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Impact of asthma on children´s gustatory sensitivity, masticatory and feeding behaviors

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ABSTRACT

Asthma is a chronic inflammatory disease, in which disturbances in breathing, masticatory and swallowing functions may impact the eating behavior. The aim of the study was to evaluate the impact of asthma on taste sensitivity, masticatory behavior and feeding problems in children. The sample consisted of 91 children (6-7y) divided into two groups: asthma (n=46) and control group (n=45). Interviews were held with parents/guardians and clinical examinations were performed to gather information on medical, dental and feeding aspects. The gustatory sensitivity for sucrose and urea (sweet and bitter, respectively) were measured by staircase method designed for this age-range. The respiratory and masticatory functions were evaluated using the Orofacial Myofunctional Evaluation with Scores-expanded (OMES-e) protocol. Feeding problems were assessed using the Montreal Children's Hospital Feeding Scale, exploring oral motor, sensory, appetite, maternal concerns, child's behavior, and strategy aspects after transcultural adaptation to Brazilian Portuguese. The two groups were homogeneous relative to sociodemographic characteristics and nutritional status. Although the total OMES-e scores did not differ between groups, the frequency of changes in food incision and escape were different ($p=0.007$ and $p=0.0011$, respectively). The Asthma group required more time and higher number of masticatory cycles to eat the test-food ($p<0.05$). The gustatory thresholds for sweet and bitter were different, with asthmatic children requiring significantly higher concentrations to perceive the taste ($p<0.001$). The frequency of children classified by their parents according to feeding difficulties also differed between groups ($p=0.001$; Fisher's exact test). Asthmatic children showed remarkable changes in taste, chewing and eating behaviors, thereby pointing out the eating problems they may experience, which should be considered when designing and implementing therapeutic interventions.

Key-words: Asthma, Child, Mastication, Taste, Feeding Behavior

1. INTRODUCTION

Asthma is a chronic inflammatory disease characterized by lower airway hyperresponsiveness and variable airflow limitation (Brazilian Society of Pneumology and Tisiology, 2012). Although asthma onset may develop at any age, the first symptoms usually occur in childhood (Martinez and Vercelli, 2013). It is considered the main cause of childhood morbidity among chronic diseases, with a variable prevalence worldwide (Asher and Pearce, 2014). Considerable increase in its prevalence has been observed in recent years, especially in children (Solé et al., 2015; Global Initiative for Asthma - GINA, 2018).

Asthma is a multifactorial disease that has been associated with genetic, environmental, gestational and socioeconomic factors (Cardoso et al., 2004; Chatkin and Menezes, 2005; Martinez and Vercelli, 2013). Among environmental factors, changes in lifestyle, diet and increased exposure to allergens have been cited (Casagrande et al., 2008). Clinically, asthma presents as recurrent episodes of wheezing, dyspnea, chest oppression and cough, particularly at night and in the morning on awakening (Brazilian Society of Pneumology and Tisiology, 2012), resulting from bronchial spasm, mucosal edema, and hypersecretion. Asthma treatment is mainly based on pharmacological treatment (Brasil, 2010), such as inhaled corticosteroids and fast-acting beta-agonists associated with systemic corticosteroids for relieving the crisis in both children and adults of any age (Brazilian Society of Pneumology and Tisiology, 2012).

Breathing difficulties, deviation in the positioning of the phonoarticulatory organs (Carvalho-Oliveira et al., 2016) and incoordination between breathing, chewing and swallowing (Cunha et al., 2012) may cause feeding and swallowing problems, which to the best of our knowledge, has not been widely recognized in children. This is probably because individuals with asthma have difficulty maintaining the respiratory balance during eating (Cunha et al., 2012). Besides, disturbances in taste perception due to changes in salivary flow, pH and the use of drugs such as corticosteroids (Alaki et al., 2013; Hummel et al., 2011) have been mentioned in adults but not in children.

Eating behavior is a complex concept that includes biological and social aspects (Sanlieret al., 2018). In the clinical practice, caregivers have reported a variety of problematic behaviors such as refusing certain types of food, nausea, refusing certain textures or preferring to eat in a very specific way (Arvedson, 2008), but

among asthmatic children the signs and symptoms of eating problems have not been mentioned in the literature. Although some of these behaviors are transient and common in the pediatric population, between 3 and 10% of children have severe dietary difficulties or problems which, if not treated, could lead to poor nutrition or developmental disorders (Corbett and Drewett, 2004). In this sense, the use of validated instruments is important to search for evidence and details about changes related to feeding behavior, thereby helping clinical diagnosis, designing therapies and decision making (Lopes et al., 2015).

