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5	Corresponding Author	Family Name	**Gomes**
6		Particle	
7		Given Name	**Cristiane Faccio**
8		Suffix	
9		Organization	Maringá University Center
10		Division	Department of Speech Therapy
11		Address	Av. Neo Alves Martins, 2951 apto 132, Centro, Maringá 87013-060, Paraná, Brazil
12		e-mail	fono.crisgomes@hotmail.com
13	Author	Family Name	**Costa Gois**
14		Particle	**Da**
15		Given Name	**Márcia Larissa Cavallari**
16		Suffix	
17		Organization	Universidade Estadual de Londrina
18		Division	Department of Pediatric Speech Therapy
19		Address	Londrina, Paraná, Brazil
20		e-mail	
21	Author	Family Name	**Oliveira**
22		Particle	
23		Given Name	**Bárbara Carvalho**
24		Suffix	
25		Organization	Universidade Estadual de Londrina
26		Division	Department of Physical Therapy
27		Address	Londrina, Paraná, Brazil
28		e-mail	
29	Author	Family Name	**Thomson**
30		Particle	

31		Given Name	**Zuleika**
32		Suffix	
33		Organization	Universidade Estadual de Londrina
34		Division	Department of Pediatrics and Pediatric Surgery
35		Address	Londrina, Paraná, Brazil
36		e-mail	
37	Author	Family Name	**Cardoso**
38		Particle	
39		Given Name	**Jefferson Rosa**
40		Suffix	
41		Organization	Universidade Estadual de Londrina
42		Division	Department of Physiotherapy
43		Address	Londrina, Paraná, Brazil
44		e-mail	

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48	Abstract	**Objectives:** To analyze the development of a method for using Surface Electromyography (sEMG) to evaluate the suckling of premature infants and describe five case reports. **Methods:** The five premature infants who took part in the study were submitted to sEMG evaluation of the masseter and buccinator muscles during different feeding methods. **Results:** Higher masseter muscle activity was observed in the infants that breastfed or used a cup; masseter muscle activity was reduced and buccinator muscle activity was increased in infants who were fed artificially using only a bottle. **Conclusions:** Masseter action was reduced in bottle-fed infants, and there were similarities in masseter activity during breastfeeding and cup-feeding.

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ORIGINAL ARTICLE

Surface Electromyography in Premature Infants: A Series of Case Reports and Their Methodological Aspects

Cristiane Faccio Gomes · Márcia Larissa Cavallari Da Costa Gois · Bárbara Carvalho Oliveira · Zuleika Thomson · Jefferson Rosa Cardoso

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Abstract

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Conclusions Masseter action was reduced in bottle-fed infants, and there were similarities in masseter activity during breastfeeding and cup-feeding.

Keywords Electromyography · Premature infants · Sucking behavior · Feeding methods

C. F. Gomes (✉)
Department of Speech Therapy, Maringá University Center, Av. Neo Alves Martins, 2951 apto 132, Centro, 87013-060 Maringá, Paraná, Brazil
e-mail: fono.crisgomes@hotmail.com

M. L. C. Da Costa Gois
Department of Pediatric Speech Therapy, Universidade Estadual de Londrina, Londrina, Paraná, Brazil

B. C. Oliveira
Department of Physical Therapy, Universidade Estadual de Londrina, Londrina, Paraná, Brazil

Z. Thomson
Department of Pediatrics and Pediatric Surgery, Universidade Estadual de Londrina, Londrina, Paraná, Brazil

J. R. Cardoso
Department of Physiotherapy, Universidade Estadual de Londrina, Londrina, Paraná, Brazil

Introduction

The function of sucking is of extreme importance in the life of the newborn as evidenced by the fact that sucking movements can already be observed in the 27th wk of corrected gestational age, although in a disorganized form. Neuromuscular stability occurs in healthy newborns when their corrected gestational age reaches 36 wk [1].

Premature infants present a high risk of feeding problems due to several factors, such as: neurological and neuromuscular immaturity, reduced oral and global muscular tonus, absent or reduced oral reflexes, respiratory difficulties that may compromise the coordination of suction, deglutition and respiration. Furthermore, an extended posture causes difficulties in sealing the lips and tongue and maintaining mandibular stability, both of which are very important in feeding [1–6].

