile for age >95 obese.

In the next stage the teeth were examined for DMFT/dmft index in the Paediatric Dentistry Department of Tîrgu-Mures University of Medicine and Pharmacy, on a dental chair and under good operating light. DMFT index for permanent teeth and dmft index for primary teeth were calculated according to the World Health Organisation (WHO) recommendations. Teeth with carious lesions were recorded as decayed, and also teeth with a softened floor and undermined enamel. White spots were not considered carious lesions and no X-rays were used in the study.

Saliva was stimulated by chewing on a piece of paraffin wax for 5 minutes. The patients, sitting in an upright position, were instructed to not swallow and to collect saliva in a sterile container. One hour prior to saliva collection, patients were asked not to eat and drink. The estimation of salivary buffer capacity was done using the CRT buffer strips (Ivoclar, Vivadent). The test surface of the strip was covered with saliva, without scratching it. After 5 minutes, as recommended by the manufacturer, the final colour of the strip was assessed and the buffer capacity estimated: blue colour = high buffer capacity, green colour = medium one and yellow colour = low buffer capacity.

Results and discussions

The sample (N = 162) consisted of 94 girls and 68 boys. The mean age of the full sample was 8.98 ± 1.99 years, the mean dmft was 2.58 ± 2.49 and the mean DMFT was 1.75 ± 1.99. Statistical analyses were performed using R software (R Core Team, 2014).

A Mann-Whitney-Wilcoxon test was used to assess differences between boys and girls on age, BMI, dmft and DMFT. While no significant differences were found between genders on age and BMI, results suggest that boys have higher levels of dmft (M = 3.26, SD = 2.33) compared to girls (M = 2.16, SD = 2.53), p = .003, and lower levels of DMFT (M = 1.00, SD = 1.26) compared to girls (M = 2.30, SD = 2.24) (table 1).

The association between weight status, dmft and DMFT was tested further by splitting the full sample into three groups: underweight (below the 5th percentile), normal weight (between the 5th percentile and the 85th percentile) and overweight/obese (above the 85th percentile). Table 2 provides descriptive statistics for each weight group.

Because an analysis of variance (ANOVA) revealed that age differed significantly between weight groups, F (2,159) = 4.10, p = .02, age was controlled in subsequent analyses. Sex was not controlled in subsequent analyses because the weight groups did not differ significantly from each other on gender (X^2 = 0.78, p = 0.68). Prior to testing differences between weight-groups in an ANOVA, dmft and DMFT scores were residualized after controlling for age.

With regard to dmft, an ANOVA on residualized scores found a significant effect, F (2,159) = 4.82, p = 0.009. A pairwise Tukey HSD test found that overweight and normal weight subjects did not differ significantly (p = 0.85), but that underweight subjects had higher residualized dmft scores (M = 1.01, SD = 2.38) compared to their normal weight counterparts (M = -0.37, SD = 2.20), p=.007. Furthermore, there was a trend suggesting that overweight subjects (M = -.13, SD = 2.38) had lower residualized dmft values compared to underweight subjects, p = .08.

With regard to DMFT, an ANOVA on residualized scores also found a significant effect, F(2,159) = 6.34, p = .002. A pairwise Tukey HSD test found that underweight and overweight subjects did not differ significantly (p = 0.94). However, normal weight subjects had lower residualized DMFT scores (M = -0.41, SD = 1.79) compared to underweight subjects (M = 0.54, SD = 0.96), p = .007, and compared to overweight subjects (M = 0.42, SD = 1.65), p = .02.

The contribution of the buffer value to DMFT and dmft was also examined. Because a *yellow* buffer value was only present in 5 subjects, these subjects were excluded from subsequent analyses.

Separate ANOVAs were conducted for DMFT and dmft, examining main effects of weight category and buffer value on DMFT and dmft respectively.

For dmft, the main effects of weight category, F(2,151)=4.66 and buffer, F(1,151)=12.74, were significant at p=.01 and p<.001 respectively. More specifically for the effect of buffer on dmft, the green buffer group had higher residualized dmft values (M=0.73, SD = 2.53) than the blue buffer group (M=-0.62, SD = 1.98).

A similar pattern was observed for DMFT. The main effects of weight category, F(2,151)=5.81 and buffer, F(1,151)=5.77, were significant at p=.004 and p=.02 respectively. More specifically for the effect of buffer on DMFT, the green buffer group had higher residualized DMFT values (M=0.37, SD = 1.71) than the blue buffer group (M=-0.37, SD = 1.55

The analysis of the salivary buffer capacity of each weight group is shown in table 3. The Pearson's Chi-squared test showed no significant correlation for any weight group: p-value = 0.1032.