The hypothesis tested was that asthma may cause disturbances in breathing, masticatory and swallowing functions, and thus, may impact taste, masticatory behavior and feeding practices. Thus, this study aimed to evaluate the impact of asthma on gustatory sensitivity, masticatory and feeding behaviors in children.

2. MATERIAL AND METHODS

2.1. Study design and ethical aspects

This was a cross-sectional, analytical study that evaluated children with a medical diagnosis of asthma, who were undergoing treatment at the Child Asthma Outpatient Clinic of Piracicaba (Brazil); a control group composed of schoolchildren without asthma was also selected from public schools in the same municipality.

This research was approved by the Research Ethics Committee of the Piracicaba School of Dentistry (University of Campinas, Brazil), under protocol number 2.256.580), and was conducted in compliance with all principles of the Declaration of Helsinki (WMA, 2016). Written informed consent form were provided by all children and their parents/guardians, agreeing to participate in the study.

2.2. Sample

The sample size calculation was performed based on the results of the study of Castro et al. (2012), who evaluated myofunctional changes in chewing, swallowing and speech in children aged 7 to 10 years, diagnosed with asthma. Considering the results of X2=15.916, degree of freedom = 1, alpha level = 5% and test power of 80%, it was found that approximately 50 individuals in each group would be required.

The study included 91 children aged 6 to 7 years, who were divided into two

groups:

- ASTHMA GROUP: 46 children (16 girls and 30 boys) selected from the Child Asthma Outpatient Clinic of Piracicaba (Brazil), diagnosed by a pediatrician as having intermittent, mild persistent, moderate persistent, or severe persistent asthma considering the medical records. In addition, they were diagnosed as either presenting allergic rhinitis, or not.

Information was also gathered on the use of drugs to treat or control the disease, such as: salbutamol (or albuterol, bronchodilator, beta2 agonist) and beclomethasone dipropionate (synthetic corticosteroid with local anti-inflammatory activity). Treatment time, classification and time since diagnosis of asthma were also assessed by reviewing the medical records.

- CONTROL GROUP: 46 children (25 girls and 20 boys) selected from public schools of Piracicaba, whose parents/caregivers and teachers reported that they were not undergoing medical treatment/using medication, and not presenting chronic diseases.

2.3. Anamnesis

The questionnaire was structured for the purpose of gathering important information on the children's medical and dental history that could influence the studied variables, to be obtained from their parents/guardians. For the asthma group, the questionnaire was applied during an interview with the parents/guardians who were present at the consultation by one of the authors (CAG). For the control group (schoolchildren), the questionnaire was sent to the children's parents, and in cases in which any question was left blank, incomplete or unanswered, parents/guardians were contacted by phone. The following data was collected:

- *Socioeconomic factors:* parents/guardians' educational level (illiterate, incomplete/complete elementary school, incomplete/complete high school and incomplete/complete higher education), and the purchasing power and possession of goods and services (ABEP, 2015);
- *Medical history and medication use profile;*
- *Current and past feeding habits:* characteristics of dietary habits such as natural, artificial or mixed breastfeeding, duration of breastfeeding, age of introduction of solid foods, food allergies, problematic behaviors, and picky eating. The characteristics of

the foods consumed the day before the interview in terms of sugary and processed foods were also assessed (Brazil, 2015);

- *Sucking habits, sleep disorders, and dental aspects:* dental and orthodontic treatments (current or past), as well as the presence of signs and symptoms of orofacial pain or temporomandibular disorders (TMD) (Carrara et al., 2010).

The inclusion criteria were: children 6 to 7 years old and the presence of mixed dentition. Exclusion criteria were: presence of active caries (caries lesions) and tooth loss due to caries or trauma; toothache; past or current orthodontic and / or speech therapy; severe malocclusions (crossbite; canine and/or molar relationship of Angle's Class II or III; overbite; overjet); dental prothesis; temporomandibular dysfunction; other chronic diseases such as epilepsy, cancer, rheumatoid arthritis, hypertension or diabetes mellitus; chronic use of medications such as benzodiazepines, antidepressants, insulin, antihypertensive drugs, among others; inappropriate behavior and/or refusal to collaborate in the evaluation of the proposed variables; history of food allergy or intolerance, especially chocolate (which was included in the protocol).

