Original Article

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Analysis of the masticatory process of asthmatic children: Clinical and electromyographic research

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Summary

Introduction: The prevalence of asthma has grown considerably in recent decades, but some studies have shown stabilization of this trend. The masticatory process of asthmatic children may be altered due to asthma-related anatomo-functional changes.
Objective: The study objective was to determine the clinical and electromyographic characteristics of the masticatory process in asthmatic children and compare the electrical activities of their masseter and anterior temporal muscles (at rest and during maximal voluntary contraction and mastication) with those of non-asthmatic children.
Method: Case study. Asthmatic and non-asthmatic groups, each consisting of 30 children of both sexes between 6 and 10 years of age, were evaluated. Mastication was evaluated clinically and electromyographically in all subjects. RESULTS: The masticatory process did not differ significantly between asthmatic and non-asthmatic children.
Conclusion: Although the masticatory process did not differ significantly between asthmatic and non-asthmatic children, the masticatory process of asthmatic children may be altered because of anatomical changes of Asthma.
Keywords: asthma, mastication, electromyography, child, stomatognathic system.

Introduction

Data from the International Study of Asthma and Allergies in Childhood (ISAAC) show that asthma should be considered an important public health problem (1). Studies show that 24% of school-age children have asthma (2). The prevalence of asthma has grown considerably worldwide in recent decades, although some studies have shown stabilization of this trend (3).

Morphological and physiological analysis has shown the similarities and structural differences between the nasal mucosae and the mechanisms related to asthma, including the influence of mouth breathing secondary to nasal obstruction. Anatomo-functional changes not associated with asthma may influence the mastication process (4).

Mastication is the combination of stomatognathic functional events that mechanically break down food into tiny pieces, aiding the digestion and absorption of nutrients necessary for the body's metabolic activity (5). Mastication is a complex process that depends on muscles, ligaments, bones, and teeth, all controlled by the central nervous system. The muscles involved in mastication mediate movements and postures that bring the teeth together and move them apart or intensify the interocclusal pressure (6).

The activity of masticatory muscles can be evaluated by instruments and systems that measure and analyze the electrical activity of muscle (7). The literature on electromyographic analysis of masticatory muscles contains studies of pre-adolescents (8) and young or elderly adults (8, 9, 10), but few reports involving children (11).

The high number of asthmatic children is an alarming public health issue (3). Therefore, there is interest in studies that relate asthma to functional alterations of the stomatognathic system. The objective of this study was to determine the characteristics of mastication in asthmatic children treated at a pediatric and allergology ambulatory clinic of the Hospital das Clínicas of Pernambuco and to measure the side prevalence of mastication, number of cycles, total duration of mastication, and electrical activities of the right and left masseter and temporal muscles of asthmatic and non-asthmatic children.

METHOD

This was a descriptive and cross-sectional study that was conducted from April–December 2008 at the pediatric and allergology ambulatory clinic of the Hospital das Clínicas, which is affiliated with the Universidade Federal of Pernambuco (UFPE).

The population consisted of 2 groups: a group of asthmatic children consisting of 30 children with diagnoses of moderate or serious asthma and a non-asthmatic group consisting of 30 children without asthma. All children were between 6 and 10 years of age. Children with neurological impairments, serious cardiopathies, orthodontic devices, craniofacial abnormalities, or hypertrophy of the tonsils and/or adenoids, as well as those who were suffering asthma attacks at the time of evaluation, were excluded from this study.

This study was approved by the Committee of Research Ethics of Universidade Federal of Pernambuco, approval # 224/2006, and was supported financially by the CNPq-Edictal Universal Process 476370/2007-8. The adult responsible for each child was initially apprised of the objectives of the study, later informed that the study had been approved by the committee of ethics in research of the Universidade Federal of Pernambuco, and afterwards was requested to sign a declaration of free consent to the child's participation in the study under the clarified terms. The data were collected by evaluation of the subjects in a room in the Department of Allergology of the Hospital das Clínicas in the presence of an adult responsible for the child and at least 1 of the researchers.

We adapted a previously published protocol for evaluation of mastication (12, 13). The child was requested to sit comfortably in a chair and eat a 25-g French roll in a normal manner. The child was recorded during mastication with a *Sony Handycam DCR-TRV130 Digital*-8 TRV130 NTSC set on a tripod at a distance of 5 feet from the subject, and the data were recorded on a 8-mm tape. The duration of mastication was also recorded with a Casio® stopwatch.

