ASSOCIATION BETWEEN MASTICATORY ACTIVITY AND GROSS MOTOR FUNCTION, SPASTICITY AND TOPOGRAPHIC CLASSIFICATION IN CEREBRAL PALSY

Associação da atividade mastigatória com a função motora ampla, espasticidade e classificação topográfica na paralisia cerebral

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ABSTRACT

Purpose: to verify the existence of an association between the degree of spasticity, the level of motor function and wide topographical classification of CP children with amplitude and time parameters of electromyographic activation of temporalis (AT) and masseter (MA) muscles. **Methods:** muscle activity during chewing task was evaluated in fifteen children with CP. The clinical instruments used were the Modified Ashworth Scale for spasticity, the Gross Motor Function Classification System (GMFCS) for gross motor function. We analyzed the parameters of muscular symmetry and time of active and inactive period of the masticatory cycle. **Results:** there was an association between the level of motor function and the symmetry of the MA, between the highest degree of spasticity and decrease in the inactive period and increase in the active period of the masticatory muscles and between the topographical classification and symmetry of the MA and the symmetry of the AT. **Conclusion:** the symmetry and the time of activation of AT and MA should be considered during therapy of oral motor function of CP children.

KEYWORDS: Masticatory Muscles; Cerebral Palsy; Electromyography

INTRODUCTION

Cerebral palsy (CP) or chronic non-progressive encephalopathy is a term that describes a group of non progressive disorders of movement and posture associated with an immature brain defect[1]. The CP usually interferes in the functioning of the musculoskeletal system, including disorders of muscle tone, posture and voluntary movements[2]. Muscle weakness, limited muscle synergisms, contractures and biomechanical changes also contribute to disability in CP and their functional limitation[3].

The most common type of **cerebral palsy is the spastic** form[4]. Spasticity is related to a significant restriction in range of motion of the affected muscles, an abnormal pattern in reciprocal inhibition between antagonist muscles and results in functional impairment[5]. Such disturbances of movement, posture and tone can also affect oral-motor functions[6-8]. However, no studies were found that evaluated how these disorders can influence these oral functions.

Although there are studies about the problems found in children with CP during mastication, still are sparse researches that aim to evaluate the activity and behavior of the muscles of the stomatognathic system in this pathology. This study may contribute to a better understanding of changes in the stomatognathic system, and thus aid the development of more appropriate intervention methods.

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The objective of this study was to investigate the association between the degree of spasticity, the level of motor function and the topographic classification of CP volunteers with amplitude and time parameters of electromyographic activation of the anterior temporal (AT) and masseter (MA) muscles.

METHODS

This study is cross-sectional design. Participants were 15 volunteers with spastic CP who met the inclusion and exclusion criteria previously defined and selected through an interview process. Inclusion criteria were: aged between seven and 13 years and ability to understand simple commands. Exclusion criteria were: presence of associated disorders such as mental retardation, congenital malformations, sensory changes, application of botulinum toxin or surgery in the evaluated region over the past six months, use of braces and history of trauma to the face or to the temporomandibular joint, cervical and shoulder girdle.

The parents or responsible of all volunteers were informed about the procedures and objectives of the study. They provided their written informed consent prior to child's participation in the research.

The Gross Motor Function Classification System (GMFCS) **was used to** classify motor function[9]. The GMFCS classifies motor impairment according to five levels. Level I – walks without limitations; level II – walks with limitations; level III – walks using a hand-held mobility device; level IV – self-mobility with limitations and may use powered mobility; level V – transported in a manual wheelchair.

The Modified Ashworth Scale (MAS)[10] was used for the assessment of **spasticity**. It is an ordinal scale ranging from 0 to 4. The grade 0 – no increase in muscle tone; grade 1 slight increase in muscle tone, manifested by a catch and release or by minimal resistance at the end of the range of motion when the affected part(s) is moved in flexion or extension; grade 1+ (1.5) – slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the ROM; grade 2 – more marked increase in muscle tone through most of the ROM, but affected part(s) easily moved; grade 3 considerable increase in muscle tone, passive movement difficult; and grade 4 – affected part(s) rigid in flexion or extension.

All EMG signals were recorded using a commercially-available 16-bit surface EMG system (System of Brazil; Model EMG-1200C) with Disposable bipolar sensors (Medi-trace Kendall-LTP, Chicopee MA 01022). Signals were amplified with a gain of 2000 (20 – 500 Hz filter setting) prior to sampling (2000 Hz) and the minimum ratio Common Mode Rejection was 100 dB.