Table 1
COMPARISONS BETWEEN GENDER, AGE, BMI, dmft AND DMFT

	Girls (n=94) M (SD)	Boys (n=68) M (SD)	p
Age	9.20 (2.02)	8.67 (1.93)	.090
BMI	16.97 (3.47)	16.75 (2.90)	.882
dmft	2.16 (2.53)	3.26 (2.33)	**.003**
DMFT	2.30 (2.24)	1.00 (1.26)	**<.001**

Table 2
COMPARISONS BETWEEN AGE, BMI, DMFT, DMFT AND *p*H AFTER WEIGHT GROUPS

	Underweight (n=37) M (SD)	Normal Weight (n=87) M (SD)	Overweight/Obese (n=38) M (SD)
Age	8.59 (2.05)	9.38 (1.91)	8.43 (1.96)
BMI	13.48 (0.58)	16.37 (1.56)	21.32 (2.66)
Dmft	3.76 (2.49)	2.03 (2.34)	2.68 (2.49)
DMFT	2.08 (1.38)	1.56 (2.14)	1.87 (2.13)
pH	6,9(1.85)	8.1(1.95)	7.6 (2.19)

Table 3
BUFFER CAPACITY AFTER THE WEIGHT GROUP

Buffer capacity	High(blue)	Medium (green)
Underweight	16	20
Normal weight	51	34
Overweight	15	21

As regarding salivary *p*H, we found that the underweight group had a significantly lower mean salivary pH value, than that of the normal weight group and overweight group. However, no significant difference was seen between the mean salivary *p*H values of overweight and normal weight children.

Malnutrition and dental caries are both widely recognized public health problems with diet being a common risk factor. There are a great number of studies researching this relationship, but results are limited and often controversial.

A cross sectional study was designed in order to investigate the relationship between dental caries, salivary buffer capacity and dental caries in children aged 6 to 12 years from Mures County, Romania.

Our results are in conformity with other studies reporting that undernourished children have a higher incidence of caries [5,8,11]. Similar results were found by Delgado-Angulo [12] and Xavier [13], who found DMFT to be twice as high in undernourished children compared with obese children and children with normal weight.

A negative correlation between BMI and caries incidence was found by Hasan et al. in a study on 5 years old children, but the differences were not statistically significant. The children with malnutrition presented also a lower salivary flow rate and *p*H [14]. Similar findings were also recorded by Siddiqui et al. in a study on 376 children aged 5-6 years [15]. Another study on kindergarten children from Sulaimani city found a higher dmft in undernourished children, compared to the well-nourished group [16].

Panwar et al found in his study a higher incidence of caries in children with normal weight [17]. Similar results were found by Sadeghi et al [18] and Xavier et al [13], Shakya et al [11] who found no significant association between BMI and DMFT and dmft.

In contrast to our study, a positive correlation between BMI and caries incidence was found in 1290 Germanan children by Willerhausen et al [19]. Similar results were found by Siddiqui Fawaz et al [15] and Mohammandi et al [20].

A study from Brasilian preschool children showed a significant association between caries and overweight children [13]. Another study conducted in the USA with children aged between 2 and 6 years, found a significantly higher caries risk in overweight children just in the age group 60 to 72 months [21]. A recent study from China among 32,461 school children aged 7-9 years reported that children with higher BMI presented lower odds of caries [22]. In accordance with those findings, Yang et al found a negative association between caries severity and weight [21].

In contrast to our study, Ain et al [24] founded in their study that salivary *p*H had a negative correlation with BMI in obese patients. This could be due to the reduced salivary flow which is a modulator of salivary *p*H. When salivary flow decreases less bicarbonate is released, hence decreasing *p*H [24]. Similar results were found by Christoforou et al who reported in his study on children aged 7 to 9 years that a greater BMI implied a lower buffer capacity [25]. Pannunziu et al showed a higher *p*H for stimulated saliva in overweight children. The obese group had similar *p*H values with the other groups. No differences between the 3 study groups were found with regard to buffer capacity [26].

The DMFT index for the age 12 in 2015, proposed by the World Health Organization is to be one [27]. In their studies, Gyergyay et al [28] funded no important correlation between the DMFT index, and amylase activity.

The limitations of this study included the small study sample size and the specific population, namely school children from Mures County, Romania. No X-rays were used in the process of caries detection, thus dmft and DMFT values could be underestimated. Furthermore it is recommended that future studies take into consideration other variables that can potentially affect the frequency of carries, such as socio-economic status, oral hygiene, and dietary habits. Nevertheless, the present study contributes to the growth of international specialty literature, supporting further research in this field.

Conclusions

This study shows a negative relationship between dmft, DMFT and BMI in the children of our study group. Underweight children from our study group tend to have a medium buffer capacity and a significantly lower *p*H. Our recommendations are to improve awareness of the importance of maintaining dental health, dietary counselling and taking appropriate preventive measures.

The relation between salivary parameters, dental health and anthropometric measurements deserve further research, using a larger sample size.

Both undernutrition and dental caries can have life-long negative repercussions for children. An interdisciplinary approach between the paediatric dentist and primary health care providers or paediatricians can offer a good opportunity to prevent and treat these childhood diseases. It is a problem of great importance to know the risk factors of caries and determine high risk populations.

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