The electrical activities of the masseter and temporalis muscles were measured in microvolts (μV) by the MIOTOOL 200/400 instrument from Miotec® connected to an LG notebook with a 110GB HD and an Intel® Pentium® Dual-Core T2330 1.10 GHz processor and running the Windows® Vista Premium operating system. Additional equipment used (all from the Miotec® company) included a Communication Cable USB connection between the computer and electromyography instrument, Miograph 2.0 Software (a data acquisition system that provided the opportunity to choose from 8 independent gains per channel, which was used to a gain of 1000), a 7.2-V NiMH 1700-mA rechargeable battery with a life of approximately 40 h that allowed operation in isolation from the utility system, 4 SDS500 sensors connected to clamp sensors, Cable Reference (earth), and MEDITRACE® draft and disposable electrodes consisting of Ag/AgCl immersed in a conductive gel and responsible for collecting and carrying the electromyography signals. This type of electrode has been described previously (14).

Before the electrodes were placed, each child's skin was cleaned with a 70% alcohol swab to remove any excess skin oil that could increase the impedance of the uptake signal (15, 16). The electrodes were placed bilaterally and oriented longitudinally with the muscle fibers (17). To avoid interference in the signal acquisition, the reference electrode was placed at the ulnar styloid process of the right arm.

The electrical activities of the right and left masseter muscles were recorded in the following situations: mandible in the resting position (5 seconds), occlusion with maximum voluntary contraction (5 seconds), and mastication of 1 25-g French roll (entire time required to masticate all of the bread was recorded). The subjects were prevented from seeing the computer screen in order to avoid any visual feedback that could affect the evaluation. After data acquisition, the electromyographic traces were evaluated with specific attention to recording the mastication, determining the duration of the second mastication process, and counting the cycles from the subject's second incision of French bread until the end of the last deglutition. The Kolmogorov–Smirnov test was used to determine whether the data for each variable recorded in the study were normally distributed. Student's t-test was used for comparison of the variables between groups. The level of significance was 5% for all tests. The Excel 2000 and SPSS v. 8.0 software programs were used for the analysis.

RESULTS

Table 1 presents the data for mastication speed, alternate bilateral mastication, simultaneous bilateral mastication, unilateral mastication, alternate bilateral mastication on the right side, and alternate bilateral mastication on the left side of the asthmatic and non-asthmatic children. No significant difference was found between the asthmatic and non-asthmatic groups.

Table 2 presents the data for the total number of cycles and total duration of mastication of a French bread (25 g) in the asthmatic and non-asthmatic children.

Table 3 shows the Pearson's correlation coefficients for the associations between the duration of mastication of

Table 1. Mastication parameters (mastication speed, alternate bilateral mastication, simultaneous bilateral mastication, unilateral mastication, alternate bilateral mastication on the right side, and alternate bilateral mastication on the left) of asthmatic and non-asthmatic children.

Mastication Characteristics	Non-asthmatic		Asthmatic		p-value
	N	%	N	%	
Alternate bilateral mastication					
Yes	20	66.7	16	53.3	
No	10	33.3	14	46.7	0.430
Simultaneous bilateral mastication					
Yes	4	13.3	3	10.0	
No	26	86.7	27	90.0	1.000
Unilateral mastication					
Yes	6	20.0	11	36.7	
No	24	80.0	19	63.3	0.252
Alternate bilateral mastication on the right side					
Yes	10	33.3	8	26.7	
No	20	66.7	22	73.3	0.779
Alternate bilateral mastication on the left					
Yes	10	33.3	7	23.3	
No	20	66.7	23	76.7	0.567

Table 2. Total number of masticatory cycles and total duration of mastication in asthmatic and non-asthmatic children.

	N	Minimum	Maximum	Average	Standard Deviation	p-value
Total number of masticatory cycles						
Non-asthmatic	30	10.00	81.00	30.00	15.84	
Asthmatic	30	10.00	70.00	26.90	13.33	0.415
Total duration of mastication of a French bread (25 g)						
Non-asthmatic	30	69.30	955.00	262.25	179.38	
Asthmatic	30	90.04	600.00	256.78	129.92	0.893

Table 3. Pearson's correlation coefficients for the associations between the duration of mastication of each piece of bread and the number of masticatory cycles on the right side, number of masticatory cycles on the left side, number of masticatory cycles on both the right and left sides, and total number of total masticatory cycles.

