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ROBERTA PAULA DE FARIA MELO

CORRELATES OF ELECTRONIC AND VISUAL ASSESSMENTS OF CHEWING PERFORMANCE BY MEANS OF A MIXING ABILITY TEST AND MAXIMUM BITE FORCE IN CHILDREN WITH MIXED DENTITION

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Trabalho de conclusão de curso apresentado à Faculdade de Odontologia da UFU, como requisito parcial para obtenção do título de Graduado em Odontologia

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ATA DE DEFESA - GRADUAÇÃO

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Reuniu-se em Web Conferência pela plataforma MConf - RNP, em conformidade com a Resolução nº7/2020 do Conselho de Graduação desta Universidade, a Banca Examinadora, designada pelo Colegiado do Curso de Graduação em Odontologia, assim composta: Professores: Guilherme José Pimentel Lopes de Oliveira - FO/UFU; Roberto Bernardino Júnior - ICBIM/UFU; e Alessandra Maia de Castro Prado - FO/UFU, orientador(a) do(a) candidato(a).

Iniciando os trabalhos, o(a) presidente da mesa, Dr(a). Alessandra Maia de Castro Prado, apresentou a Comissão Examinadora e o(a) candidato(a), agradeceu a presença do público, e concedeu ao(à) discente a palavra, para a exposição do seu trabalho. A duração da apresentação do(a) discente e o tempo de arguição e resposta foram conforme as normas do curso.

A seguir o(a) senhor(a) presidente concedeu a palavra, pela ordem sucessivamente, aos(às) examinadores(as), que passaram a arguir o(a) candidato(a). Ultimada a arguição, que se desenvolveu dentro dos termos regimentais, a Banca, em sessão secreta, atribuiu o resultado final, considerando o(a) candidato(a):

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SUMÁRIO

Abstract

Background. Chewing function may be influenced by several factors, including physiological and anatomical features, but there are few studies exploring these factors in children.

Aims. To assess the chewing function of children with mixed dentition by means of a mixing-ability test using a two-color chewing gum, and to test the correlation between chewing performance and occlusal bite force.

Design. A sample of 43 children with mixed dentition was selected. Masticatory tests were performed using a two-colour chewing gum that was chewed for 10, 20 and 30 chewing cycles, performed in a random order. The chewed specimens were flattened, scanned, and both sides of digitalized images were submitted to electronic colourimetric analysis to assess the level of colour mixture, measured by the circular variance of hue (VOH). The maximum occlusal bite force (MOBF) was determined by measuring the bite force at maximum occlusion in the region of primary molars.

Results. Positive regression coefficients were observed there was a decrease in VOH values as the number of chewing cycles increased.

Conclusion. The results of VOH demonstrated that the tested method was effective for the analysis of chewing performance in children, and bite force and coordination required to chew the gum are different and uncorrelated aspects.

Keywords: Bite force; Masticatory muscles; Mixed dentition; Validation Studies.

1. Introduction

Chewing function is the first step of the digestive process, which consists of rhythmic jaw opening and closing movements aiming to break down the food particles for swallowing.[17] As smaller particles of ingested foods lead to greater nutrient absorption, greater chewing efficiency is essential for good nutrition.[1] Nevertheless, food crunching during chewing may be influenced by several factors such as anatomical factors and physiological characteristics such as malocclusion,[2] orofacial dysfunction,[3] body mass index,[4] caries lesion,[5] among others. The bite force is one of the components of masticatory function,[8] and it is reported to increase with age, gender, and body height.[9]

The evaluation of chewing performance is useful for evaluating the individual's functional capacity and establish strategies for future rehabilitation treatments for impaired oral function.[13] Nevertheless, although there are several studies concerning different aspects of the chewing function in adults, there is a scarcity of studies exploring the chewing function in the infant age.[7]

Chewing performance can be objectively assessed by determining an individual's ability to grind or pulverize foodstuff before swallowing.[20] The comminution test has been the most widely used method, suggested as the gold standard.[16] However, children are not always able to shred the test food, as their maximum bite force may be less than that required to crush the test food particles, and potentially refuse to chew or accidentally ingest them.[10] Therefore, colorimetric assessment using two-color chewing gums has been proposed as an alternative method to improve the assessment of chewing function, avoiding the need for special equipment and making chewing efficiency testing more feasible.[11,18] This method allows the evaluation of bolus formation and also the degree of mixing of the two colors as an indicator of chewing efficiency.[12,13] Schimmel et al[14] summarized the characteristics of an ideal two-color chewing gum test as having properties such as easy chewability, good taste, commercial availability, packaging, and storage properties.[15]