The evaluation form was completed with anthropometric data, classification topographical and GMFCS. The MAS was applied with volunteers in the supine position. The joints are moved passively from a position of maximal possible flexion to maximal possible extension. To assess knee flexor muscles, the hips and knees were kept in flexion. The examiner stabilized a thigh with one hand. With the other hand stabilized the ankle to move the knee to the maximum extent. To assess elbow flexor muscles, the examiner extended the forearm from maximum possible flexion to maximum possible extension. The volunteers's arm extended as much as possible and with the palm of the hand facing inward (neutral supination). The score was based on the sum of the results obtained by means of four measures related to flexor muscles of bilateral elbows and knees. The results were summed to give an index for each volunteer with maximum score of 16 points in the highest degree of spasticity[11].

During the evaluation of muscle activity the volunteers remained seated in a chair with the head positioned in the Frankfurt plane (parallel to the ground), hands on thighs aligned with the shoulder, back support at the height of the shoulder blades. The electrodes were longitudinally aligned to the muscle fibres and fixed on the skin of the MA and AT muscles, bilaterally[8,12]. The reference electrode was fixed on the manubrium of the sternum. The electrical impedance of the skin was reduced by cleaning the area with hydrophilic cotton soaked in 70% alcohol solution.

To make comparisons of the EMG signal between the volunteers, the values of masticatory activity were normalized by a reference contraction (RC). The RC was measured by the isometric contraction of clenching in maximum intercuspation. The contractions of the MA and AT muscles were sustained for 5 seconds and repeated three times with an interval of 1 minute between repetitions.

After training, the mastication task was repeated three times, with a duration of 10 seconds and 1 minute intervals between each sampling. During data acquisition, a metronome with 60 beats per minute was used during the gathering of data, as well as bars of parafilm, folded 15 times to the size of 1.5 cm by 3.5 cm and placed between the occlusal surface of the first and second upper and lower molar, bilaterally.

We implemented a calculation routine using Microsoft Excel software to detect the beginning (onset) and the end (offset) of muscle activity during the task of mastication[13]. This detection method uses the filtered EMG signal (band-pass filter with 20 to

500Hz bandwidth) obtained during the 10 seconds mastication task. The routine automatically scrolls down the EMG signal using a fixed size window of 200ms and calculates the RMS and standard deviation values for each one of these windows. Based on the lowest RMS value of the analyzed EMG signal, a reference value will be defined and it will be used by the routine to differentiate the inactive period (IP) and the active period (PA) of each muscle (Figure 1). For this purpose, the first and last identified cycles of each attempt were disregarded and the central cycle was selected. It is a routine calculation faster and more accurate when compared to visual graphical analysis commonly used in the selection of the masticatory cycle. An objective statistical criterion in determining the beginning and the end of the electromyographic activity facilitates and standardizes the data processing[13].

The symmetry of the muscular activity of paired muscles during the task of mastication was evaluated[14,15]. The rectification and filtering of the signals was also carried out with a cut-off frequency of 6HZ to obtain the linear envelope, which was reduced to 100 points[16]. If the contraction of paired muscles is symmetric when the index is 100%.

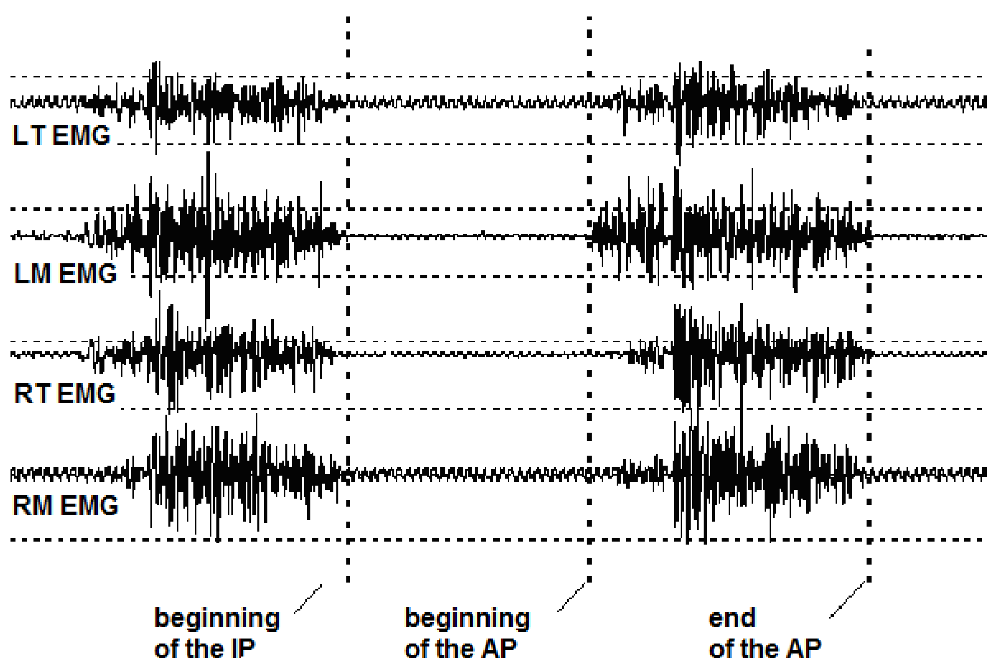

Figure 1 – EMG signal of Left Temporal (LT), Left Masseter (LM), Right Temporal (RT) and Right Masseter (RM) muscles for a chewing cycle (Inactive Period (IP) and Active Period (AP).

