Electromyographic activity of perioral muscle in breastfed and non-breastfed children

Suzane Rodrigues Jacinto-Gonçalves* / Maria Beatriz Duarte Gavião** / Fausto Berzin***/ Anamaria Siriani de Oliveira**** /Tatiana Adamov Semeguini*****

The objective was to verify the electrical activity of the Mm. orbicularis oris *and* mentalis *during suction of different liquids in breastfed and non-breastfed children from 2.5-3.5 years old. It was used a signal conditioner (MCS-V2-Lynx Eletrônica Ltda, SP, BR) and Beckman Ag-AgCl bipolar surface electrodes. Breastfed children presented higher activity for mentalis and smaller values for the* M. orbicular oris *than non-breastfed children, suggesting the existence of different profiles of muscle activation between them.*

J Clin Pediatr Dent 29(1): 57-62, 2004

INTRODUCTION

Breastfeeding is the first preventive measure for correct development of the masticatory system and for the general development of the child. The work performed by the baby during breastfeeding provides adequate development of mastication, swallowing, phonation, and breathing, by stimulating the orofacial muscles. In breastfeeding the mandible is positioned further forward; masticatory muscles, such as the *temporalis*, the *pterygoideus lateralis* and *mylohyoideus* start maturing and re-positioning; the tongue stimulates the palate, preventing the harmful action of the cheek muscles; and *M. orbicularis oris* helps the growth and development of the anterior masticatory region. There is stimuli and response integration leading to normal growth and development of the system components.[17]

O'Brien *et al.*[22] reported that in bottle-feeding with nonphysiologically designed nipple the baby might force it out of the mouth, or regulate and stop milk flow with the tip of the tongue. Thus, certain muscles normally involved in breastfeeding are either immobilized (both parts of the *Mm. orbicularis oris* and *masseter*), overactive (*M. mentalis*), or malpositioned (the tongue is pushed backwards), and this situation can lead to abnormal orofacial development.

There are studies in literature about the influence of orofacial muscles in teeth positioning, emphasizing the importance of studying the electrical pattern of the *M. orbicularis oris* and the influencing factors such as breastfeeding. The imbalance between these muscles and the teeth may cause major morphological, functional, and esthetic damage.[7,6,23,18]

It has been found that a child will follow the same patterns in certain oral reflex movements, years after initial learning.[13]

The aim of this study was to verify the electrical activity of the *Mm. orbicularis oris* (*pars superior*) and *mentalis* and the muscle activation pattern, during suction of liquids with different densities in children, who were breastfed for at least 6 months and those breastfed up until only two months of age.

MATERIALS AND METHOD

Subjects

Children of both sexes, aged two and a half to three and a half years, were selected from schools and daycare centers in Campinas and Piracicaba cities, Brazil (BR), having a full set of deciduous teeth and established occlusion.

The parent/guardian answered and signed an anamnesis questionnaire, with data on time, duration, and frequency of breast and bottle-feeding and about the general health status.

* Suzane Rodrigues Jacinto-Gonçalves, Department of Pediatric Dentistry - Dental School of Piracicaba, State University of Campinas (FOP/UNICAMP).

** Maria Beatriz Duarte Gavião, Department of Pediatric Dentistry, Dental School of Piracicaba, State University of Campinas (FOP/UNICAMP).

*** Fausto Berzin, Department of Morphology, Dental School of Piracicaba, State University of Campinas (FOP/UNICAMP).

**** Anamaria Siriani de Oliveira, Department of Medicine, Biomechanics Rehabilitation, Medicine College of Ribeirao Preto, Sao Paulo University (FMRP-USP).

***** Tatiana Adamov Semeguini, Postgraduate in Physiological Sciences, West of Sao Paulo University (UNOESTE).

Send all correspondence to Dra. Maria Beatriz Duarte Gavião, Faculdade de Odontologia de Piracicaba –UNICAMP, Av. Limeira 901, CEP 13414-903 Piracicaba SP, Brazil.

E-mail:mbgaviao@fop.unicamp.br

Table 1. Breastfeeding duration (in months) for each child in the study.

	Child	Duration of breastfeeding
Group I	1	6 months
	2	10 months
	3	7 months
	4	12 months
	5	8 months
	6	8 months
Group II	1	1 month
	2	0 month
	3	1 months
	4	2 months
	5	1.5 months
	6	2 months

Figure 1. Child during sucking movement – front view.