Another important parameter for assessment of the functional state of the masticatory system is the occlusal bite force. The maximum occlusal force has been reported as strongly associated with the swallowing threshold in children[1] and better mental health status was closely associated with higher swallowing threshold in young adults.[21] The occlusal bite force can be impaired by malocclusion,[22] which can be influenced by contact areas on posterior teeth.[23] Nevertheless, there is scarce information on the association between occlusal bite force and chewing performance in children with mixed dentition. Therefore, the aim of this study was to assess the chewing function of children with mixed dentition by using a mixing-ability test with a two-color chewing gum, and to verify the relationship between chewing performance and occlusal bite force.

2. Material and methods

This study included a sample of 43 children with mixed dentition. The research protocol was previously approved by the local research ethics committee (protocol 3.438.596). All caretakers signed an informed consent and children signed a consent form before taking part in the study. The inclusion criteria comprised children and pre-adolescents aged 8 to 11 years who were in the mixed dentition stage (with the first primary molar in occlusion), norm reactive, and in good general health. Participants should have sound teeth or with satisfactory restorations. The following exclusion criteria were considered: those who do not agree to perform the chewing tests, have previously restored teeth with secondary caries, cracks or fractures, and those with malocclusion or bruxism.

2.1 Test food and chewing test protocol

A two-colored chewing gum (Vivident Fruitswing Karpuz/Asai Üzümü, Perfetti van Melle, Turkey) served as the test food. Each gum had the dimensions of 43×12×3mm, comprising one piece with two layers, violet (grape flavor) and green (watermelon flavor). This method and chewing gum were selected for

having properties that may possibly be best suited for use in children to get the cooperation in any task.[18] Participants were positioned comfortably in the dental chair and instructed about the test. Three subsequent tests were performed (10, 20, and 30 chewing cycles) in the preferred chewing side. The number of chewing cycles was counted by the operator. Between each test, a one-minute interval was used for rest and to avoid muscle fatigue. The sequence of the three tests for each individual was defined randomly using sets of unsorted random numbers (https://www.randomizer.org/). After each cycle, the chewed gum was collected by the operator, and both sides were photographed with a digital camera using a 100 mm macro lens, 1:3 magnification, and a fixed 35 cm focus distance and saved in JPEG format. Then, specimens were placed separately in a transparent plastic bag and labeled with an identification code. For the analysis of the mixture level between the two colors of the gum, specimens were assessed by a visual assessment method (unflatten chewed gum) and by an electronic colorimetric method (flattened chewed gum).

2.2 Visual assessment

Specimens were classified by two independent examiners using as reference an ordinal rating scale that classifies the chewed gum specimens according to the level of mixture of the two colors: 1 – not mixed, impressions of cusps or folded once; 2 – large parts of chewing gum unmixed; 3 – bolus slightly mixed, but bits of unmixed original color; 4 – bolus well mixed, but color not uniform; and 5 – bolus perfectly mixed with uniform color.[14] The analysis performed by examiners were blinded to the identification of the participant and the number of chewing cycles. The photographed specimens were used to assess the intra-rater agreement of the visual analysis.[15] In order to assure the independence of ratings, all specimens were examined in random order, examiners were blinded to their first ratings, and a minimum of one month was considered between the repeated measurements.

