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Changes in masticatory muscle activity in children with cerebral palsy

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ABSTRACT

The objective of the study was to determine whether children with cerebral palsy (CP) have abnormal bilateral masseter and temporal muscle activation during mastication. The muscular activity of 32 children aged between 7 and 13 years was assessed during the task of non-habitual mastication by means of surface electromyograms. During non-habitual mastication, the amplitude of all assessed muscles in the inactive period and the amplitude of the Right Masseter and Left Temporal muscles in the active period of children with CP was greater ($p < 0.05$) in relation to the group of children with Typical Development (TD). Considering each muscle individually, only the duration of the active period of Right Masseter and Right Temporal muscles in children with CP was lower ($p < 0.05$) than in the TD children. Considering the four analyzed muscles, the duration of time of general active period, when at least one muscle should be activated, was higher in children with CP ($p < 0.05$) than in children with TD showing greater time variation in inactivation ($p < 0.05$). The higher muscle activity during the phases of the masticatory cycle, with longer duration of the active period and with greater variability between the muscles to inhibit this activity show greater difficulty in coordinating the muscles of mastication in children with CP compared to children with TD.

1. Introduction

Cerebral palsy (CP) describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain (Rosenbaum et al., 2007). Children with CP generally show abnormalities of muscle tone (Dietz and Sinkjaer, 2007) and deficit in the development of postural control that influence the recruitment of motor units and the degree of muscular contraction (Graaf-Peters et al., 2007). Difficulties of movement control may influence the functional performance and interfere directly in daily life activities (Mancini et al., 2002).

CP has been associated with sensory and motor dysfunction of the orofacial region which include dysphagia, dysarthria, impaired mastication and sialorrhea (Avivi-Arber et al., 2011). Among the many daily activities that an individual performs, one can consider chewing as one of the most important and essential to life. This activity, common to most people, can become much more complex for people with CP due to the compromising of their motor functions, making it slow and time-consuming (Aurélio et al., 2002).

Evolution of mastication is gradual and depends on several central and peripheral factors, anatomical changes, maturation of the nervous system and alteration of the functional demands (Papargyriou et al., 2000). The impairments that children with CP present during mastication are the result of the interaction of several factors, including faulty oromotor control, abnormal neurological maturation and postural deficit (Reilly et al., 1996; Fung et al., 2002).

Muscle imbalance of the stomatognathic system is also associated with CP (Ries and Bérzin, 2005, 2009). Over 90% of children with CP present significant difficulties in orofacial motility, which can result in malnutrition (Reilly et al., 1996), dehydration, aspiration and pneumonia (Aurélio et al., 2002). They may also have communication disorders and impairment of social interaction skills (Rosenbaum et al., 2007). These factors determine a careful analysis of the masticatory process in these individuals.

Analysis of the masticatory muscle activity is an important procedure for clinical evaluation of the stomatognathic system (Ferrario et al., 2006). One can identify the phases of a masticatory cycle and thus evaluate the functional state of the neuromuscular system during mastication (Bérzin, 2004). Information on the time of muscle activation, the functioning of muscle activity and muscle activity level can identify alterations in muscle coordination (Hug, 2011).

Although there are many reports in the literature describing the feeding problems of children with CP (Reilly et al., 1996; Fung et al., 2002; Avivi-Arber et al., 2011) and the importance of mastication in their digestive process (Reilly et al., 1996; Aurélio et al., 2002), there are relatively few studies that have evaluated the

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activity and the behavior of the muscles of the stomatognathic system in this population. This article provides an analysis of the amplitude and duration of activation of the masseter (MA) and anterior temporal (AT) muscles during the task of mastication in typically developing children (TD) and in children with CP. As a result, the assessment provided by this study, may contribute to a better understanding of the changes in the stomatognathic system and, thus, assist in the development of more appropriate intervention methods. Thus, the objective of the study was to determine whether children with cerebral palsy have abnormal bilateral masseter and temporal muscle activation during mastication.