From this evaluation, twelve children were selected and classified into two groups:

(Group I: six children breastfed for at least six months

(Group II: six children, who had not been breastfed or breastfed up until two months of age

The duration in months of breastfeeding for each child is demonstrated on Table 1.

Both groups showed the following characteristics: presence of all deciduous teeth, no alteration that might affect the mesiodistal and occluso-cervical sizes, normal occlusion as per Foster and Hamilton,[4] good health, and not under medication that might directly or indirectly interfere with muscle activity. Children, who did not want to participate, were excluded even if they fitted the sample profile.

The parents/guardians received verbal and written explanation about the aim of the study and the protocol. The children received explanations about the methodology in language accessible and suitable for their age. After both parties agreed, the parents/guardians were asked to sign the Formal Participant Consent Form, as per National Health Council Resolution 196/1996, approved by the Ethics Committee of Dental School of Piracicaba, State University of Campinas, BR.

INSTRUMENTATION

To record the electromyographic (EMG) signals a 16-channel signal conditioner - MCS-V2 was used from *Lynx Eletrônica Ltda, Sao Paulo (SP), BR* - with 12 byte dynamic band resolution, *Butterworth*–type band pass filter set at 509 – 10.6Hz**,** gain of 600 times, A/D converter board (model CAD 12/36, *Lynx Eletrônica Ltda, SP, BR*) and *Beckman* Ag-AgCl bipolar disc surface electrodes, with 10mm of detection surface diameter. The inter-electrode distance was 1 cm. The software *Aqdados,* version 4.18 (*Lynx Eletrônica Ltda., SP, BR*) displayed several raw and conditioned signals simultaneously, as root mean square (RMS), mean, maximum, minimum, and standard deviation, and 1 KHz sampling frequency.

PROCEDURES

During the experiment, the child sat comfortably, with a straight back and head orientation according to Frankfurt's plane parallel to the ground (Figure 1).

Skin and electrodes were cleaned with 70° GL ethyl alcohol and electrodes were coated with gel. The ground electrode was fixed to the right wrist. The electrodes were fixed to *M. orbicularis oris* (*pars superior*) 2mm above the free edge of the lip, and to the *M. mentalis* a little bit above the free edge of the chin.

ELECTROMIOGRAPHIC SIGNALS

Three different situations were measured: sucking yogurt, water, and chocolate cream, using a straw with 6.5mm in diameter. Each child had nine disposable cups without lids, three with yogurt, three with water, and three with chocolate cream. To ensure repeatability during EMG recording the researcher positioned the cups. The children were offered strawberry yogurt first to motivate them to suck; this was followed by water and then chocolate cream. The latter was chosen as the best by the children and was given last to stimulate cooperation. Consistence of the liquids follows the increasing sequence: water, yogurt and chocolate cream.

Suction time was five seconds, even if the child swallowed all the content or not. The resting period was one minute between the suctions. Precautions were taken to prevent the cup being completely empty before the end of the five seconds. If this happened, that test was interrupted and repeated with a larger volume of liquid. Prior to collection, all volunteers were trained by sucking yogurt to perform the experiment as precisely as

Table 2. Means (μV) and standard deviations of values of the linear rectified normalized curve found for the *Mm. orbicularis oris (pars superior)* and *mentalis* of breastfed and non-breastfed children, in sucking water, yogurt, and chocolate cream (n = 12)

	M. orbicularis oris (pars superior)		*M. mentalis*	
	Group I	Group II	Group I	Group II
Water	92.607 (9.249)	123.180 (8.059)*	114.126* (9.863)	92.287 (6.401)
Yogurt	89.695 (5.900)	104.609 (5.933)*	118.750* (10.096)	80.666 (5.014)
Chocolate cream	87.578 (6.586)	102.951 (6.316)*	116.804* (8.642)	98.033 (9.073)

* = Highly significant p < 0.0001 – *Mann-Whitney test*

Table 3. Means (μV) and standard deviations of values of the linear rectified normalized curve found for the *Mm. orbicularis oris (superior)* and *mentalis* of breastfed and non-breastfed children, in sucking water, yogurt, and chocolate cream (n = 12)