	Duration of mastication of each piece of bread	
	Non-asthmatic	Asthmatic
Number of masticatory cycles on the right side	0.63[1]	0.27
Number of masticatory cycles on the left side	0.45[1]	0.42[1]
Number of masticatory cycles on both right and left sides	0.41[1]	0.41[1]
Total number of masticatory cycles	0.93[1]	0.87[1]

[1] $p < 0.05$

each piece of bread and the number of masticatory cycles on the right side, number of masticatory cycles on the left side, number of masticatory cycles on both the right and left sides, and total number of masticatory cycles. Significant associations were observed with all variables except the number of masticatory cycles on the right side. This means that the relationship is direct and that the time required to masticate the piece of bread increases with the number of cycles.

Table 4 shows the data for the electrical activity of the masseter during rest, maximum contraction, and mastication in non-asthmatic and asthmatic children. The electrical activity of this muscle did not differ significantly between the non-asthmatic and asthmatic groups. However, the average activity recorded on the right side was observed to be higher in the asthmatic group at rest but not when bilateral contraction of the masseter muscles was required during maximum voluntary contraction or mastication. On

Table 4. Electrical activities of the masseter during rest, maximum contraction, and mastication in non-asthmatic and asthmatic children.

	N	Minimum	Maximum	Average	Standard Deviation	p-value
Right masseter at rest						
Non-asthmatic	30	3.90	13.00	6.33	2.14	
Asthmatic	30	2.80	18.00	6.61	3.60	0.709
Left masseter at rest						
Non-asthmatic	30	4.20	13.80	6.86	2.85	
Asthmatic	30	3.30	18.70	6.78	3.46	0.922
Right masseter during maximum voluntary contraction						
Non-asthmatic	30	19.10	198.50	82.70	39.52	
Asthmatic	30	8.90	192.50	81.00	45.60	0.878
Left masseter during maximum voluntary contraction						
Non-asthmatic	30	23.40	242.50	78.73	43.49	
Asthmatic	30	10.10	171.30	74.05	35.86	0.651
Right masseter during mastication						
Non-asthmatic	30	17.40	110.50	48.78	23.01	
Asthmatic	30	14.00	97.20	43.89	20.17	0.385
Left masseter during mastication						
Non-asthmatic	30	19.90	124.60	48.36	24.18	
Asthmatic	30	10.30	109.40	43.63	21.40	0.426

Table 5. Electrical activities of the anterior temporal muscles during rest, maximal voluntary contraction, and mastication in non-asthmatic and asthmatic children.

	N	Minimum	Maximum	Average	Standard Deviation	p-value
Right anterior temporal at rest						
Non-asthmatic	30	5.30	20.80	11.56	4.58	
Asthmatic	30	5.70	117.70	15.80	19.96	0.261
Left anterior temporal at rest						
Non-asthmatic	30	5.50	32.50	13.93	6.56	
Asthmatic	30	5.40	31.30	12.79	5.74	0.474
Right anterior temporal during maximal voluntary contraction						
Non-asthmatic	30	14.70	244.70	110.62	54.26	
Asthmatic	30	19.10	242.20	99.84	50.76	0.430
Left anterior temporal during maximal voluntary contraction						
Non-asthmatic	30	22.50	261.50	110.24	62.41	
Asthmatic	30	22.00	233.90	101.41	47.78	0.541
Right anterior temporal during mastication						
Non-asthmatic	30	5.50	130.80	55.07	25.41	
Asthmatic	30	14.20	143.20	53.93	29.41	0.873
Left anterior temporal during mastication						
Non-asthmatic	30	28.90	146.00	60.85	28.07	
Asthmatic	30	17.70	110.50	59.62	22.98	0.853

the left side of face, the average electrical activity of the asthmatic group was similar to that of the non-asthmatic group at rest but lower during maximum voluntary contraction and mastication. These results demonstrate that the masseter muscles of the asthmatic group did not exhibit average electrical activity equivalent to that of the non-asthmatic group during functions requiring an increase in muscle strength.