2.3 Electronic colorimetric assessment

After the visual assessment, the specimens were flattened to a wafer of 1 mm thickness by pressing with a glass plate under manual pressure. Then, both sides of the wafer were scanned (HP Deskjet F4480, Hewlett Packard Corp., Brazil) and saved into JPEG files with 300 dpi resolution. The two images were joined into a single file, and this was placed in a maximum size of 1000 pixels in the vertical or horizontal direction. The colorimetric analysis was performed using the freeware ViewGum© software (dHAL Software, Greece, www.dhal.com), a computer program specifically developed to evaluate masticatory performance by the two-color chewing gum test.[16] The variance of the hue (VOH) was considered the measure of mixing. The smaller is the VOH value, the greater is the mixing of the chewed gum, which in turn means better chewing performance.[14,16] The step-by-step procedure for the colorimetric analysis is detailed elsewhere.[14]

2.4 Maximum bite force assessment

Maximum bite force (MBF) was measured using a mini-load cell (Gnatodinamômetro Digital Especial; Kratos, Cotia, SP, Brazil) with a capacity of 1000 N. The dynamometer is composed by a fork attached to two 6 mm thick slides each and a 3.0 mm space between them. The children were instructed to bite as hard as possible on the force gauge in the region of primary molars without moving the head. The device was positioned at the maximum oral opening and the measurements were repeated 5 times with a 3 seconds resting time between each maximum bite recording of occlusal bite force. MBF (in Newtons) for each patient was considered the mean of the 5 individual recordings.

2.5 Data analysis

Descriptive statistics were performed to describe the subjects' characteristics and functional measurements. The associations between chewing performance (VOH and Visual assessment), MBF, and the number of chewing cycles were

tested using the Spearman correlation tests. The independent sample t-test was used to compare functional variables according to gender and age groups.

In order to assess the factors associated with children's chewing performance, a multiple linear mixed-model regression was used, which considers the hierarchical structure of the repeated measurements per subjects for the three chewing tests (10, 20, and 30 chewing cycles). Therefore, the number of chewing cycles was considered as a repeated effect as well as a fixed effect in the regression model, whilst subject's age groups (8 and >8 years-old), gender, and MOBF (continuous variable) were also tested as independent variables. IBM-SPSS version 23.0 (IBM Inc., Chicago, IL, USA) was used for all statistical analyses.

3. Results

Forty-three children with mixed dentition were included in this study, 22 girls (51.2%) and 21 boys (n=48.8%). Children's ages were 8 years-old (n=28; 65.1%), 9 (n=12; 27.9%), 10 (n=2; 4.7%), and 11 (n=1; 2.3%).

The summary of measurements of the chewing performance (VOH values and visual scale scores) is depicted in Figure 1. Mean (± standard deviation) were 0.47 (±0.09), 0.36 (±0.13), and 0.28 (±0.12), for 10, 20, and 30 chewing cycles, respectively. There was a decrease in VOH values (better chewing performance) as the number of chewing cycles increased ($r=-0.638$; $P<0.001$). There was also an increase in Visual scores with a higher number of chewing cycles ($r=0.624$; $p<0.001$), which means that the level of mixture is proportional to the Visual Scale measurements. A significant correlation was also found between VOH and Visual assessment ($r=-0.509$; $p<0.001$).