	M. orbicularis oris		*M. mentalis*	
	Group I	Group II	Group I	Group II
Water	92.607 (9.249)A	123.180 (8.059)A	114.126 (9.863)A	92.287 (6.401)A
Yogurt	89.695 (5.900)B	104.609 (5.933)B	118.750 (10.096)B	80.666 (5.014)B
Chocolate cream	87.578 (6.586)C	102.951 (6.316)C	116.804 (8.642)C	98.033 (9.073)C

Means followed by different letters differ between each other by *Tukey* test ($p < 0,001$)

Table 4. Means (μV) and standard deviations of values of the linear rectified normalized curve found for the *Mm. orbicularis oris (pars superior)* and *mentalis* of breastfed and non-breastfed children, in sucking water, yogurt, and chocolate cream (n = 12)

	Group I		Group II	
	M. orbicularis oris (pars superior)	*M. mentalis*	*M. orbicularis oris (pars superior)*	*M. mentalis*
Water	92.607 (9.249)	114.126 (9.863)*	123.180 (8.059)*	92.287 (6.401)
Yogurt	89.695 (5.900)	118.750 (10.096)*	104.609 (5.933)*	80.666 (5.014)
Chocolate cream	87.578 (6.586)	116.804 (8.642)*	102.951 (6.316)*	98.033 (9.073)

* = Highly significant p < 0.0001 – Mann-Whitney test

possible. EMG signal acquisition was initiated when the signal on the computer monitor was stable rectilinear. Immediately before EMG acquisition, the child was asked to keep still and stimulated by age applicable verbal commands. All suction tests were fully supervised, and if any wrong movement was observed, collection was interrupted and repeated.

DATA ANALYSIS

All signals were processed by *Aqdados* version 4.18 (*Lynx Electrônica Ltda, SP/BR)* and the raw electromyographic signals were mathematically processed by *MATLAB* software routines (the language of technical computing Version 5.0 from *The MathWorks Inc.*) to derive activation patterns (linear envelope) and RMS values for both muscles. EMG signals were fully rectified and linear envelope was accomplished smoothing the signal with a low-pass filter of 250ms. The mean amplitude was calculated for normalization. In this study, it was chosen the one-second interval (1000 samples) of raw EMG recording, which showed more stability, and from this interval, values to perform the linear envelope and obtained the RMS values to statistical analysis.

STATISTICAL ANALYSIS

Each EMG recording composed of signals from the *Mm. orbicularis oris (pars superior)* and *mentalis* (three recordings each for water, yogurt, and chocolate cream) of each child was given a thorough visual analysis by the *EMG11* routine totaling 216 signals. From each five second recording, we chose the most stable interval for each signal; the one-second interval (1000 readings) with the most regular sucking period was chosen. From these readings, we obtained the mean for each group.

During analysis, signals were grouped according to muscle and liquid; this facilitated visual study. Statistical analysis was performed using *GraphPad InStat*® version 3,01, from the *Graph Pad Software Inc.*, and the following tests were performed: descriptive statistical signal analysis, with mean and standard deviation, *Kolmogorov-Smirnov* test, *Wilcoxon* test, and *Mann – Whitney* test, One-way *Anova* with post test: *Tukey-Kramer* Multiple Comparisons test performed if *Anova* test result was $p < 0.05$.

RESULTS

The results are shown in Tables 2 to 4 and Figures 2 to 4.

There were highly significant differences in the electrical activity of the *Mm. orbicularis oris (pars superior)* and *mentalis* between breastfed and non-breastfed children in sucking water, yogurt, and chocolate cream. Breastfed children showed higher electrical activity for *M. mentalis* than non-breast-fed children, with the three liquids, while for the *M. orbicularis oris* the results were opposite, breastfed children determinate lesser values than non-breast-fed children.