Table 5 presents the measurements of the electrical activity of each anterior temporal muscle during rest, maximal voluntary contraction, and mastication in non-asthmatic and asthmatic children. Differences were suggestive in the electrical activities recorded but not significant between the asthmatic and control groups. However, the activity measurements for the right anterior temporal muscle at rest were higher in the asthmatic

group. Therefore, children in the asthmatic group exhibit greater electrical activity in both the right masseter and temporal muscles at rest.

Discussion

Alternate bilateral mastication was observed in 66.7% of the non-asthmatic children and 53.3% of the asthmatic children; a previous study that aimed to describe mastication in children with mixed dentition found that this pattern occurred in 69% of the individuals analyzed (18). The literature indicates that alternate bilateral mastication evenly distributes the force of mastication, subjecting the muscles and joints to alternating periods of work and rest and leading to synchrony and muscle and functional balance (19, 20, 21).

A study of 26 5-to-7-year old children at a private school in Recife indicated that the masticatory pattern can be related to the craniofacial growth pattern and that growth can be directly related to a child's habits at this age. In that study, 38.5% of the children exhibited alternate bilateral mastication, which is the ideal pattern. Such balanced distribution of masticatory force supports the harmonious growth of the face (21).

In the present study, 13.3% of the non-asthmatic children and 10.0% of the asthmatic children exhibited a simultaneous bilateral masticatory pattern, also known as vertical structure. A study conducted in 2003 on 61 children with mixed dentition found that 23% exhibited predominantly vertical movements during mastication of French bread (18).

Unilateral mastication was observed in 20% of the non-asthmatic children and 36.7% of the asthmatic children. Unilateral mastication is known to stimulate inappropriate growth or prevent stabilization of stomatognathic structures (19). An examination of unilateral mastication in 4-to-5-year old children with normal occlusion found that mastication was predominantly unilateral in 65% of the children studied (22).

The alternate bilateral pattern with right-sided predominance was observed in 33.3% of non-asthmatic children and 26.7% of asthmatic children. Similar findings were reported in a study of 20 children selected from 2 private schools, of which 35% exhibited predominantly left-sided and 30% exhibited predominantly right-sided mastication (22).

The average total number of masticatory cycles was 30 in the non-asthmatic children and 26.9 in the asthmatic children; these data are consistent with the findings of a study of the total number of masticatory cycles in which the range was 9 to 60 cycles (23).

There are few studies comparing the duration of mastication between adults and children. In this study, the duration of mastication was shorter in asthmatic than in non-asthmatic children. A study comparing the durations of mastication of different types of food in children (24) found that food consistency affects the duration of mastication. However, that study did not relate these durations to possible changes in the stomatognathic system.

The hypothesis that asthma interferes with masticatory function cannot be confirmed because the results of this study show that asthmatic children may tend to masticate for a shorter length of time. The difficulties in and incoordination of breathing experienced by asthmatic children may be directly related to their reduced masticatory times, as such children may have difficulty maintaining the necessary balance required for breathing during feeding.

The electromyographic activity of the masticatory muscles at rest is known to be higher in patients with disorders of the stomatognathic system than in healthy individuals, indicating that such disorders increase basal masticatory muscle tone (25, 26). Any condition that causes an imbalance in the orofacial muscles can lead to such changes in tone (27). This information is consistent with the results of the present study. The equal or greater electrical activities at rest of the masseter and temporal muscles of asthmatic children relative to those of non-asthmatic children may therefore be due to the incorrect performance of mastication by asthmatic children.

These values were reversed during maximum voluntary contraction and mastication because the muscles require a degree of coordination to perform the orofacial actions of the stomatognathic system in a functional manner. These results also concur with those for masticatory time, implying that asthmatic children compensate with their smaller muscles.

Mastication requires coordinated action of the orofacial muscles, which in turn need optimal electrical activity in order to perform their functions. In this study, the duration of mastication was longer in non-asthmatic children than in asthmatic children. The average electrical activity at rest of the anterior temporal and masseter muscles was higher in the asthmatic group, but this trend was reversed during maximum voluntary contraction and mastication. These results imply that the electrical activity is directly linked to the function of each muscle group, with non-asthmatic children processing their food for longer and thus requiring more electrical activity of the muscles during mastication.

Conclusions

While the masticatory process did not differ significantly between asthmatic and non-asthmatic children, this study found indications that the masticatory process of asthmatic children may be somewhat altered by asthma-related anatomo-functional changes.

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