This study was approved by the Ethics Committee of the institution, under reference number 26/2009.

Participants were characterized using descriptive statistics (mean, standard deviation and **95% confidence interval**). After checking the normality of the data through the Shapiro-Wilk test, we used the Spearman correlation coefficient to examine the relationship between the degree of spasticity, the level of motor function and topographical classification with parameters of amplitude and duration activation of MA and AT muscles. Correlation values smaller than 0.20 indicate very low **association;** values between 0.20 and 0.39 low **association;** values between 0.40 and 0.69 moderate **association**; values between 0.70 and 0.89 high association; and values between 0.90 and 1.0 association too high.

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 17.0 for Windows and for all procedures we adopted the significance level of 5% ($p < 0.05$), two-tailed distribution.

RESULTS

Volunteers with spastic CP had a mean age of 9.9 ± 2.0 years, height 1.3 ± 0.2 m and body mass 30.6 ± 8.1 kg. 40.0% (6/15) were male and 60.0% (9/15) were female. Regarding the topographical classification 40.0% (6/15) of the volunteers had hemiparesis, 46.7% (7/15) had diparesis and 13.3% (2/15) showed quadriparesis. In relation to motor impairment assessed by GMFCS, 6.7 (1/15) of subjects were classified at level I, 46.7% (7/15) at level II, 20.0% (3/15) at the level III and 26.7% (4/15) at level IV. According to the MAS, the mean and standard deviation of the index for the spasticity degree was 3.8 ± 2.5 points.

Table 1 shows the results of electromyographic variables, MA symmetry, AT symmetry, time of the inactive period, time of the active period and the total duration of the masticatory cycles.

Table 2 shows the values of Spearman correlation coefficient, which was used to examine the relationship between the degree of spasticity (MAS), the level of motor function (GMFSC) and topographical classification with electromyographic variables.

The topographic classification was highly associated with the MA symmetry (p=0.00) and moderately with the AT symmetry (p=0.01). We observed a moderate association between the level of motor function and MA symmetry (p=0.00). In the analysis of the masticatory cycle time (ms) was found moderate association between the higher degree of spasticity and the inactive period decrease (p=0.04), as well as with active period increase (p=0.04). In the analysis of the masticatory cycle time (%), the greater spasticity was highly associated with inactive period decreased (p=0.00) and active period increase (p=0.00).

Table 1 – Mean values, standard deviations (SD) and confidence intervals of the mean (95% CI) of the muscle symmetry and masticatory cycle time of volunteers with cerebral palsy (n = 15).

	Mean	SD	95% CI
Masseter Symmetry (%)	80.62	9.65	75.27 - 85.96
Temporal Symmetry (%)	81.10	7.09	77.17 - 85.03
Time of the Inactive Period (%)	43.45	13.12	36.19 - 50.71
Time of the Inactive Period (ms)	473.25	176.64	375.40 - 571.10
Time of the Active Period (%)	56.55	13.12	49.28 - 63.81
Time of the Active Period (ms)	614.01	250.42	475.30 - 752.70
Total duration of the Masticatory Cycle (ms)	1087.26	269.15	938.20 - 1236.30

ms= millisecond

Table 2 – Correlation between the level of Gross Motor Function Classification System (GMFCS), degree of spasticity (Ashworth) and topographical classification in relation to the masticatory cycle time of volunteers with cerebral palsy (n = 15).

	Topographical Classification	GMFCS	Ashworth
Masseter Symmetry (%)	0.82**	0.65**	0.44
Temporal Symmetry (%)	0.60*	0.24	0.21
Time of the Inactive Period (%)	-0.06	-0.40	-0.52*
Time of the Inactive Period (ms)	-0.09	-0.42	-0.72**
Time of the Active Period (%)	0.09	0.39	0.52*
Time of the Active Period (ms)	0.09	0.42	0.72**
Total duration of the Masticatory Cycle (ms)	0.19	0.16	0.13

Spearman's correlation coefficient. ms=millisecond. Statistically significant: *p<0.05; **p<0.01.

DISCUSSION

The CP is a disorder characterized by the presence of abnormal muscle tone and lower performance on functional abilities and gross motor function[17]. In this study, the spasticity, the gross motor function and the topographical classification were associated with parameters of amplitude and activation time of the masticatory muscles, showing aspects of oral motor dysfunction.