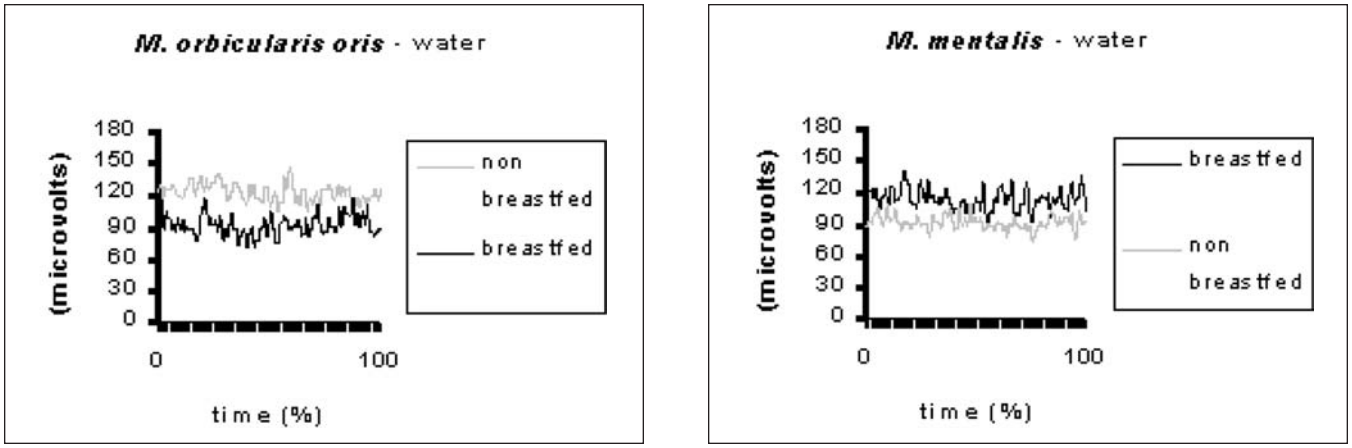

Figure 2. Normalized linear envelope - sucking water – Mm. orbicularis oris (pars superior) and mentalis

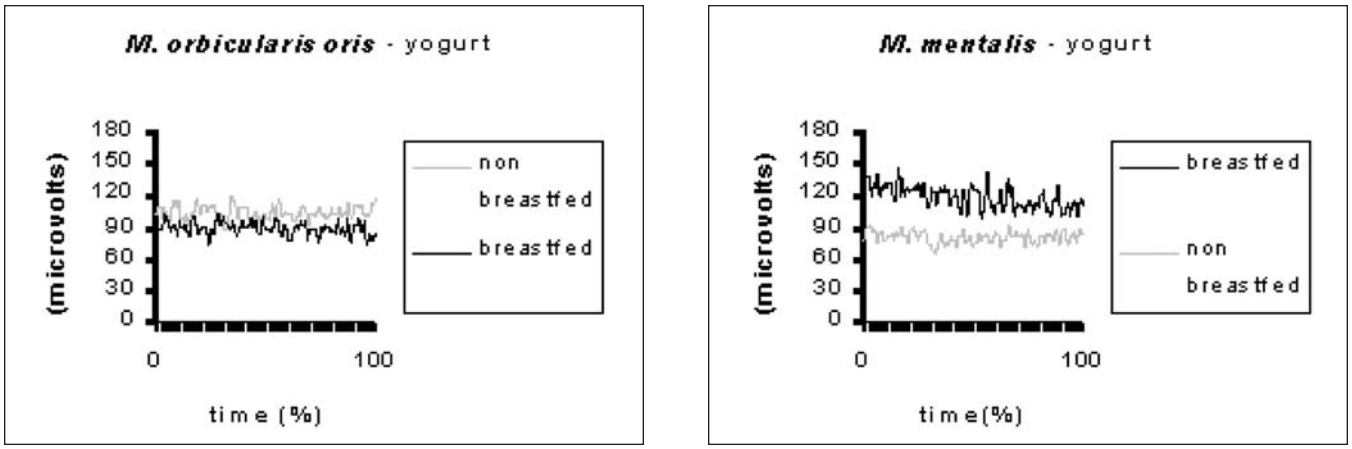

Figure 3. Normalized linear envelope – sucking yogurt – Mm. orbicularis oris (pars superior) and mentalis