2.4. Clinical Examination

After obtaining the consent to participate, a clinical examination was performed by one of the authors (CAG). The anthropometric assessment involved measurements of height and weight by an analogical scale and stadiometer to calculate the body mass index (BMI = Kg/m2) and to classify the participants as presenting severe thinness, thinness, normal-weight, overweight and obesity according to the growth reference data for age and sex (WHO, 2007).

The clinical oral examination was performed at the outpatient clinic (asthma group) or at the school (control group), in a well-lit room, using a mirror, probe, and personal protective equipment. The presence of caries experience was assessed using the DMFT index (total decayed, missed and filled teeth), according to WHO (2013).

The morphological examination of occlusion was performed observing the anteroposterior relationship of primary canines and first permanent molars (Angle's Classes I, II or III); buccolingual relationship of canines, primary first and second molars and permanent first molars (normal or crossed); incisors relationship: normal, overbite, overjet, and crossbite.

2.5. Assessment of taste sensitivity

The detection thresholds for sweet and bitter tastes (sucrose and urea, respectively) were assessed using a methodology (two-alternative, forced-choice) proposed by Visser et al. (2000) for young children. Thirteen sucrose concentrations (1.5, 3.0, 6, 12, 18, 24, 30, 45, 60, 120, 180, 240 and 300 mmol/L) and 15 urea concentrations (3.75, 7.5, 15, 30, 60, 120, 180, 240, 300, 450, 600, 1200, 1800, 2400 and 3000 mmol/L) were prepared periodically and stored in a refrigerator for the test.

The test was presented to the child using a story in which the "magician" made "magic potions" but unintentionally mixed all the solutions. The liquids were presented in small glasses containing 3 ml of each solution, one glass of tastant solution and one glass of distilled water simultaneously. The child was challenged to help the researcher find out which glass had the magic potion. To assess the sucrose detection threshold, the child tried a 300 mmol/L of sucrose solution (more concentrated) and a glass of distilled water at the beginning of the test; when the child was not able to differentiate sucrose from water, the instructions were repeated and the was test started again. If the child missed more than twice, the test was interrupted and re-scheduled for another day. Then, the solution with 240mmol/L of sucrose was tested. To increase the speed of the procedure, the concentration was initially lowered by two steps, until the first incorrect response was given. Subsequent increases or decreases in concentration were always made one step at a time. The test was stopped when two incorrect responses were given relative to the sameconcentration, that is, the child did not differentiate the tastant from water. The detection threshold was defined as the first level above this concentration.

After an interval of 10 minutes, the detection threshold for urea was assessed. To avoid strong aversive reactions, the child was first offered a 300 mmol/L solution of urea, which is moderately strong in flavor. The solution was presented as another magic potion. When the child showed that he/she could taste the solution, the test began at a concentration of 300 mmol/L. If the child could not discriminate the tastant from water, the procedure started with concentrations of 1200 mmol/L. Subsequent procedures were similar to those for sucrose. The child was instructed to rinse his/her mouth between trials and not to swallow the solutions.

2.6. Assessment of respiratory function

The breathing mode was assessed using the Orofacial Myofunctional Assessment protocol-expanded (OMES–e), a protocol previously validated for use in the pediatric population (Felício et al., 2010) with the aim of screening the breathing function. Breathing mode was evaluated by audio-video records and scores were assigned, using a procedure that was carried out by a blinded, previously trained speech therapist, who assigned scores on a scale of 1 to 4 points (4- normal pattern/nasal; 3- slight oronasal breathing; 2- moderate oronasal breathing; 1- severe oronasal breathing) as previously described.

Recordings were made after cleaning the nasal cavities with tissue and saline solution; if the child presented cold/flu, he/she was rescheduled for another evaluation.

2.7. Assessment of masticatory behavior

The masticatory behavior was evaluated using the validated protocol OMES-e / Mastication domain (Felicio et al., 2010), with a speech therapist (in a blinded procedure) assigning scores to each item evaluated by means of the audio-video records. The test was performed by chewing one chocolate filled cookie Bono® (Nestlé, São Paulo, Brazil), as recommended by the protocol.

The type of incision, chewing type and other behaviors and signs of change were evaluated, such as movements or changes in the posture of the head or other parts of the body, and food escape. The total chewing time required for test-food ingestion was measured in seconds, and was considered from the time the test-food was placed in the mouth until the last swallowing action was completed. The total number of chewing cycles required was also checked.

