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Interference of Severe Idiopathic Scoliosis in the Respiratory and the Stomatognathic System in Women

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Abstract: The present study aimed to analyze the changes in the respiratory and the stomatognathic system caused by acute idiopathic scoliosis. Methods: Twenty women, aged 18 to 30 years (23.80 ± 2.94 years) were divided into two groups: Scoliosis Group (n=10) with acute idiopathic scoliosis and Control Group (n=10) with healthy participants. The masticatory muscle activity and the muscle activity of the spine were evaluated by means of electromyography. A manuvacuometer was used to measure the respiratory muscle strength to understand how the disorders caused by severe idiopathic scoliosis in the spinal system can affect the performance of both the stomatognathic and the respiratory system. Electromyographic and respiratory muscle strength data were tabulated and submitted to statistical analysis (SPSS 21.0) using the Student's t test for independent samples, with a significance level of 5% and a 95% confidence interval. Results: The results obtained showed that the convex side of the curve in severe idiopathic scoliosis has produced functional changes in the stomatognathic system, increasing the action potential of the masseter, temporal and sternocleidomastoid muscles. The results showed that the strength generated by the inspiratory and expiratory muscles was reduced by the influence of the action potential of the multifidus muscles that create rotational motion between vertebras. Conclusion: It can be concluded that acute idiopathic scoliosis has interfered in the clinical conditions of mandibular rest, chewing raisins and peanuts, neutral cervical posture, spine extension and respiratory muscle strength

Keywords: *Scoliosis, Electromyography, Stomatognathic System, Respiratory System, Posture, Muscle.*

I. Introduction

Scoliosis can be defined as a three-dimensional deformity of the spine, presented with abnormal curvatures in the sagittal and frontal planes, commonly associated with vertebral rotation in the transverse plane [1]. It may be associated with malformation of the vertebrae, spine displacement and fractures, legs of difference lengths, hormonal imbalance, poor posture and muscle spasms. This condition can cause several physical problems, such as back pain, reduced lung capacity, decreased physical mobility and ability to work, as well as some psychosocial problems that include poorer body image, and uncertain prognosis. Scoliosis leads to strength imbalance and uneven length of the legs, showing the musculature of the concave side retracted and more elongated muscles on the convex side of the curve, which are characteristics of muscular asymmetry [2].

The musculoskeletal system is composed of several muscular chains that are integrated with one another; any disturbance of a body segment will lead to a reorganization of other human body segments [3]. The knowledge that the human body is fully connected by an aponeurotic muscle tissue that interferes with the joints of the skeletal system, allows the health professionals to understand the body descendant and ascendant adaptation in order to reset the balance that has been lost due deformities [4]. Studies suggest that the assessment performed through electromyography can be an important indicative of predisposition regarding scoliosis progression involving other systems. Some authors have found that muscle asymmetry increased myoelectric activity on the convex side [5-7].

Asymmetries and changes in myoelectric activity also cause cardiopulmonary impairment [8], such as alterations in the inspiration-expiration ratio, and coughing. The difficulty in clearing secretions and properly exhaling air from the lungs can lead to infections [9]. Respiratory performance depends not only on the mechanical properties of the lungs, but also on the interaction between complacency and elastance, associated with the respiratory muscle function. An imbalance between complacency and muscle function has been observed in patients with severe idiopathic scoliosis as a result of reduced total lung capacity and increased residual volume [10].

The objective of this study was to understand the disorders caused by severe idiopathic scoliosis in the stomatognathic system and in the respiratory pattern, using electromyography and manovacuometry.

The findings of the present study can assist a multidisciplinary team comprised of dentists, physiotherapists, physicians and other health professionals in the rehabilitation process of women with severe idiopathic scoliosis and to improve their quality of life. It can also guide new research on the topic, still scarce in literature, seeking the optimization of the quality of life of individuals, as well as providing additional information on functional analysis.

II. METHODS

A. Sample

Twenty women, aged 18 to 30 years (23.80 ± 2.94 years), were selected for the study. The participants were divided into two groups: Scoliosis Group (n=10) with acute idiopathic scoliosis and Control Group (n=10) with healthy participants. Sample selection and the criteria for inclusion/ exclusion were determined as follows: Patients with severe idiopathic scoliosis (SG) who were not undergoing clinical treatment or using medications, and presented with clinical signs and symptoms of severe idiopathic scoliosis. CG included those patients with no history of diseases associated with functional, neurological changes and no signs of idiopathic scoliosis.