The World Health Organization (WHO) advises breastfeeding exclusively during the first 6 mo of life. Moreover, the use of artificial nipples (bottles and pacifiers) is not recommended since they reduce the duration of breastfeeding and can lead to alterations in oral motor function [7].

The use of cups has been recommended as a substitute for bottles in infant feeding since it impedes both incorrect sucking and confusion when returning to the breast [8].

sEMG is a non-invasive method for evaluating muscle activity that can also be used for practical speech therapy intervention. A recent systematic review of sEMG studies about infant feeding pointed out that some authors described neither the method used to evaluate the sEMG signals nor the feeding method tested; furthermore, they made no comparison among feeding methods [9].

Studies with full-term infants have demonstrated that masseter muscle action is reduced in bottle-fed babies, and one study pointed out similarities between the activity of the masseter muscle during cup-feeding and breastfeeding. Studies with premature infants could not be compared among themselves due to the different methods and muscles evaluated [10–12].

The objective of the present study was to describe five case reports and analyze the development of a method for using sEMG to evaluate the suckling of premature infants.

Material and Methods

The present study was part of a larger study of 50 premature infants involving different feeding methods. To characterize the methodological aspects, five random cases (one from each group) were analyzed.

Five premature infants of both genders with a gestational age of 28 to approximately 35 wk were evaluated; they ranged in postnatal age from 31 to 73 d, and were submitted to sEMG of the masseter and buccinator muscles during different feeding methods. The infants were evaluated according to the at-home feeding method adopted by the family.

Premature infants between 28 and 35 wk of gestational age of both sexes were considered for inclusion. Exclusion criteria were bronchopulmonary dysplasia, head and neck deformities and grade III or IV intracranial hemorrhage.

Case 1 (Subject A) involved sEMG during breastfeeding of a baby who was exclusively breastfed. *Case 2* (Subject B) involved sEMG during cup-feeding of a baby who was both breastfed and cup-fed, which is an alternative method to breastfeeding recommended by the WHO [13]. *Case 3* (Subject C) involved sEMG during breastfeeding of a baby who was predominantly breastfed but also bottle fed. *Case 4* (Subject D) involved sEMG during bottle feeding of a baby who was predominantly breastfed but also bottle fed. The objective in this case was to verify whether a predominance of breastfeeding could modify the suction that the infant used when bottle feeding. *Case 5* (Subject E) involved sEMG during bottle-feeding of a baby fed exclusively by artificial means. The mothers of the infants signed a free and informed consent document approved by the Human Research Ethics Committee of the institution involved (nº 068/06).

For babies who were both breastfed and bottle fed, both an orthodontic nipple with the original manufacturer's opening and commercial infant formula were used.

A dual-channel electromyography system (*EMG System*, *model EMG2000*) was used for the examination. The system included a 12-bit analog to digital (A-D) converter plate with a channel connected to each of the two active electrodes as well as one reference electrode.

The EMG signal was quantified using the root mean square (RMS). The electrodes were connected to a high impedance ($1.0\times10^{12}\Omega$) pre-amplifier (20× gain), with a common mode rejection ratio >100 dB; the signals were adjusted to 2,000 samples per second and were band-pass filtered at a frequency of 20 to 450 Hz.

Silver chloride mini-electrodes (45×45 mm) were prepared for correct fixation on the evaluated muscle regions. The electrodes were positioned 16 mm apart along longitudinal axis of the muscle [10]. Electrolyte gel was chosen for the procedure as well as Transpore® tape to ensure adherence in spite of perspiration, movement or milk escape during the exam.

After palpating and finding the muscles, the skin was cleaned with ethanol and the electrodes were placed longitudinally on the muscle bundle with 16 mm spacing between the active and reference electrodes. The electrodes were then attached with the tape; the reference electrode was always placed on the lateral malleolus of the fibula.

After the placement of the electrodes, the mother was asked to feed her baby in the way he was normally fed at home. There was no contact between the left side of the infant's face and the mother's body in order to allow placement of the electrodes on that side.

sEMG evaluation was synchronized with a video recording of the feeding. The filming and electromyographic evaluation began and concluded concomitantly (the researcher controlled the EMG recording while an assistant controlled the filming on a digital camera).

