CHANGES IN MANDIBULAR AND CERVICAL MOTOR CONTROL OF CHILDREN WITH CEREBRAL PALSY

Alterações no controle motor mandibular e cervical de crianças com paralisia cerebral

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ABSTRACT

Purpose: to study was to analyze the electrical activity of Masseter and Temporalis muscles and the pattern of posture and movement of the head and jaws of children with cerebral palsy (CP). **Methods:** the sample comprised 32 volunteers with spastic CP and with normal development, with ages ranging from 7 to 13 years of age, characterized based on the Classification of Angle and Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD). Simultaneously, we evaluated the position and movement of the head and jaw and electrical activity of Temporalis and Masseter muscles by means of kinematic and electromyography. **Results:** the CP was not associated with the presence of TMD or with the alteration of dental occlusion. In the CP group, there was greater asymmetry of the temporalis muscle ($p<0.05$), more head extension at maximum mouth opening ($p<0.05$), greater range of head extension ($p<0.01$) and greater range of anterior projection of the head ($p<0.05$). **Conclusion:** the greater asymmetry in muscle activity, the greater extension and projection of the head during the chewing cycle can be causes of disorders of the oral motor function of children with CP.

KEYWORDS: Cerebral Palsy; Masticatory Muscles; Electromyography

INTRODUCTION

Children with Cerebral Palsy (CP) have developmental disorders of movement and posture causing activity limitation. Abnormalities of muscle tone, muscle weakness, muscle synergisms limited, awkwardness, contractures and altered biomechanics are common[1]. Such disturbances result in a developmental delay and can also affect the development of orofacial organs providing inadequate performance the functions of speech, sucking, chewing, swallowing and respiratory changes[2,3].

It is considered that the temporomandibular disorder (TMD) is triggered by multifactorial processes related to the combination of imbalances between occlusal, anatomical, psychological, neuromuscular and postural factors[4]. Its main features are pain, joint sounds, abnormal mandibular function, including disorders related to articulation and the masticatory and cervical muscle complex.

Several studies have been published on the effects of the association of cervical and mandibular movements during mastication[5,6]. It is believed that during mastication, the mutual influence between the trigeminal and cervical system can allow the system trigeminal to modulate the cervical movements[6].

In children with CP, the righting and balance reactions, necessary to maintain posture and head control are incomplete. In contrast, many times the pathological reflexes are intense stopping this cervical control and which can lead to changes in the stomatognathic system[7]. The functional performance of the CP is connected to the motor impairment and there may be involvement of the orofacial muscles[8].

There are few studies that aim to study the motor control of chewing activity of children with CP. Most studies on posture and movement disorders in these

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children are related to gross motor function. Assess the balance of the masticatory muscles of children with CP can help in the diagnosis of disorders of the oral motor function.

The relevance of the subject determines the need for further studies and research on motor control during chewing task. Understanding the changes of posture and movement during chewing task may, in a second phase, assist in targeting intervention measures of the interdisciplinary team. The objective of this study is to analyze the electrical activity of the anterior temporal (AT) and masseter (MA) and the posture and movement pattern of the head and jaw of typical development (TD) and CP children.

METHODS

After approval by the Research Ethics Committee (Case No 26/2009), parents or responsible of all children were informed about the procedures and objectives of the study and signed the informed consent term after explanations and agreed in participating in the study.

Subject

This is a cross-sectional exploratory study. Participants were thirty-two (32) volunteer children between the ages of seven to thirteen years old, divided into CP group (16 children) (age=9.94±1.98 yrs, weight=30.43±10.36 Kg and height=1.36±0.17 m) and TD group (age=9.31±1.66 yrs, weight=33.56±8.28 Kg and height=1.39±0.14 m), without any neurological and/or musculoskeletal impairment. According to the Gross Motor Function Classification System (GMFCS)[9], eight CP children had mild impairment (GMFCS level I and II), three had moderate impairment (GMFCS level III) and five had severe motor impairment (GMFCS level IV). Both groups were selected in a non -probabilistic (intentional) way.