The study was approved by the Research Ethics Committee of the Claretiano Centro Universitário (CAAE 22230313.1.0000.5381). All participants were informed about the experiment and agreed to participate by providing their free and informed consent according to the resolution 466/12 of the Health National Council. Any subject was allowed to withdraw from the research protocol at any time.

B. Materials

Electromyographic analysis was performed using a portable MyoSystem-I PS4, equipment with 12 channels, eight channels for EMG (for active and passive electrodes), four auxiliary channels, and software for storage, and data analysis. The electrodes were placed on the following muscles: right masseter (RM), left masseter (LM), right temporalis (RT), left temporalis (LT), right sternocleidomastoid (RSCM), left sternocleidomastoid (LSCM), right longissimus thoracis (RLT), left longissimus thoracis (LLT), right iliocostalis (RIC) left iliocostalis (LIC), right multifidus (RM) and left multifidus (LM).

For the evaluation of maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP), a GER-AR® analog manovacuometer with a range of -300 to +300 cmH2O was used. Subjects were instructed to breathe through a disposable mouthpiece. The test was performed once for training.

C. Procedures

Muscle activity was evaluated by means of EMG recordings during the following clinical conditions: rest (4s); maximal habitual intercuspation (10s); habitual mastication of 5g of peanuts (10s) and 5g of raisins (10s). For the functional analysis of the sternocleidomastoid, longissimus, ileocostal and multifidus muscles, the tests were performed in the following clinical conditions: neutral cervical posture, cervical flexion in clockwise/counterclockwise rotation in the right - left direction, spine in extension and at rest (10s).

To evaluate the respiratory pressure, the participants sat on a chair in high Fowler's position; their hands along the body and knees flexed at 90°; they took the mouthpiece into their mouth, and placed a nose clip on the nose. The tests were performed by the same examiner who instructed the participants to exhale against the obstructed mouth piece. The participants had to inhale deeply and as fast as possible. The residual volume provided the MIP values. The first test was conducted three times with an appropriate 1 minute- rest period. In the best of these trials, the highest value was considered. After the mouthpiece and the nose clip on the nose were replaced, the participant had to breathe in with maximal effort via the mouth piece as deeply and fast as possible, the MEP was then measured. The second test was conducted three times with an appropriate 1 minute-rest period. In the best of these trials, the highest value was considered. The procedure was performed by the same examiner to avoid bias.

All data were tabulated and analyzed using the SPSS software (SPSS Inc., Chicago, IL, USA) version 21.0 for Windows. Student´s t-test was used for group comparison. are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document. Please do not revise any of the current designations.

III. RESULTS

Tables 1, 2 and 3 show the EMG values in the clinical conditions of jaw movement, mastication and cervical flexion.

TABLE I. MEANS AND STANDARD DEVIATION OF THE RMS FOR THE MUSCLES MASSETER. RIGHT MASSETER (RM) AND LEFT MASSETER (LM) IN THE CLINICAL CONDITION OF REST, MAXIMAL HABITUAL INTERCUSPATION (MHI), RAISIN MASTICATION (RM), PEANUT MASTICATION (PM). * - SIGNIFICANT DIFFERENCE ($p<0.05$).

Clinical Conditions	**RM (SG) (n=10)**	**RM (CG) (n=10)**	**LM (SG) (n=10)**	**LM (CG) (n=10)**
Rest	4.80 (±1.42)	7.78 (±2.40)	5.71 (±1.07)	5.27 (±1.37)
MHI	80.57 (±18.29)	99.18 (±28.67)	82.31 (±27.61)	171.25 (±59.76)
RM	101.78 * (±24.41)	50.43 (±6.71)	75.05 (±7.19)	99.01 (±30.13)
PM	157.96 * (±22.65)	96.41 (±13.70)	154.39 (±19.75)	184.93 (±38.10)

TABLE II. MEANS AND STANDARD DEVIATION OF THE RMS FOR THE MUSCLES TEMPORAL. RIGHT TEMPORAL (RT) AND LEFT TEMPORAL (LT) IN THE CLINICAL CONDITION OF REST, MAXIMAL HABITUAL INTERCUSPATION (MHI), RAISIN MASTICATION (RM), PEANUT MASTICATION (PM). * - SIGNIFICANT DIFFERENCE (P<0.05), ± STANDARD DEVIATION.