2. Materials and methods

2.1. Subjects and examination

This cross-sectional study included 32 children ($n = 16$ TD children, being 5 females and 11 males, and $n = 16$ children with CP, being 9 females and 7 males) within the age range of 7–13 years (mean = 9.63 ± 1.83) with mixed dentition (at least two contacts between the premolars and molars). The children with CP were classified according to the Gross Motor Function Classification System (GMFCS) (Palisano et al., 1997). Exclusion criteria were: associated disorders such as mental retardation, congenital malformations, systemic diseases, genetic syndromes, sensory alterations (i.e., vestibular, visual or auditory), application of botulinum toxin or surgery in the evaluated region over the past 6 months, use of braces and history of trauma to the face or to the temporomandibular joint, missing teeth (between the canine and deciduous or permanent molars) and current or previous orthodontic treatment.

The children (TD and CP group) were assessed and then characterized according to the temporomandibular joint (TMJ) and mandibular occlusion. 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 (Winter et al., 2008). The TMJ was evaluated for the presence of temporomandibular dysfunction (TMD), according to the Research Diagnostic Criteria for TMD (RDC/TMD), Axis I (Dworkin and LeResche, 1992), based on history and clinical signs.

The parents or responsible of all subjects were informed about the procedures and objectives of the study and provided their written informed consent prior to child's participation in the research, according to guidelines administered by a Research Ethics Committee.

2.2. Electromyography recordings

All EMG signals were recorded using a commercially-available 16-bit surface EMG system (System of Brazil; Model EMG-1200C). 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. The skin beneath the sensor was prepared by cleansing the site with a 70% solution of alcohol and removing body hairs with a disposable razor. Signals were amplified with a gain of 2000 (20–500 Hz filter setting) prior to sampling (2000 Hz). The electrodes were longitudinally aligned to the muscle fibers and fixed on the skin of the MA and AT muscles, bilaterally. The reference electrode was fixed on the manubrium of the sternum. The best location of the electrodes was determined by using a muscle function test. To locate the MA muscle (2 cm above the angle of the jaw) and the AT muscle (vertically, from the anterior margin of the muscle) an isometric contraction of jaw elevator muscles was requested of the volunteer (Sommerich et al., 2000; Ries et al., 2008).

2.3. Evaluation protocol

The children 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 90° (Fig. 1). A short training period was carried out before the beginning of each sampling to better orientate the children to the proposed activities. The mastication task was repeated three times, with a duration of 10 s and 1 min intervals between each sampling. 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.

So as to make comparisons of the electromyographic signal of the individuals, the values of the activity of interest were normalized by a contraction reference. For the MA and AT muscles, the contraction reference was measured by the isometric contraction of clenching in maximum intercuspation. The contractions of the MA and AT muscles were sustained for 5 s and repeated three times with an interval of 1 min between repetitions.

2.4. Analysis

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 (Abbink et al., 1998). This detection method uses the filtered EMG signal (band-pass filter with 20–500 Hz bandwidth) obtained during the 10 s mastication task. The routine automatically scrolls down the EMG signal using a fixed size window of 200 ms 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 for additional calculations. The defined reference value is equal to 3σ (where σ is the standard deviation of the RMS value). A window of 200 ms is equivalent to $n = 400$ data points, provided that the sample rate of the EMG was 2 kHz.

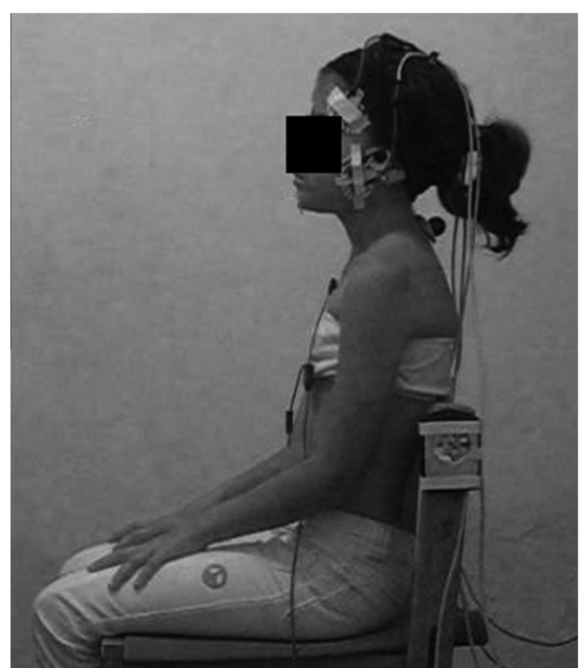

Fig. 1. Sitting position used during electromyographic evaluation of masseter and temporal muscles during mastication task.