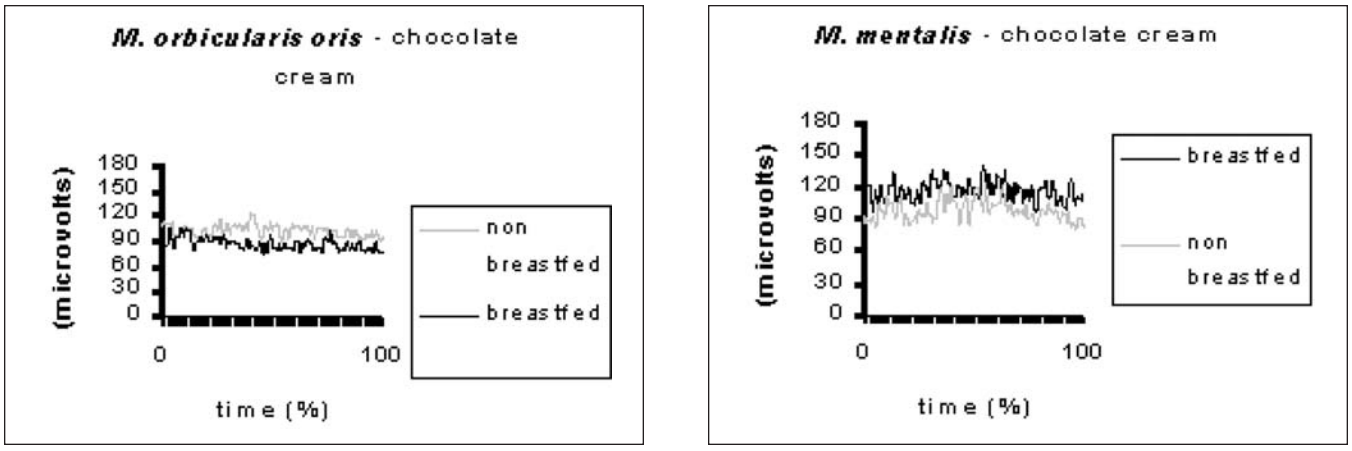

Figure 4. Normalized linear envelope – sucking chocolate cream – Mm. orbicularis oris (pars superior) and mentalis

Considering the consistency of the liquids, it was observed significant statistical difference among them for both muscles (*Anova* test - $p<0.0001$). In relation to *M. orbicularis oris*, breastfed and non-breastfed children presented higher electrical activity in sucking of water, followed by yogurt and chocolate cream (*Tukey-Kramer* test - $p<0.01$). The activity of the *M. mentalis* showed different patterns: breastfed children had the highest activity during sucking of yogurt, followed by chocolate cream and water (*Tukey-Kramer* test: $p<0.01$). For the non-breastfed children the sequence was chocolate cream, water, and yogurt, respectively (*Tukey-Kramer* test: $p<0.01$).

M. mentalis of breastfed children was more active than *M. orbicularis oris* with the three liquids, while for non-breastfed children the reverse was observed, with statistical difference for both muscles (*Mann-Whitney* test - $p<0.0001$). There were marked differences in the muscle action between the groups.

DISCUSSION

Sucking is a complex behavior that results from the integration of muscle activity of the lips, checks, jaws, tongue and palate. The sequence of events that must occur is crucial if the infant is to be successful in oral feeding. These complex movements are supposed to be acquired shortly after birth.[11]

The habit of sucking is the first coordinated muscular activity of the infant.[22]

It has been found that a child will follow the same patterns in certain oral reflex movements, years after initial learning.[13] A study by Moyers[12] was made of children whose records had been kept from infancy. As long as nine years after weaning, if given a bottle from which to suckle, they produce the same suckling, swallowing, and respiratory rhythms they had when infants. If they swallowed in a suckle-suckle-swallow type of pattern, i.e., two suckles for one swallow, two-for-one, this same rhythm appeared years later. It may be a three-for-one or even a four-for-one ratio, but the pattern is maintained. Such primitive reflexes are difficult for us to change, thus we considered that the suction pattern in our sample during the data collecting was similar to the first months of life.

Considering the importance of breastfeeding at least six months of age in relation to orofacial development,[22,16] it was observed in the present study if children, who just completed the primary occlusion and were breastfed in the first months of life, had different perioral muscular pattern from non-breastfed children, during sucking different liquids with a straw. It was taking into account that children follow the same patterns in certain oral reflex movements, years after initial learning.[13] The results showed that the *M. orbicularis oris (pars superior)* had higher electrical activity for non-breastfed children compared to breastfed children, suggesting the existence of different profiles of muscle activation between the studied groups.