2.8. Assessment of feeding difficulties

The feeding behavior and related problems were assessed using the Montreal Children's Hospital Feeding Scale after the transcultural adaptation to Brazilian Portuguese; the instrument was developed by Ramsay et al. (2011) in the English language and translated to and validated for European Portuguese by Lopes et al. (2015).

The instrument is composed of 14 items that should be answered by parents and/or caregivers and explores aspects such as motor and oral sensory processing, appetite, maternal concerns about nutrition, child behavior during meals, caregiver strategies and family reactions to the child's diet.

The transcultural adaptation to Brazilian Portuguese was performed according to the guidelines proposed by Reichenheim and Moraes (2007), and this process is described in detail in the Supplementary Material 1.

The final version was applied to parents/caregivers and the total score was calculated and interpreted as described in the study by Lopes et al. (2015), classifying the children as having “no feeding difficulty”, “mild”, “moderate” and “severe difficulty” according to the parents’ or caregivers’ perception (Supplementary Material 2).

2.9. Statistical analysis

Data were statistically analyzed using SPSS 24.0 software (IBM Corp., NY, USA), considering an alpha level of 5%; the statistical planning was pre-specified by one of the authors (PMC, Applied Statistics Spec.).

Exploratory statistics consisted of percentages, means, standard deviation, medians, and quartiles. Normality was tested by the Shapiro-Wilk test and observation of the quartile-quartile-plot (QQ-plot) graphs.

The frequency of feeding problems and oro-myofunctional changes were ompared between groups by Chi-square and Fisher's exact tests. Comparisons between groups for continuous sociodemographic variables were made using the t-test or Mann-Whitney test.

By using the Two-way general linear model - ANOVA, the effect of group (control or asthma) and sex (male or female) and the interaction between these factors (group*sex) on the observed variance of the oro-myofunctional variables, feeding difficulties and taste; the effect size (partial Eta squared) and test power for each model were also obtained. The results of Levene's equality of variance and normality tests were evaluated as ANOVA assumptions. A Bonferroni-type adjustment was made to prevent alpha inflation.

Finally, the effect of corticosteroid and beta2-agonists (bronchodilator) use on sweet and bitter taste sensitivity was tested by using multivariate analysis of variance (MANOVA).

3. RESULTS

A total of 91 children were included. The asthma group included 46 children classified according to the severity as having intermittent asthma (n = 17), mild persistent asthma (n = 15), moderate persistent asthma (n = 11) and severe persistent asthma (n = 3); 54% of asthmatic children had controlled asthma (the others partially controlled or uncontrolled) and 76% of them were diagnosed as having allergic rhinitis. Furthermore, 74% of them were beta2-agonist users and 72% were corticosteroid users (46% of children used both medications).

The characteristics of the clinical groups is shown in Table 1; the two groups did not differ regarding sex, age, and nutritional status (BMI), showing the homogeneity of the sample. According to the classification proposed by WHO (2007), in the asthma group, 19 of the 46 children presented overweight (41%) and 3 were classified as having thinness or severe thinness (6.5%). In the control group, 11 of the 45 children presented overweight (24.4%) and 4 children were classified as having thinness or severe thinness (8.9%).

In addition, the socioeconomic characteristics of the groups did not differ: educational level of the head of household (80% and 70% with >8 years schooling), declared income (mean = R$2238.6 and R$2151.0) and the socioeconomic score (mean = 16.1 and 17.2) for the control and asthma groups, respectively.

Table 1. Sociodemographic characteristics of the sample

Group	n	Sex	Age (years)	BMI (Kg/m^2)
		f/m	*Mean (SD)*	*Mean (SD)*
Control	45	25/20	6,9 (0,3)	16,1 (2,7)
Asthma	46	16/30	6,3 (0,5)	17,0 (3,2)

SD, standard deviation; BMI, body mass index.

p>0.05

The oro-myofunctional characteristics of mastication and breathing mode, evaluated by the OMES-e protocol, are described in Table 2. Two children were excluded from the evaluation due to the impossibility of analyzing the video records (lack of quality). Although the Mastication domain score did not differ between groups, the two groups were observed to differ in the frequency of normal incision of food (with incisors), with the control group showing higher frequency. For the frequency of food escape, this was higher in asthma group ($p = 0.007$ and $p = 0.0011$, respectively). The Breathing domain score also did not differ between groups ($X^2=1.050$; $p=0.3846$).