No feeding lasted more than 5 min due to the rapid onset of fatigue in the premature babies. A Canon digital camcorder (*model PowerShot A470*) was used. The objective was to differentiate the feeding stages. In general, when the feeding started it was possible to observe adaptation in the latch and suction, independently from the method adopted. The adaptation period, or Time 1 (T1), consisted of initial rejection of feeding, inconstant latch, or fast sucking followed by long pauses. After T1 the suction was constant with pauses between suction groups, slower suctions followed by deglutition, which was classified as T2. The final period (T3) was characterized by either the satisfaction or fatigue of the baby, and included a reduction in rhythm and suction groups, as well as an increase in pauses. Each examination and film segment was individually analyzed in order to classify periods 1, 2 and 3 for the evaluated infants. The infants were submitted to a

Table 1 Description of the premature infants who took part in the study ($n=5$) and were submitted to sEMG during feeding Q3

Infants	Gender	GA (wk)	WB (kg)	DB (d)	Apgar 1′5′	
A	M	28	2.36	56	7	8
B	F	34	2.24	31	7	9
C	M	34	2.36	37	7	8
D	F	29	1.34	73	1	2
E	F	30	1.51	42	7	9
Mean		31	1.96	48	5.8	7.2
PD		2.8	0.49	16.4	2.6	2.9

F female; *M* male; *GA* gestational age; *WB* weight at birth; *DB* days after birth; *Apgar 1′ e 5′* Apgar index in the first and fifth min; *PD* standard deviation

t2.1 **Table 2** Distribution of the values obtained in MSR by sEMG of the masseter and buccinator muscles of the premature infants (n=5) at Times 1, 2 and 3 of the feeding

t2.2 Values MSR[a]	Time 1 (T1)	Time 2 (T2)	Time 3 (T3)	Total time
t2.3 Subject A				
t2.4 Masseter	122	113	108	2′ 39″
t2.5 Buccinator	77	62	55	
t2.6 Subject B				
t2.7 Masseter	193	234	177	4′ 55□
t2.8 Buccinator	208	215	165	
t2.9 Subject C				
t2.10 Masseter	55	49	48	2′ 19″
t2.11 Buccinator	40	71	60	
t2.12 Subject D				
t2.13 Masseter	90	132	132	1′ 56″
t2.14 Buccinator	66	93	90	
t2.15 Subject E				
t2.16 Masseter	27	46	33	3′ 36″
t2.17 Buccinator	77	66	22	

[a] The electromyographic was quantified by the mean square root (MSR) in microvolts (μv)

single electromyographic evaluation, which was performed during their first clinical visit after being released from the hospital.

Results

All included infants were premature, between 28 and 34 wk of gestational age with birth weights between 1.34 and 2.36 kg and weights on the examination date between 2.80 and 4.03 kg.

The group included three females and two males, between 31 and 73 d postpartum, with an Apgar score of 1 to 7 in the first min and 2 to 9 in the fifth min (Table 1).

The lowest masseter muscle activity registered by sEMG occurred in the exclusively bottle-fed infant. It was observed that Subject A presented higher masseter activity than buccinator activity, constant muscle activity with reduction in T3, which suggests satisfaction or economy of motor unit recruitment.

Subject B presented, in general, higher activity of the masseter muscle than the buccinator, increased muscle activity in T2 and decrease in T3 for both muscles, which indicates possible temporary muscle fatigue, a fact that may suggest satisfaction or economy of motor unit recruitment.

Subject C demonstrated similar muscle activity, but during T2 there was an increase in the activity of the buccinator and reduction in the activity of the masseter, which suggests, respectively, muscle fatigue and satisfaction or greater use of the buccinator muscle during breastfeeding.

t3.1 **Table 3** Studies using surface electromyography (sEMG)