It has been considered that non-breastfed children generally tend to have incompetent lips and malocclusion. Despite our sample had presented normality in relation to morphological occlusion and considering that incompetent lips cannot be clinically detected,[15,9,24] the highest electrical activity for the *M. orbicularis oris (pars superior)* in non-breastfed children could suggest they should have incompetent lips. This fact is in accordance with Yamamuchi *et al.*,[24] who examined lip incompetent subjects without dental or skeletal deformities, suggesting that they had both types of lip incompetence, i.e. adaptative and habitual lip function. Thus, the consideration about lip incompetence in non-breastfed children could be due to nonnutritive sucking habits, which were not present in the time of the present study, but they could be present during the first years of life in consequence of bottle-feeding that dis not provide enough muscular activity to supply the suction reflex.[22,1,8]

In relation to the *M. mentalis*, breastfed children showed higher electrical activity than non-breastfed ones, controversially to Turgeon-O'Brien *et al.*,[22] who considered that the chin muscle becomes overactive in bottle-feeding with inadequate nipple. Before eruption of primary teeth, when children are breast or bottle-feeding, the type of swallowing is termed infantile or visceral: the tip of the tongue protrudes through the anterior gum pads and takes part in the anterior lip seal,[5] with manly the participation of *M. orbicularis oris*, *M. buccinator*, and continuation beyond the pterygomandibular raphe into the superior pharyngeal constrictor.[3]

With the eruption of primary teeth the tongue position starts to retract from the anterior gum pads, shifting to adult or somatic swallowing, characterized by decreased use of perioral muscles, because the teeth and the lips are in contact and the tongue remains within the confines of dental arches.[5,22]

Since all of our sample had primary teeth, consequently the swallowing pattern changed, and in order to suck a liquid with a straw other activation pattern was required and others orofacial muscles could be participated for the movement to be efficiently performed. This could be the reason of lower activation of the *M. mentalis* in non-breastfed children that should not develop properly the transition from visceral to somatic swallowing. It must be considered again that, the non-breastfed children could have presented incompetent lips and in gripping the straw, the *M. orbicularis oris (pars superior)* may have been used more.

The results of Murray, Larson and Logemann,[14] corroborated these considerations, since they observed that larger volume of liquids may require active engagement of the labial muscles to prevent oral spillage of liquids prior to initiation of the oral swallow and it is possible that additional muscle groups are recruited during puckering inherent in straw usage. On the other hand, breastfed children must have received adequate stimuli during feeding in the first years of life, and the same patterns in oral reflex movements are followed years after initial learning,[13] leading a lesser activity for the *M. orbicularis oris* than *M. mentalis*. This consideration can suggest an analogy with the results of Sou *et al.*,[20] and Matsushita, Horikawa and Tamura,[10] who found that the perioral muscles in suckle-feeding, the *Mm. temporalis, orbicularis oris* and *suprahyoideus,* the last were the most active, especially in the breastfed infants. Tamura *et al.*[21]

observed also that the activity of *Mm. suprahyoideus* increased significantly with the age, while there was no appreciable increase in the activity of the *Mm. temporalis, masseter* and *orbicularis oris* and they suggested that the active tongue- and jaw-lowering movements play a primary role in increasing sucking strength during the suckle-feeding period of infants.

In relation to liquids, it was observed for the *M. orbicularis oris (pars superior)* that water determined the highest electrical activity, followed by yogurt and after by chocolate cream, with significant statistical difference (Table 3). It is an interesting finding, because the chocolate cream had the most consistency, so it was expected stronger activity than the other two. However, we inferred that in order to get the liquid through the straw, the child must use more suction force to get the chocolate cream than yogurt, following by water, thus requiring the participation of other orofacial muscles. The *M. buccinator*, for example, could have increased proportionally its activity in order to performer a high negative pressure inside the mouth to get the liquids, in accord with their consistence. Blanton, Briggs and Perkin[2] considered that EMG from the superior and inferior lip are compound recordings from various, separately innervated muscles. In addition, such recordings include the activity in the *M. buccinator*.

For the *M. mentalis* (Table 3), there was a different activity pattern in relation to the liquid consistencies, showing variability in both studied groups, with statistical difference ($p<0.001$). The reason of this variability could be attributed to the participation of synergic muscles, since that the sucking with a straw during the time determined in the present study is also accompanied by swallowing, involving other physiological mechanisms with the participation of various muscles. In this way, it is important to verify the participation of such muscles, since small children can acquire non-nutritive sucking habits, compromising the proper development of oral functions.

CONCLUSION

According to these results, it was found that there are different profiles of muscle activation related to the duration of breastfeeding, that is, breastfeeding could influence the electrical activity of the *Mm. orbicularis oris (pars superior)* and *mentalis* in the sucking of different consistent liquids, in the studied sample.