Exclusion criteria were: use of braces and history of trauma to the face, to the temporomandibular joint, to the cervical and the shoulder girdle; absence of teeth; systemic diseases; genetic syndromes; sensory alterations (i.e., vestibular, visual or auditory); use anti-inflammatory drugs; application of botulinum toxin or surgery in the evaluated region over the past 6 months; inability to understand simple orders and maintain a sitting position.

Experimental Procedure

The children were assessed with anthropometric measures and issues related to the inclusion and exclusion criteria of this study. The children were also subjected to kinematic and electromyographic evaluation (simultaneous), chosen at random, after wearing appropriate clothing.

Clinical Evaluation

For both groups, the clinical evaluation of the morphological aspects of dental occlusion was based on Angle's classification of malocclusion, with visual inspection of the anteroposterior relationship between the mandible and maxilla, which ranked each subject in Angle class I (normal), Angle class II (retrognathia mandibular) or Angle class III (mandibular prognathia)[10]. Also for both groups, a subject can be assigned from **zero** (no **TMDs**) to **five** different **diagnoses**, based on history and clinical signs, was performed by Axis I RDC/TMD[11]. The jaw movements were measured with a digital caliper (Western brand). Because the groups are made up of children and the questionnaire was developed for adults, were answered only the questions Q3 and Q14 of the same. These issues are related to the presence of pain in the face, ear and / or head and lock jaw history, which are all relevant in the classification of TMD according to RDC/TMD axis I.

Kinematics and Electromyography Evaluation

For biomechanical analysis, the child 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 and knees and hips at 90º. During EMG and kinematic exams, all subjects were instructed to remain with arms relaxed, hands resting on your thighs and **eyes opened** and directed **towards a target of 5 cm in diameter placed at eye level**, 1.95 m in front of them.

All EMG signals were recorded using a commercially-available 16-bit surface EMG system (System of Brazil; Model EMG-1200 C). Signals were amplified with a gain of 2000 (20–500 Hz filter setting) prior to sampling (2000 Hz). The minimum Common Mode Rejection was 100 dB. Disposable bipolar sensors (Medi-trace Kendall-LTP, Chicopee MA 01022) were located on the Right Masseter (RM), Left Masseter (LM), Right Temporal (RT) and Left Temporal (LT) muscle with a between-electrodes center-to-center distance of 20 mm[12]. The electrical impedance of the skin was reduced, by cleaning the site with hydrophilic cotton soaked in an alcohol at 70%. Muscle function test was performed before electrode placement. For AT (vertically along the anterior margin of the muscle) and MA (2cm above of the external angle of the jaw) muscles the electrodes were positioned on muscle belly (parallel to muscular fibres) that was located during dental clenching. The reference electrode was placed on the sternum. After placement of the electrodes surface EMG of the AT and MA was performed during chewing and during maximum voluntary teeth clenching (MVC). The values of chewing were normalized by a MVC. All MVC were sustained for 5 s and repeated three times with an interval of 1 min between repetitions. A metronome with 60 beats per minute was used during the gathering of data, as well as bars of parafilm placed between the occlusal surface. The chewing task was repeated five times, with a duration of 10 s and 1 min intervals between each sampling.

Mandibular motion in 2-dimensional space was recorded in sagittal plane by the Canon Power Shot A710 IS® camera. This system tracks the movements at a sample rate of 30 Hz. The subjects were seated upright with camera on a tripod to 0.85 cm and a perpendicular distance of 1.2 m of volunteers. The shooting occurred in the randomized side in DT group and the most affected side in CP group. For kinematic evaluation black spherical markers made on a white circular base were stuck with double-sided tape: glabella (midline of the face and 1 cm above the nose), canthus of the eye, tragus (cartilage above the ear), the tip of the chin, spinous process of C7[13]. To calculate the real coordinates, a system of two-dimensional calibration 1.0 x 1.0 was placed in the plane of the filming.

Data Analysis

Of five attempts to chewing performed for each subject, we analyzed only the first three free of any technical problem.