The mandibular movement during mastication is considered asymmetric[18,19]. Normative values of symmetry of masticatory activity for children were not found in the scientific literature. Despite the small sample size in this study, it was observed in 12 children with typical development (average age of eight years), a symmetry index of MA muscle 91.5 ± 6.2% and of AT muscle 92.0 ± 8.3%[8]. In healthy adults, was considered a normal Symmetry index of electrical activity was considered normal in healthy adults of at least 82.0 ± 1.3%[20] or 87.1 ± 1.6% for the MA muscle and 88.1 ± 1.4% for the AT muscle[21]. The present study found values lower than these parameters, although not be the same population. Children with CP have activity patterns of the muscles involved in chewing more asymmetric compared with the typical development group[8].

The symmetry parameters of MA and AT muscles showed, respectively, high and moderate association with the topographic classification of CP. In the presence of spastic quadriparesis and spastic diparesis we found more symmetry in the electrical activity of the masticatory muscles when compared with spastic hemiparesis. One explanation for this result is the fact that these volunteers, although more committed, have a more symmetric distribution of their alterations. In children with spastic hemiparesis are observed early asymmetries of movements and functional abilities due to a unilateral distribution of spasticity[22]. The functional asymmetry characteristic of hemiparesis is also observed in oral motor function.

The symmetry of the MA was moderately associated with the GMFCS. Thus, the higher the symmetry of the electrical activity of the MA muscles in CP volunteers, the greater their gross motor function limitations and functional abilities. This result, seemingly contradictory, may be related to greater asymmetry of volunteers with spastic hemiparesis and a lighter level of motor and functional impairment observed with the GMFCS. In contrast, volunteers with spastic quadriparesis and diparesis are more symmetrical in their oral motor function with a higher level of motor and functional impairment.

The sum of the degrees of muscle tone in the different joints obtained by MAS has been used in clinical practice and research[11,23,24]. Spastic **cerebral palsy** is characterized by increased muscle tone causes alterations in posture and movement and prevents proper motor development.

It was expected that the degree of spasticity was associated with measures of the amplitude of the electromyographic activity of the masticatory muscles, but was only associated with the time. The sample size may have influenced the absence of some associations. No studies were found that evaluated the association of spasticity with parameters of the electrical activity of oral motor function of children with CP. There are also a few studies that evaluate the association of spasticity with other alterations of the stomatognathic system. In the assessment of oral function of children with CP, Ries and Bérzin (2005) found no association between the severity of spasticity with the severity of temporomandibular dysfunction[11].

In this sample the highest degree of spasticity was associated with a shorter time inactive period and longer active period of the masticatory muscles. The shorter time inactive period and longer active period shows the greatest difficulty in relaxation of volunteers more spastic. Although there was no relationship with the total duration of the masticatory cycles, this behavior in the MA and AT muscles activity can cause an overload in the stomatognathic system, which in turn may contribute to alterations in oral motor function. The alterations in the parameters of the time periods of the masticatory cycle characterize the muscle activity dysfunction of spastic CP. Knowledge of the specific alteration that causes a movement disorder of masticatory muscles allow a multidisciplinary team to establish more appropriate therapeutic strategies.

CONCLUSION

These results indicate multifactorial relationships for alterations in oral motor function in the presence of CP. Most spasticity was associated with less time to relax and the largest contraction time during the chewing cycle. Volunteers with hemiparesis compared to those with quadriparesis and diparesis showed a lighter level of motor and functional impairment, yet with greater asymmetry of the muscles AT and MA. The symmetry and the time of activation of AT and MA muscles should be considered during therapeutic approach for difficulty chewing in CP.

RESUMO

Objetivo: verificar a existência de associação entre o grau de espasticidade, o nível de função motora ampla e a classificação topográfica de voluntários com PC com parâmetros de amplitude e tempo da ativação eletromiográfica dos músculos temporal (TA) e masseter (MA). **Métodos:** a atividade muscular durante a tarefa de mastigação foi avaliada em quinze voluntários com PC. Os instrumentos clínicos utilizados foram: a Escala Modificada de Ashworth para espasticidade, o Sistema de Classificação de Função Motora Ampla (GMFCS) para função motora ampla. Foram analisados os parâmetros de simetria muscular e tempo do período ativo e inativo do ciclo mastigatório. **Resultados:** durante o ciclo mastigatório observou-se associação entre o nível de função motora ampla e a simetria do MA, entre o maior grau de espasticidade e a diminuição do período inativo e aumento do período ativo e entre a classificação topográfica e a simetria do MA e do TA. **Conclusão:** a simetria e o tempo da atividade dos músculos TA e MA devem ser considerados durante a terapia da função motora oral na PC.

DESCRITORES: Músculos Mastigatórios; Paralisia Cerebral; Eletromiografia

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