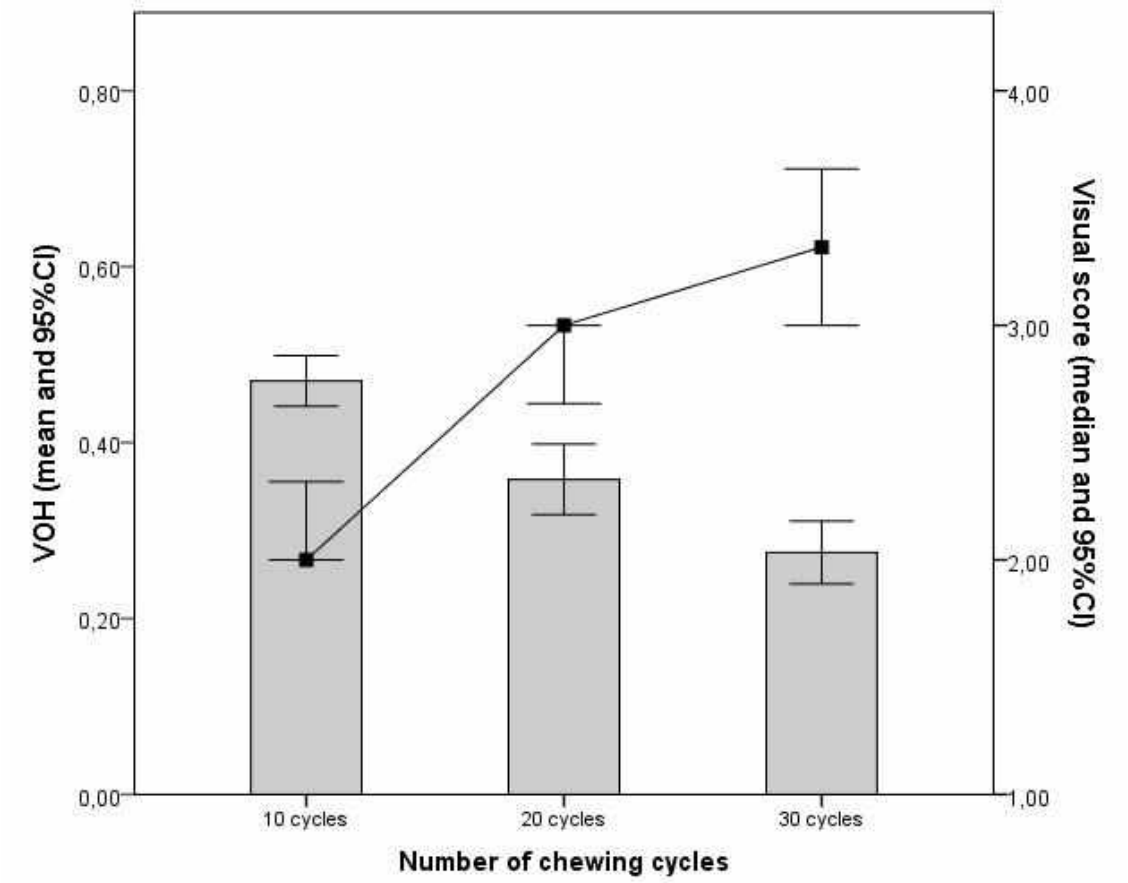

Figure 1. VOH (bars) and Visual score (line) values according to the number of chewing cycles.

The overall mean MBF was 144.0 (±47.3) N. No difference was found between girls (142.9±41.9) and boys (145.1±53.5) (p=0.880). A significant correlation between MBF and chewing performance was observed for the VOH measurements for 10 chewing cycles (r=0.316; p=0.046). No other significant correlation was found between VOH or Visual assessments and MBF, considering the different number of chewing cycles and the overall measurements.

A linear mixed-effects model was constructed using the −2 log-likelihood test to compare different models when considering or not the hierarchical structure of data (p=0.054). The test of fixed effects of the final multilevel model revealed significant p-values for the number of chewing cycles (p<0.001), gender (p=0.002), and MBF (p=0.024). No effect of age was observed (p=0.591).

Positive regression coefficients were observed for a decreasing number of chewing cycles (higher VOH values), compared to 30 cycles chewing tests. Similarly, the positive coefficient (b=0.059) for female gender reveals a higher probability of higher VOH values for girls (estimated marginal means= 0.0396 *vs* 338 for boys; p=0.002), which means lower mixing ability for girls. Mean MBF was positively associated with VOH values (b=0.0004; p=0.024), which means higher MBF for children with lower VOH values (better mixing ability) (p=0.024).

Table 1. Estimates of fixed effects for the linear mixed-effects model. Dependent variable is the VOH values

Parameter	Estimated Marginal means	Estimate	95% CI		t	Degrees of freedom	p-value
			Lower Bound	Upper Bound			
Intercept		0.241	0.015	0.468	117.32	2.107	0.037
10 cycles	0.469 (0.01)	0.195	0.153	0.237	81.05	9.276	0.000
20 cycles	0.357 (0.02)	0.083	0.033	0.133	83.54	3.308	0.001
30 cycles	0.274 (0.02)	0					
Girls	0.396 (0.01)	0.059	0.023	0.094	116.36	3.240	0.002
Boys	0.338 (0.01)	0					
MBF	–	0.0004	0.0001	0.0008	116.36	2.288	0.024
Age (years)	–	-0.007	-0.033	0.019	116.36	-.539	0.591

When the mean Visual scale measurements was tested as dependent variable, only the number of chewing cycles were found to have a significant effect ($p<0.001$). No effects of gender ($p=0.918$), MBF ($p=0.234$), or age ($p=0.461$) was observed.