The kinematic analysis of head and jaw movements occurred in the medial chewing cycle cut from the electromyography signal through a routine that runs through the already filtered EMG signal, using a fixed window size 200ms and defines the lowest RMS value of the signal. Having the lowest RMS value and its standard deviation will be defined the reference value to differentiate the resting state and the activity muscular state[14]. The reference value was used equal to 3σ (where σ is the standard deviation of the window of 200ms).

For scanning, which was performed visually, frame by frame, the system software used was the Ariel Performance Analysis System (APAS). The cycle synchronization between EMG and the camera was made through a flash.

In kinematic analysis of chewing cycle was calculated the angle formed by the line connecting C7 to the tragus of the ear and the horizontal, which gives the position of the head relative to the trunk. Its decreasing values are indicative of a more forward head posture[13]. From this angle were considered other variables: 1) Forward Head Posture at Early Chewing (FHPEC) measured by the angle value at the onset of the chewing cycle, 2) Forward Head Posture at Maximum Mouth Opening (FHPMMO) expressed the angle value at the time of maximum mouth opening, 3) Forward Head Posture Amplitude (FHPA) calculated by the maximum extension of the head minus the minimum extention of head, 4) Forward Head Posture Mean (FHPM) calculated by averaged to the angular values of the forward posture of the head.

Also was calculated the angle formed by the line connecting the tragus of the ear to the canthus of the eye and the horizontal, which gives the position of the upper cervical spine with increasing values indicative of a more extended head[13]. From this angle were analyzed variables: 1) Head Extension at Early Chewing (HEEC) expressed by the angle value at the onset of the chewing cycle, 2) Head Extension at Maximum Mouth Opening (HEMMO) expressed by the angle value at the time of maximum mouth opening, 3) Head Extension Amplitude (HEA) calculated by the maximum extension of the head minus the minimum extension of the head; 4) Head Extension Mean (HEM) averaged values of the angular extension of the head.

Also was calculated the opening of the mouth of a chewing cycle through the joint angle measured between the glabella, tragus and chin. The objective of this angle was to analyze the variables: 1) Mouth Opening Amplitude (MOA) calculated by the maximum opening of the mouth least the minimum opening of the mouth (Figure 1).

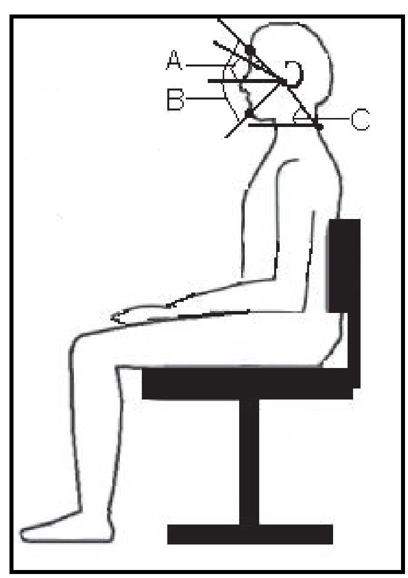

Figure 1 – Angles measured during the chewing cycle: (a) angle between eye, tragus and horizontal, (B) the angle between the glabella, tragus and chin (c) the angle between the tragus, C7 and horizontal.

Electromyography variables were analyzed: Symmetry Index of AT and MA muscle (ATS and MAS) and the Antero– Posterior Coefficient (APC)[15] during a chewing cycle for each of the three attempts. The symmetry index of muscle activity was calculated by temporal quantification between the normalized EMG waves of paired muscles and the common area between the two EMG waves was identified. The two EMG waves were superimposed and the ratio between the superimposed areas and the total area was calculated. The APC compare muscle activity between the MA and TA muscles. In this index EMG waves were overlapped and was calculated the ratio between the areas not overlapped and the overlapped MA and AT muscle areas of both sides. The activity of the muscles analyzed is balanced, both the symmetry index as the APC, when the value is 100 %.

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 (root mean square– RMS EMG potentials). This processing was carried out using MATLAB software (Version 5.3 The MathWorks Inc.). For normalization, the EMG potentials were expressed as a percentage of a maximum 1s RMS value obtained across the three repetitions of the RVC for each muscle and subject.