Clinical Conditions	RT (SG) (n=10)	RT (CG) (n=10)	LT (SG) (n=10)	LT (CG) (n=10)
Rest	28.40 * (±6.11)	10.59 (±3.15)	6.54 (±1.71)	10.47 (±2.36)
MHI	182.79 (±41.37)	272.56 (±81.79)	59.44 (±14.65)	120.64 (±37.34)
RM	230.75 (±29.96)	136.79 (±37.42)	86.38 (±8.55)	66.99 (±13.61)
PM	319.81 (±49.91)	222.59 (±64.61)	122.87 (±18.85)	88.31 (±15.32)

TABLE III. MEANS AND STANDARD DEVIATION OF THE RMS FOR THE MUSCLE STERNOCLEIDOMASTOID. RIGHT STERNOCLEIDOMASTOID (RSCM) AND THE LEFT STERNOCLEIDOMASTOID (LSCM) IN THE CLINICAL CONDITION OF CERVICAL NEUTRAL POSITION (CNP), RIGHT ROTATION (RR), LEFT ROTATION (LR). * - SIGNIFICANT DIFFERENCE (P<0.05), ± STANDARD DEVIATION.

Clinical Conditions	RSCM (SG) n=10	RSCM (CG) n=10	LSCM (SG) n=10	LSCM (CG) n=10
CNP	25.39 * (±6.89)	8.19 (±2.34)	14.63 (±4.32)	13.71 (±4.35)
RR	18.96 (±4.66)	12.27 (±4.98)	26.91 (±9.08)	47.81 (±15.89)
LR	33.52 (±6.88)	32.02 (±5.86)	17.78 (7.65)	18.94 (±7.57)

The spinal cord was analyzed under the clinical conditions of rest and extension, as shown in Figures 1 and 2. Means of the respiratory and expiratory muscle strength are shown in Figure 3.

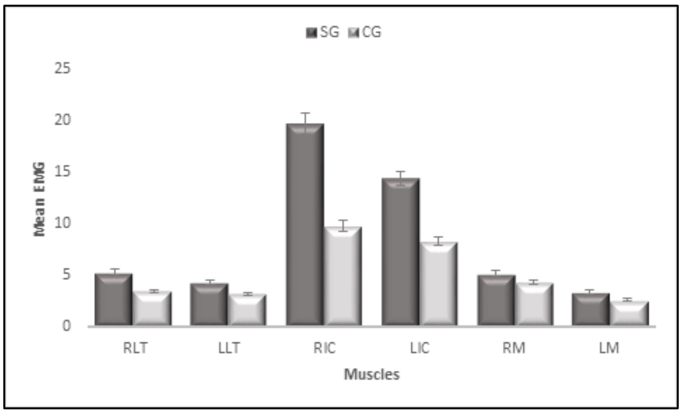

Figure 1. Analysis of the spinal muscles in SG and CG in the clinical condition of rest. Right Longissimus Thoracis (RLT), Left Longissimus Thoracis (LLT), Right Iliocostalis (RIC), Left Illiocostalis (LIC), Right Multifidus (RM) and Left Multifidus (LM). * - significant difference (p<0.05).

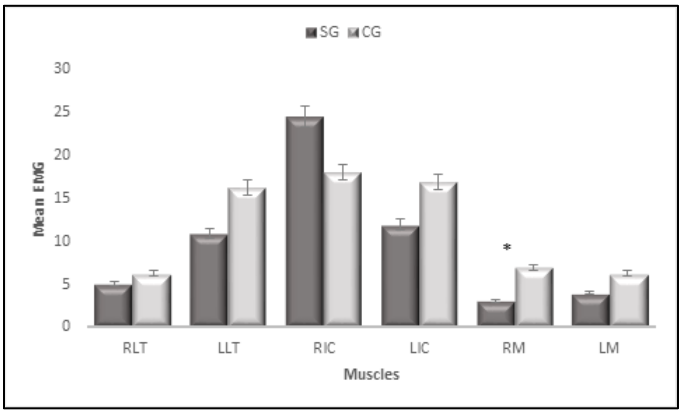

Figure 2. Analysis of the spinal muscles in SG and CG in the clinical condition of spine extension. Right Longissimus Thoracis (RLT), Left Longissimus Thoracis (LLT), Right Iliocostalis (RIC), Left Iliocostalis (LIC), Right Multifidus (RM) and Left Multifidus (LM). * - significant difference (p<0.05).

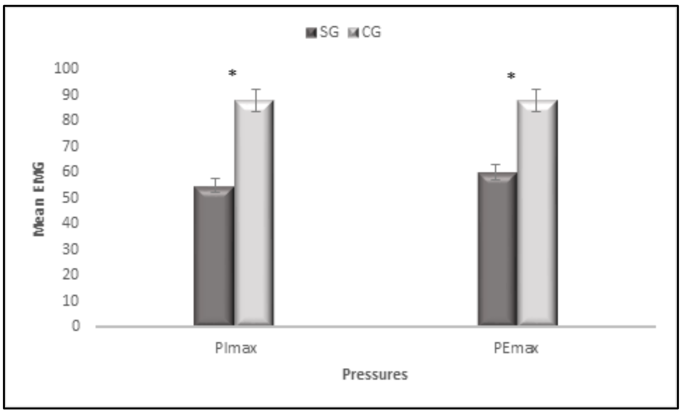

Figure 3. Comparison of Maximum Inspiratory Pressure (MIP), Maximum Expiratory Pressure (MEP) measured in cmH2O. Scoliosis group (SG) and Control group (CG). * - significant difference (p<0.05).