ACKNOWLEDGMENTS

This study was supported by CAPES

REFERENCES

1. Aarts C, Hornell A, Kylberg E, Hofvander Y, Gebre-Medhin M. Breastfeeding patterns in relation to thumb sucking and pacifier use. Pediatr 104: 50, 1999.
2. Blanton PL, Briggs NL, Perkin RC. Electromyographic analysis of the buccinator muscle. J Dent Res 49: 389-394, 1970.
3. Boniver A. [Considerations apropos bad habits in children]. Rev Belge Med Dent 41: 167-72l, 1986.
4. Foster DO, Hamilton MC. Occlusion in the primary dentition study of children at 2-1/2 to 3 years of age. Br Dent J 126: 76-79, 1969.
5. Graber TM, Rakosi T, Petrovic AG. Dentofacial orthopedics with functional appliances. 1st ed. St. Louis, C.V. Mosby, p. 449, 1985.
6. Gould MSE, Picton DCA. A method of measuring forces acting on the teeth from the lips, cheeks and tongue. Br Dent J 112: 235-242, 1962.
7. Kydd WL. Maximum forces exerted on the dentition by the perioral and lingual musculature. J A D A 55: 646-51, 1957.
8. Larsson E. Sucking, chewing, and feeding habits and the development of crossbite: a longitudinal study of girls from birth to 3 years of age. Angle Orthod 71: 116-119, 2001.
9. Marx R. The circum-oral muscles and the incisor relationship: an electromyography study. Rep Congr Eur Orthod Soc 41: 187-201, 1965.
10. Matsushita S, Horikawa Y, Tamura Y, Yoshida S. Electromyographic activities of perioral muscles during sucking periods in infants. Jpn J Pediatr Dent 32: 817-825, 1994.
11. Mizuno K, Ueda A. Development of sucking behavior in infants who have not been fed for 2 months after birth. Pediatr Int: official journal of the Japan Pediatric Society 43: 251-255, 2001.
12. Moyers RE. The infantile swallow. Tr European Orthodont Soc 40: 180, 1964.
13. Moyers RE, Carlson DS. Maturation of the Orofacial neuromusculatura. In Enlow, D.H. Facial Growth. 3rd ed. Philadelphia: W.B Saunders Company, pp. 267- 279, 1990.
14. Murray KA, Larson CR, Logemann JA. Electromyographic response of the labial muscles during normal liquid swallows using a spoon, a straw, and a cup. Dysphagia 13: 160-166, 1998.
15. Neiberg IG. An electromyography and cephalometric radiography investigation of the orofacial muscular complex. Am J Orthod 46: 627-628, 1960.
16. Page DC. Breastfeeding is early functional jaw orthopedics (an introduction). The Funct Orthod 18: 24-27, 2001.
17. Pastor I, Montanha K. Breastfeeding on the stomatognathic system development. Rev Odontopediatr 3: 185-191, 1994.
18. Prabhu NT, Munshi AK. Ultrasonographic observation of the circumoral musculature: an in-vivo study. J Clin Pediatr Dent 19: 195-203, 1995.
19. Sobotta J. Human anatomy atlas. 19th. ed. Rio de Janeiro: Guanabara Koogan, p. 70, 1988.
20. Sou M, Tamura Y, Takayanagi E, Yoshida S. Masticatory muscle activities during sucking, part 2. Differences between breast and bottle-feeding. Jpn J Pediatr Dent 30: 541-550, 1992.
21. Tamura Y, Matsushita S, Shinoda K, Yoshida S. Development of perioral muscle activity during suckling in infants: a cross-sectional and follow-up study. Dev Med Child Neurol 40: 344-348, 1998.
22. Turgeon-O'Brien H, Lachapelle D, Gagnon PF, Larocque I, Maheu-Robert LF. Nutritive and nonnutritive sucking habits: a review. J Dent Child 63: 321-327, 1996.
23. Vig PS, Cohen AM. Vertical growth of the lips: a serial cephalometric study. Am J Orhod 75: 405-415, 1979.
24. Yamamuchi K, Morimoto Y, Nanda RS, Ghosh J, Tanne K. Morphological differences in individuals with lip competence and incompetence based on electromyographic diagnosis. J Oral Rehabil 27: 893-901, 2000.