Statistical Analysis

Participants were characterized using descriptive statistics (mean, standard deviation) and for each variable, the arithmetic mean of three attempts was considered. The difference between the mean age, body mass and height between the TD and CP groups was analyzed by using the Student's T-test. To verify the existence of the association and its risk among TD and CP groups with TMD and the presence of changes in occlusion was applied, respectively, the chi-square test and odds ratio (OR).

After checking the data normality by the Shapiro – Wilk test, we used the t test for independent data on parametric variables and the Mann-Whitney non– parametric variables. Analysis was performed using the program Statistical Package for Social Sciences (SPSS) version 17.0 for Windows, and for all procedures was adopted significance level of 5% ($p<0.05$), with two-tailed distribution.

RESULTS

The t test showed that there was no difference in the mean age, body mass and height between CP and TD groups ($\rho > 0.05$). In the group of children with TD, 50% (8/16) did not show any TMD signs or symptoms and 50% (8/16) are TMD, yet this same group 56.25% (9/16) have Angle class I, 37.50 % (6/16) Angle class II and 6.25% (1/ 16) Angle class III. In the group of children with CP, 56.25% (9/16) did not show any TMD signs or symptoms 43.75 % (7/16) are TMD; still in the CP group 43.75% (7/16) showed Angle class I, 37.50 % (6 /16) Angle class II and 18.75% (3/16) Angle class III. The Chi-square test showed that there is no association between TD and CP groups with TMD ($p=0.72$) and changes in occlusion ($p=0.48$). The cross-product ratio also showed that TD and CP and TMD/changes in occlusion are independent variables.

Table 1 shows the results of electromyography variables of the TD and CP groups. It was observed that the CP group has greater bilateral asymmetry between the right and left muscles MA, between the right and left AT muscles and a greater imbalance in the activity of the four muscles analyzed. However, the only significant difference was considered on ATS ($p<0.05$).

Table 2 shows the results of angular and space-temporal kinematic variables to the extension of the head. CP children were higher extension of the head while chewing. However, the only significant difference was considered for the variable HEA ($p<0.01$) and the HEMMO ($p<0.05$).

Table 3 describes the results of angular and space-temporal kinematic variables of the forward head posture and the opening of the mouth. We observed greater forward head posture to the CP group in all variables. For the angular FHPEC, FHPMMO and FHPM, the smaller the average angular value the greater the forward head posture. However, for space-temporal variable FHPA, the higher the value of the displacement of the head the greater forward head posture, and it was the only one that was statistically significant ($p<0.05$). Also observed for the CP group, further opening the mouth during chewing cycle, however, this result was not statistically significant.

Table 1 – Mean, standard deviation (SD) and confidence interval of the mean (95% CIM) of the electromyographic variables of the groups with Typical Development (TD) (n = 16) and Cerebral Palsy (CP) (n = 16)

	Mean (SD)		95% CIM		P
	TD	CP	TD	CP	
MAS [a] (%)	82,80 (7,73)	80,39 (9,37)	78,67- 86,92	75,40 - 85,39	0,49
ATS [b] (%)	85,10 (7,71)	81,44 (6,98)	80,99 - 89,21	77,72 - 85,16	0,04*
CAP [b] (%)	85,82 (7,15)	84,16 (4,94)	82,01 - 89,64	81,53 - 86,80	0,62

[a] T Test for independent data; [b] Mann-Whitney; Statistically significant difference: *p<0.05; MAS = Masseter Symmetry; TAS = Temporal Symmetry; CAP = Coefficient antero-posterior.

Table 2 – Mean, standard deviation (SD) and confidence interval of the mean (95% CIM) of the kinematic variables of angular head extension of the groups with Typical Development (TD) (n = 16) and Cerebral Palsy (CP) (n = 16)

	Mean (SD)		95% CIM		P
	TD	CP	TD	CP	
HEEC [a] (graus)	20,10 (6,59)	25,97 (14,09)	16,59 – 23,60	18,46 - 33,47	0,14
HEMMO [a] (graus)	21,18 (6,36)	29,93 (14,87)	17,79 - 24,57	22,00 – 37,85	0,04*
HEA [b] (graus)	4,21 (1,43)	8,54 (6,58)	3,45 – 4,97	5,04 – 12,05	0,00**
HEM [a] (graus)	20,65 (6,40)	27,24 (14,46)	17,24 – 24,06	19,54 – 34,95	0,11

[a] T Test for independent data; [b] Mann-Whitney; Statistically significant difference: * p<0.05, ** p<0.01; HEEC = Head Extension at Early Chewing; HEMMO = Head Extension at Maximum Mouth Opening; HEA = Head Extension Amplitude; HEM = Head Extension Mean.