Table 2. Comparison of masticatory aspects and breathing mode evaluated by the Orofacial Myofunctional Assessment with scores - expanded (OMES–e) and taste sensitivity: a two-way general linear model

Group	n	OMES-e Mastication						OMES-e nasal breathing	Sucrose threshold (mmol/L)	Urea threshold (mmol/L)
		Incisors Bite	Bilateral chewing	Head movement	Posture changes	Food escape	Total score			
		n (%)	*n (%)*	*n (%)*	*n (%)*	*n (%)*	*Mean (SD)*	*n (%)*	*Mean (SD)*	*Mean (SD)*
Control	40	35 (87.5) *	11 (27.5)	1 (2.5)	0 (0)	0 (0) **	15.9 (2.8)	35 (87.5)	29.2 (22.9)	133.0 (71.0)
Asthma	43	26 (60.5) *	11 (25.6)	5 (11.6)	3 (7)	10 (23.5) **	15.2 (5.1)	34 (79)	111.4 (72.0)	528.3 (396.3)
						ANOVA 2-way model		*p-value*		
						Group effect	0.616	-	**<0.001**	**<0.001**
						Sex effect	0.351	-	0.932	0.103
						*Group*sex interaction effect*	0.552	-	0.398	0.141

* Chi-square test; X^2=7.775; p=0.007
** Fisher's exact test; p = 0.0011

Regarding the chewing time and number of chewing cycles required for test-food ingestion, the Asthma Group was observed to spend more time (mean= 86.3±33.9 sec; F= 4.282; p= 0.042; *Eta* partial squared= 0.051; test power= 0.53) and required higher number of chewing cycles (mean= 50.3±16.9; F= 8.552; p= 0.005; *Eta* partial squared= 0.10; test power= 0.82) from the time of food incision until completing the swallowing action (control group: 73.0±25.1 and 40.0±16.0, respectively). These aspects did not differ between sexes and there was no group*sex interaction effect (p>0.05), i.e., the observed group effect (asthma) on chewing time and number of chewing cycles was not sex-dependent.

Taste sensitivity for sucrose (sweet taste) and urea (bitter taste) also differed between groups, showing a significant *group* effect with large effect size (sucrose: p<0.001, partial Eta squared=0.368 and power=1.0; urea: p<0.001, partial Eta squared=0.360 and test power=1.0); no significant sex and group*sex interaction effects were observed (p>0.05), meaning that the effect of asthma on taste sensitivity was not sex-dependent. On the other hand, the effect of corticosteroid and beta2-agonists (bronchodilator) use on sweet and bitter thresholds was not significant (p>0.05), probably because the number of medication users was too high, preventing a reliable comparison for this aspect as observed by the low power of the test (5-30%).

Table 3 shows the characteristics of feeding and dietary behaviors reported by the parents or caregivers. According to the results, higher frequency of choking or coughing during feeding was reported by parents of asthmatic children, as well as a higher frequency of children considered "selective" or who only accepted a very limited variety of foods compared with the Control Group. In the Asthma Group, parents reported that feeding became a concern at age 3 on average; in the Control Group, all but one parent/caregiver reported that they did not have concerns about their child's feeding.

Table 3. Description of children's dietary and feeding aspects reported by the parents and assessed by the Montreal Children's Hospital Feeding scale - Brazilian Portuguese version

Group		Control group n= 45	Asthma group n= 46	*p-value* Fisher's exact or Chi-square test
Anamnesis				
Choking or coughing with some foods	*n*	0	10	0.0011
Vomiting		2	5	NS
Selectivity		6	23	0.0004
Holding food in the mouth		3	9	NS
Eating while watching television		11	19	NS
Age when feeding became a concern (years)	*Mean (SD)*	-	3.1 (1.1)	-
Age when started to feed with spoon (months)		6.8 (2.8)	8.3 (5.8)	-
Montreal Children's Hospital Feeding scale				
Total score	*Mean (SD)*	26.5 * (11.3)	40.0 * (16.2)	-

SD, standard deviation; NS, not significant.
* Two-way ANOVA model (significant *group* effect: F = 21.207, p <0.001, partial Eta squared = 0.196, test power = 0.995; *sex* and *group*sex* interaction effects: p = 0.474 and p = 0.871, respectively).