4. Discussion

The findings of this study showed that the mixing-ability test using a two-color chewing gun was able to assess the chewing efficiency of children with mixed dentition, as it correlates with the number of chewing cycles and bite force. Results suggest that it is a good option for assessment of chewing efficiency in children, since traditional masticatory tests may have limitations, especially regarding the acceptance of test foods and procedures. Masticatory tests demand an adaptation of jaw muscle activity according to different types of food, and this adaptation to food hardness is immature in children groups. In addition, children commonly present signs of apprehension in the experiment environment and sometimes do not perform the task legibly and in a reliable manner. [26]

The results of VOH demonstrated that the tested method was effective for the analysis of chewing performance in children. Nevertheless, it is important to highlight the role of a “child-friendly” method, and prior explanation and motivation for achieving reliable results. The child's behavior with the dentist may be influenced by variables such as age, parental behavior, parental anxiety, medical and dental history, awareness of their problem, type of dental settings, behavior management and procedural techniques followed by the dentist.[29] Moreover, it is very important before any procedure to use features such as live modeling and tell-show-do, which are very effective techniques for achieving treatment goals in all age groups.[30]

This study showed that the two-color chewing gum test was a reliable method for quantifying chewing performance for children in mixed dentitions, and the possibility of correlating the bolus kneading ability with the analysis of the two-color chewing gum mixture was evident. There was a decrease in VOH values as the number of chewing cycles increased, corroborating with other studies that showed that this same protocol was able to discriminate the number of chewing cycles with significant differences in VOH between all children groups.[10] [18] Nevertheless, the assessment of chewing performance in children using a method that is dependent on counting the number of chewing cycles is somewhat difficult, as chewing function aims to form a unique bolus size that is liable to be swallowed, each individual can achieve this goal in a different number of cycles and at a different speed.[18] In addition, preschool children have difficulties to understand instructions and measurements may not be fully accurate.[10]

Our study suggested that the bite force and coordination required to chew the gum are different and uncorrelated aspects. Previous studies also found that the bite force was not a primary determinant of masticatory performance, and both variables were not dependent on body variables in children ages 3 to 5.5 years [28] and an increase in bite force is observed from primary to early mixed dentition due to the increase in masseter thickness and the developmental stage of the dentition. [25] Nevertheless, MOBF is an important parameter to be tested before performing chewing performance tests. MOBF is an important tool for assessing the functional state of the masticatory system,[26] and may be influenced by three main factors: the number and area of occlusal contacts, occlusal forces reflected by maximum bite force, and amount of excursion during chewing.[27] It has been also reported that MOBF may vary according to age, body size increase, dental maturation, and especially the presence of the first permanent molar in occlusion.[25] These results indicate that dental maturation may lead to a gain in chewing ability. However, this factor is a limitation of our study, as there was not a larger sample size that allows stratification by age group.

We also found that female gender showed a higher probability of higher VOH values ($p = 0.001$). Some studies on masticatory performance comparing

genders have shown that women spend more time preparing artificial food for swallowing than boys, although there was no statistical difference between the number of chewing cycles.[1] This may be one of the factors responsible for this difference between genders. Moreover, male subjects tend to have higher MOBF than females, regardless of age.[24] These MOBF values found in men can be explained by the fact that they have a larger tooth size and consequently have larger areas of the periodontal ligament.[10,18] However in In the present study, no statistical difference was found concerning gender and MOBF. It was observed that MOBF values were positively associated with those of VOH. Showing that children who had better ability to mix gum, resulting in better chewing performance, had lower MOBF (P = 0.026). where perhaps it can be explained by the fact that chewing gum requires more coordination than strength, unlike grinding tests, that the higher the bite force, the greater the chance of grinding, leading to higher chewing unemployment.

Although maximum bite force, age, and gender have been investigated as possible factors related to chewing performance in children with a mixed denture, other factors such as diet, weight, height, and environmental factors should be further investigated. A larger sample and evaluation time is needed to clarify which conditions allow children to better develop their chewing performance.

5. Bullet Points

- The two-color chewing gum test is a reliable method to quantify chewing performance for children in mixed dentures.

- Bite force and coordination required to chew the gum are different and uncorrelated aspects.

- Female gender showed a higher probability of higher VOH values.

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