Table 3 – Mean, standard deviation (SD) and confidence interval of the mean (95% CIM) kinematic variables of angular head previous projection and mouth opening of the groups with Typical Development (TD) (n = 16) and Paralysis cerebral palsy (CP) (n = 16)

	Mean (SD)		95% CIM		P
	TD	CP	TD	CP	
FHPEC (graus)	44,92 (7,55)	41,00 (9,26)	40,90 - 48,94	36,07 - 45,94	0,09
FHPMMO (graus)	45,14 (7,75)	41,41 (9,14)	41,01 - 49,27	36,54 - 46,28	0,05
FHPA (graus)	1,89 (0,82)	3,54 (2,35)	1,45 - 2,33	2,29 - 4,79	0,01*
FHPM (graus)	44,99 (7,68)	41,78 (9,16)	40,90 - 49,09	36,90 - 46,66	0,09
MOA (graus)	9,73 (3,80)	12,80 (6,59)	7,71 - 11,76	9,28 - 16,31	0,11

Test de Mann-Whitney; Difference statistically significant: * p<0,05; FHPEC = Forward Head Posture at Early Chewing; FHPMMO = Forward Head Posture at Maximum Mouth Opening; FHPA = Forward Head Posture Amplitude; FHPM = Forward Head Posture Mean; MOA = Mouth Opening Amplitude.

DISCUSSION

Among the changes commonly found on neurological examination of individuals with CP are the asymmetries of posture, muscle tone and/or skills functional[16]. This asymmetry was found also during chewing task. For Both muscles, AT and MA, the asymmetry of electrical activity during an isotonic contraction was larger in the CP group. However, the difference was significant only for the AT muscle. Corroborating these findings, Ries and Bérzin (2009) found greater asymmetry in the activity of MA and AT muscles during mastication, both during isometric and isotonic contraction[8]. Disorders of tone, posture and movement of the CP child influence also muscle activity involved in chewing.

In general, the jaw movement during mastication may seem simple, but careful observation show asymmetrical characteristic and exhibit large variations from cycle to cycle[17]. Some authors admit the usual an index of symmetry for healthy adults at least 82 ± 1.34%[18] and others determined the usual parameters of MA symmetry of 87.11 ± 1.60% and AT 88,11 ± 1.45%[19]. Therefore, some degree of asymmetrical activity should be considered in most individuals, since the skull is rarely symmetrical and muscular system to try to redress this skeletal imbalance generates also asymmetric forces [20].

If we consider as normal the parameters of symmetry Felicio, Sidequersky, Tartaglia, and Sforza (2009)[19], the two groups could be within the normality. Already parameters of Ferrario, Sforza, Miani Jr, D' Addona, and Barbini (1993)[18] show that symmetry of both the AT muscle (81,44%) and MA muscle (80.39%) in the CP group, is outside the normality. The characteristic exacerbate activity asymmetry of these muscles in CP children can impair the performance of the chewing task.

The AT muscle has the function of elevation and retraction of the mandible during mastication and unlike MA muscle is more related to jaw movement than masticatory force[21]. Additionally, accounts for balance and postural control of the jaw. Thus, the greatest imbalance in the activity of the AT muscle in CP children could be due to changes in muscle tone, posture and movements in this pathology, changing the balance and postural control of the jaw.

The limitation in muscular synergisms in CP children is considered one of the causes of disability and functional limitation of same[1]. However, this limitation was not observed in balance of the EMG activity of four muscles analyzed. CP and TD groups showed similar values of the APC.