On an average, the Control Group children started to eat with a spoon at 6 months of age, while the Asthma Group started at 8 months. Regarding dietary characteristics, there was no significant difference between groups according to food intake markers: beans, fresh fruit, vegetables, hamburger and/or sausages, sweetened drinks, noodles, snacks, and crackers consumed the day before.

Table 3 also shows the total score gathered by applying the Montreal Children's Hospital Feeding scale; the Asthma Group showed the highest score, i.e., greater difficulty with feeding reported by parents or caregivers (significant group effect with large effect size), while no sex or group*sex interaction effect was observed.

Parents/caregivers of eight asthmatic children (out of 46) considered the mealtime with the child as "very difficult" and that the child's feeding influenced the family relationships in a "very negative" way. In the Control Group, only one parent

reported that the mealtime was "very difficult," and none reported that the child's feeding had a bad influence on family relationships.

Moreover, the frequency of children classified as having no difficulty, mild, moderate and severe difficulty differed between the groups (p = 0.0014; Fisher's exact test). In the control group, 89% of children were classified as having “no difficulty with feeding”, while this frequency was 62% in the Asthma Group. No children were classified as having severe feeding difficulties in the Control Group, while in the Asthma Group, 7 children were classified as having severe feeding difficulties.

4. DISCUSSION

The findings of this study, for the first time, described remarkable differences in gustatory sensitivity, masticatory and feeding behaviors in asthmatic children, and these changes emphasized the feeding difficulties reported by the parents. Indeed, parents of children with chronic diseases such as asthma may be more concerned about feeding aspects, but changes in masticatory behavior such as food escape and differences in the time and number of chewing cycles may be linked to the reported difficulties with feeding.

The study included a convenience sample of asthmatic children and a control group with fairly similar sociodemographic characteristics and nutritional status, thus allowing a reliable comparison. In most of the results found, the effect size was considered moderate to large with appropriate power of the test, showing that the study included a sufficient sample size.

4.1. Taste and Asthma

The thresholds for detecting sweet and bitter tastes differed between groups; that is, asthmatic children needed higher concentrations to discriminate between the tastant and distilled water. Clinically, changes in taste perception can ultimately lead to appetite problems, loss of interest and refusal of certain foods (Fark et al., 2013), because food may become less pleasant and may impact feeding behavior, which should be confirmed in future studies.

Among the drugs used for asthma control there are inhaled corticosteroids, the most effective medications to suppress airway inflammation; however, their adverse

effects are often underestimated in clinical practice (Hossny et al., 2016). Inhalants are among the causes of taste dysfunction mentioned in the literature, and the mechanisms involved in this process have not yet been completely elucidated. Since the largest proportion of the inhaled drug is retained in the oral cavity and oropharynx, it may affect the oral tissues, and consequently, taste (Godara et al., 2011) and smell perception (Liu et al., 2016).

Adverse effects may be attributed to the topical effects of inhaled corticosteroids on oral mucosa, which remains in the oropharynx; changes in taste perception seem to be due to the interaction of the drug metabolite with saliva and mucosa (Ciancio, 2004). The reduction in salivary flow (hyposalivation) caused by xerogenic drugs like beta 2-adrenoceptor agonists also has the potential to cause dysgeusia, due to the incomplete solubilization of the food and decreased transport of taste molecules to taste buds (Scully and Bagan, 2004; Klasser et al., 2008; Godara et al., 2011).

In the study by Pinto et al. (2013), 80% of 200 patients with moderate or severe asthma reported at least one local adverse event associated with the use of inhaled corticosteroids, including taste changes. The present study attempted to compare the effect of corticosteroid and beta2-agonists on sweet and bitter taste thresholds, but as the number of medication users was too high, it was not possible to make a reliable comparison.

4.2. Asthma, masticatory and respiratory behavior

Although the total Mastication domain score did not differ between groups, the results found showed that the frequency of normal incision of the food (with the incisors) was higher in the Control Group, while food escape frequency was higher among asthmatic children. Only two attempts to perform an oro-miofunctional evaluation of asthmatic children were found in the literature; while Cunha et al. (2012) did not observed differences in the type of chewing (unilateral/bilateral) and in the electromyographic activity of the masseter and temporalis muscles between asthmatic children and control ones, Castro et al. (2012) pointed out important changes in the stomatognathic system functioning, such as shorter chewing time, changes when swallowing liquids and solid foods (tongue projection), greater contraction of the mentalis muscle and lower frequency of bilateral alternate chewing. However, direct comparisons with the present results are difficult due to the

lack of standardization and different methodologies used in those previous studies, especially regarding the type of test-food.