IV. DISCUSSION

When the muscle potential under different clinical conditions was analyzed, the more evident results reflected directly on rest, mastication of raisins and peanuts, neutral cervical posture, spinal extension, and respiratory muscle strength. These are relevant results, and according to Abrahamsson et al. [11] the myofascial alternations can cause changes in the stomatognathic system as a response to an acute trauma or chronic overload of the stomatognathic system. Nicolakis et al. [12] investigated the relationship between craniomandibular disorders (CMD) and postural abnormalities and compared the CMD group to the control group. Posture and muscle function parameters associated with the cervical region and trunk were examined. The authors found that postural and muscle function abnormalities appeared to be more common in the CMD group and concluded that static muscle disorder is common in patients with temporomandibular dysfunction. For Arrelano [13] an active posture, in which the muscles maintain an unstable static balance, affects the functional balance when it generates movements in different parts of the body. Thus, the greatest action potential produced in the masseter, sternocleidomastoid muscles in SG compared to CG is found on the side of the convexity of the scoliotic curve, and can generate instability in the stomatognathic system. In other words, if the individual has scoliosis on the right side, the facial muscles can produce greater action potential on the same side. These data support the observations of Cheung et al. [5] who reported increased myoelectric activity on the convex side.

For Brach et al. (14) the instabilities cause changes in the stomatognathic system, generating impairment in masticatory function, alterations in lip clenching and swallowing, decreased intraoral pressure, loss of gustatory sensitivity on the anterior two-thirds of the tongue, motor speech disorder and reduced facial expression [5].

Bassani et al. [7] investigated the potential of surface electromyography (EMG) for assessing the lumbar extensors in individuals with scoliosis and concluded that surface EMG is an effective tool for the functional assessment of this condition. The EMG recordings demonstrated that the individuals with scoliosis showed lower neuromuscular activation for the multifidus muscles on the concave side when both groups were compared, determining that the dysfunction of these muscles can change the position of the head over the vertebra axial axis, and consequently, affect the stomatognathic system. The multifidus muscle plays an important role in stabilizing the joints within the spine. However, in case of spinal muscle atrophy, it does not make the necessary adjustment to stabilize the adjacent vertebrae of the spinal cord [15]. This problem causes the vertebral bodies to rotate to the convex side of the curve, evolving into deformity. According to Ribeiro [16] by inhibiting proper posture, greater muscle and ligament effort is required to maintain the individual in orthostatic position.

Chagas et al. [6] reported that imbalance muscles produce skeletal deformities. With that respect, their study suggests that the respiratory mechanics can be influenced by changes produced in severe idiopathic scoliosis, considering that SG presented a predominantly apical breathing pattern and increased action potential of the sternocleidomastoid muscle on the convex side.

The individual with severe idiopathic scoliosis can present a strategy of breathing with abnormal pattern of use of respiratory muscles with little air forced out of the lungs [17]. Studies of Chun et al. [18] have shown that there is a direct relation with increase in degree of rotation of apical vertebral and reduction in concave side lung volume.

The analyzed data suggest that the inspiratory and expiratory lung volumes are reduced in those individuals. For Chu et al. [19] scoliosis causes not only changes in the activity of postural muscles and in the stomatognathic system, but it also interferes with the dynamics of the chest wall, where any deviation in the spinal cord can generate functional changes, such as poor chest wall expansibility and reduced lung vital capacity. Hence, the use of surface electromyography and manovacuometry as additional tests in the evaluation of severe idiopathic scoliosis proved to be important of paramount importance to determine the postural and functional interferences related to the stomatognathic and the respiratory system.

V. Conclusion

It can be concluded that the convex side of the curve in severe idiopathic scoliosis caused changes in the stomatognathic system, increasing the action potential in the masseter, temporal and sternocleidomastoid muscles. The strength generated by the inspiratory and expiratory muscles decreased due to influence of the multifidus muscles, which presented reduced action potential on the convex side of the curve, causing the rotation of the vertebral bodies to produce deformities and therefore affect the respiratory mechanics.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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