The abnormal tone found in children with CP can result in abnormal patterns of posture and movement such as, delay and decrease of the head control[22]. The start of head extension generally precedes the beginning of jaw opening, which indicates the anticipatory adjustment of the head position preparatory to jaw movement[5]. The muscles of the jaw and neck have associated movements and changes in one of the structures can disrupt the other.

The HEMMO, the HEA and the FHPA in the CP group were significantly higher compared to the TD. These changes in the forward head posture and head extension could be explained by the lower control of posture and movement of the head and the presence of an extensor pattern present in children with spastic CP. Hyperextension of the head in these children affect the elevation of the larynx resulting in aspiration of food, similarly, can lead to protrusion or retraction of the tongue and an inadequate jaw movement[23]. Likewise, the correct head extension obtains biomechanical advantages which promote coordination between the head and jaw and enhances force production during bite[5].

Although it found greater forward posture and extension of the head in CP children, the difference in mouth opening amplitude between the groups was not significant. Corroborating these findings, Ries and Bérzin (2005)[12] also found no significant difference in maximal mouth opening in children with CP and TD, and the same is presented in a similar manner and within the normal range for both groups.

These changes in head posture found in CP children could be etiologic factors of TMD, for influence in jaw rest position and cause dysfunction of the masticatory muscles. However, postural changes of the head are not necessarily more frequent in subjects with TMD[4]. There are also reports that the asymmetric electrical activity of masticatory muscles is higher in individuals with TMD[24,25] and this abnormal activity can be influenced by changes oclusais[15]. It was considered that CP children have a higher incidence of occlusal changes due to abnormalities of oromotor musculature, with a higher proportion of Angle class II and minor of Angle class III[10]. Although in this study the CP children had higher asymmetry of MA and AT muscles and major changes in head movement during jaw movement, these changes do not seem to have increased the risk of TMD and occlusal changes. The TMD and occlusal changes were not associated with the presence of CP.

The functional movements of the jaw are the result of the coordinated activation of the jaw and neck muscles, allowing simultaneous movements between the temporomandibular, atlanto-occipital and cervical **spine** joints[5]. The results of this study show that motor and functional limitations of children with CP are associated with abnormalities in the control of jaw and head movements during the chewing task. It is important to evaluate cervical movements during the evaluation of orofacial myofunctional disorders in child with CP. The appropriate development of masticatory function provides muscle balance preventing disturbances in craniofacial complex.

CONCLUSION

The greater asymmetry in muscle activity during the chewing cycle, with greater change in length and forward head posture shows the greatest difficulty in controlling the jaw and head movements of children with CP. These changes in jaw and cervical motor control can be causes of disorders in oral motor function of CP children. The CP was not associated with TMD or the alteration of dental occlusion, although this group exhibit greater motor impairment and greater change in control of the head and jaw movements during chewing activity.

RESUMO

Objetivo: analisar a atividade elétrica dos músculos Temporal e Masseter e o padrão de postura e movimento de cabeça e mandíbula de crianças com Paralisia Cerebral (PC). **Métodos:** a amostra deste estudo compreendeu 32 voluntários com PC espástica e com Desenvolvimento Típico, com a faixa etária de 7 a 13 anos de idade, caracterizados com base na Classificação de Angle e Critério de Diagnóstico para Pesquisa das Disfunções Temporomandibulares (RDC/TMD). De forma simultânea, foram avaliadas a postura e movimentação da cabeça e mandíbula e a atividade elétrica dos músculos Temporal e Masseter por meio da cinemática e eletromiografia. **Resultados:** a PC não foi associada a presença de DTM ou com a alteração da oclusão dentária. No grupo PC, foi observada maior assimetria do músculo temporal ($p<0.05$), maior extensão da cabeça na máxima abertura da boca ($p<0.05$), maior amplitude de extensão da cabeça ($p<0.01$) e maior amplitude de projeção anterior da cabeça ($p<0.05$). **Conclusão:** a maior assimetria na atividade muscular, a maior extensão e projeção anterior da cabeça durante o ciclo mastigatório podem ser causas das desordens da função motora oral das crianças com PC.

DESCRITORES: Paralisia Cerebral; Músculos Mastigatórios; Eletromiografia

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