Regarding the aspects of chewing time and number of chewing cycles, asthmatic children were observed to require more time and higher number of chewing cycles to ingest the test-food, contradicting the findings of Castro et al. (2012). According to the authors, due to the difficulty these children may experience with breathing (dyspnea) during meals, and the possibility that their symptoms may worsen when the stomach is full of food or in the presence of allergic rhinitis, chewing time and meal duration can be shortened in uncontrolled asthmatic individuals. On the other hand, in cases of difficulties and changes in the masticatory process, it may take longer to complete the function, as observed in the present study. It was also observed that masticatory aspects did not differ between sexes and that the group effect (asthma) was not sex-dependent among children. In healthy adolescents, the sex effect was determinant for masticatory behavior and previous studies have shown that males had a shorter chewing time and higher chewing frequency (Scudine et al., 2016; Pedroni-Pereira et al., 2016).

A previous study evaluated sensory aspects such as oral cavity sensitivity, breathing, chewing, and swallowing of 55 asthmatic children aged 7 to 9 years using the Nordic Orofacial Test-Screening (NOT-S) protocol (Amato et al., 2015). The sensory and chewing aspects reported by the children differed from those of the control group, while clinical aspects of the face at rest and facial expression, nasal breathing, mandibular function, and speech showed no significant differences. Of the asthmatic children, 32.1% reported difficulty with chewing because they put too much food into the mouth, while 5.7% reported vomiting reflex when brushing their teeth (increased sensitivity). Corroborating this study, our results showed a higher frequency of choking or coughing during feeding as reported by the parents of asthmatic children compared with those of the controls. Nausea and cough reflex may also be adverse effects observed in individuals receiving inhaled corticosteroid therapy (Gordon et al., 1987; Hossny et al., 2016).

In the Mastication and Swallowing domains evaluated in the study by Amato et al. (2015), the most frequent symptoms reported were selecting foods according to some textures/consistencies (36.7%), followed by spending 30 minutes or more on having the main meal (35.8%), coughing during meals (20.8%) and swallowing large portions without chewing (17%). The vomiting reflex, normally present from birth to

four months of age, serves as protection of the child's airway permeability, further decreasing its intensity. However, it remains more or less exacerbated throughout life, depending on the clinical findings (Lopes, 2015).

The lack of coordination between breathing and chewing may cause choking because the food bolus has not been well-formed. As a result of inadequate chewing, swallowing may change and adapt, resenting anterior tongue projection, exaggerated contraction of the orbicularis oris muscle, compensatory head movements, and noise (Cunha et al., 2009). In other studies, the mouth breathing pattern was more present in asthmatic children than in the healthy population (Venetikidou, 1993; Nascimento Filho et al., 2004; Stensson et al., 2008; 2010); Although the frequency of allergic rhinitis was high in the asthma group (76%), the score obtained in the Breathing domain did not differ between the Asthma and Control Groups, probably because these children were under medical treatment that included rhinitis. For this reason, the presence of allergic rhinitis and mouth breathing could not justify the changes observed in masticatory behavior in the Asthmatic Group.

4.3. Feeding behavior and asthma

Feeding is an essential part of life. In addition to the concept of survival, it is well known that food plays an important role in preserving health. Studies have shown that the objective assessment of mastication and feeding should be complemented by a subjective assessment, as these are generally not concordant but complementary aspects (Feine et al., 2006; van der Bilt, 2011; Pedroni-Pereira et al., 2017). They include important cultural and regional aspects about adaptation, habits, preferences and difficulties that are not addressed in objective assessments.

The frequency of children classified as having no feeding difficulties, mild, moderate and severe difficulty by the Montreal Pediatric Hospital Food scale – Brazilian Portuguese version differed between the Asthma and Control Groups. The Asthma Group was also observed to have greater feeding difficulties reported by parents/caregivers, while there was no effect of sex on the reported difficulties. There was concern about assessing the sex effect due to some (but few) differences in feeding behavior between boys and girls, reported in previous studies (Passos et al., 2015; Sanlier et al., 2018). Moreover, parents of eight asthmatic children classified

the mealtime with the child as "very difficult" and that the child's feeding influenced family relationships in a "very negative" way.