t3.2 Author	Patients	Method used	Outcomes	Limitations
t3.3 Gomes [10]	60 term infants. Age: between 2 and 3 mo. Group1: 20 only breastfed infants. Group2: 20 breast-and bottle-fed infants. Group3: 20 breast- and cup-fed infants.	sEMG: Masseter, temporalis and buccinator muscles.	The data show that in both breastfeeding and cup feeding, the same muscles act in a similar fashion, with a greater participation of the masseter and temporalis muscles and a smaller participation of the buccinator muscles.	Does not describe the method or comparisons between muscles.
t3.4 Daniëls [11]	n=18 preterm infants. Age: 0–8 wk. Type of feeding was undefined	sEMG: Digastric and mylohyoid muscles.	Inefficient drinking in the preterm infant is characterized by short sucking bursts and by a small volume of milk intake during each sucking movement. Efficient drinking is characterized by a large amount of milk intake during each sucking movement. Sucking rate does not correlate with feeding efficiency and is therefore not a good indicator for assessing feeding behavior in the preterm infant.	Made no reference to the feeding method used during EMG; the authors evaluated muscle activity only during breastfeeding.
t3.5 Nyqvist [12]	26 breastfed preterm infants Age: mean postnatal age 18.0 d, SD 14.4	sEMG: Orbicularis oris, mylohyoid, geniohyoid, stylohyoid, and digastric muscles.	EMG data provided evidence of early sucking competence in preterm infants during breastfeeding, with wide individual variations.	The authors evaluated muscle activity only during breastfeeding.
t3.6 Tamura [14]	48 healthy, term breastfed infants. Five groups according to mo of age. Age: 1–5 mo	sEMG: Temporalis, masseter, orbicular oris, and suprahyoid muscles.	Intensified activity of the suprahyoid muscle group during suckling was evident with age. The active tongue-and-jaw-lowering movements may play a primary role in increasing sucking strength during the suckle-feeding period of infants.	Does not describe the method or comparisons between muscles and types of feeding.

Subject D presented higher masseter activity, possibly because she was bottle fed only intermittently during the day; however, there was an increase in the activity of both muscles in T2 and T3, which indicates muscle fatigue of the buccinator, possibly due to the frequent action of this muscle during bottle-feeding.

Finally, Subject E demonstrated low values of both masseter and buccinator activity, with higher activity of the buccinator in T1 and T2 and a reduction in T3, possibly caused by muscular fatigue (Table 2).

Discussion

The use of sEMG can assist professionals working with premature infants in the diagnosis of muscle activity performed in different feeding methods, with the intent to benefit these infants and intervene in the improvement of the muscle activity, which is related to the growth of structures and development functions of the stomatognathic system [9].

In the index study it was noticed that masseter muscle activity was reduced in bottle-fed infants. The sucking movements performed during bottle-feeding are different compared with those performed during breastfeeding, which causes significant muscle changes. It is assumed that the neurological stimulus of maxillomandibular growth and development loses its synergism in artificial feeding. In addition to the stomatognathic system changes, other functions will be altered in bottle-fed infants, such as: swallowing, breathing and subsequently, chewing and talking. For this reason other feeding methods have been used. The cup-feeding is an important recommended feeding method, especially due to the similarities in the muscle activity during sucking to breastfeeding [10].

There were difficulties and limitations in using the sEMG because the facial musculature of premature babies is reduced, making both electrode placement and adhesion difficult; eliminating interference was also difficult.

In several situations sEMG revealed the presence of oral motor dysfunctions, which were later clinically evaluated and treated by a speech therapy professional. Notable among the dysfunctions was elevated activity of buccinators in breastfed infants (with pain reported by their mothers due to nipple fissures), as well as a reduction in masseter activity indicated by difficulty in maintaining latch with the breast.

A recent systematic review revealed that some authors did not deem it necessary to describe the method of sEMG application or the feeding method tested, and there was no comparison between feeding methods [9].

Due to the lack of scientific studies [10, 11, 14] describing the method or comparisons between muscles and types of feeding, the present study was developed using a time-based analysis (Table 3). The development and testing of a standardized method for performing and analyzing sEMG in premature infants revealed that this type of examination is viable.

The method of the present study was based on a study performed with full-term infants [10], although some adaptations were necessary (electrode modification, electrode placement, examination duration and analysis according to temporal stages).

The data obtained in these five cases agrees with other studies performed with full-term infants [10–12], however, it is not possible to discuss or make comparisons with other studies involving premature infants, because one of the studies made no reference to the feeding method used during EMG, and in the second study the authors evaluated muscle activity only during breastfeeding [11, 12] (Table 3). Studies with a larger sample size and with other forms of EMG signal analysis such as, frequency domain fatigue and alternative forms of signal normalization should be encouraged.

Conclusions

The results of this study show that masseter activity is reduced in bottle-fed babies, and that there are similarities between the activity of the masseter muscle during breastfeeding and cup-feeding.

This study made it possible to define and adapt a method for performing sEMG in premature infants, and it indicated the relevance of sEMG for the clinical practice of speech therapy, because the results of the examination can reveal treatable oral motor dysfunctions that might frequently lead to early cessation of breastfeeding.

Conflict of Interest None.

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