Due to disturbances in breathing, mastication and swallowing functions, the individual may select more fluid, less consistent foods that do not require chewing strength and that can be swallowed quickly (Tomé et al., 2000). On the other hand, individuals may swallow a malformed food bolus that was not well mixed with saliva, accompanied by swallowing air, thus hindering digestion, leading to inappetence (Cunha et al., 2009), and therefore, to feeding difficulties. A higher frequency of parents of the Asthma Group considered their children to be "selective" or that they consumed a very limited variety of foods when compared with controls. Furthermore, in the Asthma Group, parents reported that feeding became a concern at age 3, while in the Control Group all but one parent responded they did not worry about their child's feeding.

Feeding difficulties have been described as a serious problem for children, caregivers, and health professionals because, if they occur systematically and repeatedly over time, they may lead to disturbances at various levels relative to nutrition, growth, and quality of life (Lopes et al., 2015). Although several valid instruments for assessment of feeding difficulties are available in the literature, there are few simple and quick-to-fill-out instruments for identifying these alterations (Lopes et al., 2015). As mentioned above, parents of children with chronic diseases such as asthma may be more concerned about aspect of their health, however, the changes found in the objective aspects of mastication emphasized the feeding difficulties reported by the parents.

According to the Global Asthma Initiative (GINA, 2018), asthma control has two domains: control of symptoms and the future risk of adverse outcomes (such as exacerbations and decline in lung function). In addition to traditional pharmacotherapy, various non-pharmacological treatments (such as physical activity, allergen avoidance) are recommended to improve asthma control. According to the report, in addition to its general health benefits, a healthy diet with fruits and vegetables is encouraged for these patients, of course, taking care to avoid known allergenic foods.

Jacobi et al. (2003) followed 135 children from birth to 5.5 years and observed that those considered "selective" ate less and were more likely to avoid eating vegetables. The consumption of foods that become more practical, palatable, durable

and attractive foods, after going through the production process, are called ultra-processed foods. These foods can trigger food allergies (Monteiro et al., 2010) and may exacerbate the inflammatory process, an important aspect in the patient´s treatment. The evaluation of the food consumption markers showed no difference between the groups in the consumption of fruits, vegetables, and legumes, as well as in the consumption of processed, ultra-processed and sweet foods. Replacement of homemade and fresh foods with processed and ultra-processed foods is related to overweight, non-communicable chronic diseases and nutritional deficiencies that can 639 have repercussions in adulthood (Popkin et al., 2012).

As a limitation, the cross-sectional characteristic of the study should be mentioned, which does not allow causality inferences; longitudinal studies are needed to understand in which degree the changes in masticatory and gustatory evaluations are attributed to the physiopathology of the disease (asthma) or its pharmacological therapy. Besides, masticatory function was assessed using only solid food and the evaluation of other types of texture would add important information to better understand the impacts of the disease on masticatory behavior.

Validation is about checking whether an instrument really measures the parameters it is intended to measure. Considering that the reliability of the instrument was attested, and important differences in masticatory and feeding difficulties were found between asthmatic children and control ones, both from the objective and subjective aspects, the present results contributed to the validation of the instrument for Brazilian children aged 6 to 7 years old. Future studies in children diagnosed with feeding problems are necessary to attest the construct validity of the instrument and to enable its wider use in the clinical and research fields.

CONCLUSIONS

In conclusion, important changes in gustatory sensitivity, masticatory and feeding behaviors were found in asthmatic children, highlighting the eating problems they may experience, which should be considered when designing and implementing therapeutic interventions.

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AUTHOR CONTRIBUTIONS

This study was a multidisciplinary approach undertaken by dentists, speech therapists and a pediatrician, who effectively contributed to this work: Cinthya Jeanette Arias-Guillén, Paula Midori Castelo, and Maria Beatriz Duarte Gavião participated in the conception and design of the study; Cinthya Jeanette Arias-Guillén, Kelly Guedes Scudine, Daniela A. Prado and Rogério Tuon participated in acquisition of data; Paula Midori Castelo and Elsa C. C. Lamy participated in analysis and interpretation of data; Cinthya Jeanette Arias-Guillén, Paula Midori Castelo, Maria Carolina S. Marquezin and Maria Beatriz D. Gavião participated in drafting and revising the article. All authors revised the manuscript and approved the final version.

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