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Electrical activity of the masseter and supra hyoid muscles during swallowing of patients with multiple sclerosis

Atividade elétrica dos músculos masseter e supra-hióideo durante a deglutição do paciente com esclerose múltipla

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Keywords

Multiple Sclerosis
Electromyography
Masseter Muscle
Suprahyoid Muscle
Electrical Activity
Swallowing

ABSTRACT

Purpose: characterize the swallowing muscles electromyographic activity in EM. **Methods:** we evaluated 60 individuals being 30 with definitive diagnosis in EMG and 30 without neurologic changes. Volunteers provided personal data through interview, and we also obtained data from clinical records on the time of diagnosis, disease clinic form and the EDSS scale score. We then administered the DYMUS questionnaire. All evaluations occurred according to the Swallowing Electromyographic Evaluation Protocol. **Results:** Saliva swallowing, liquid swallowing with comfortable volume and continuous swallowing showed differences in the groups at the masseter, with higher averages in the comparison group. We verified differences between masseter and supra hyoid in each group, at rest, in saliva swallowing, liquid swallowing with comfortable volume and continued swallowing. In all situations the averages were higher in the supra hyoid, being that the smaller difference occurred at rest and the higher at continuous swallow. We recorded correlations between EDSS and the activity of supra hyoid at saliva swallow, liquid swallow with comfortable volume and swallow continuous. With the DYMUS, we observed correlations with the masseter activity and with the swallowing time. The high punctuation at the DYMUS presented correlations with the increase electrical activity of the masseter. **Conclusion:** patients with more severe conditions show lower supra hyoid electric activity, and the electric activity of the masseter is related to difficulty in swallowing.

Descritores

Esclerose Múltipla
Eletromiografia
Músculo Masseter
Músculo Supra-Hióideo
Atividade Elétrica
Deglutição

RESUMO

Objetivo: caracterizar a atividade eletromiográfica dos músculos da deglutição na EM. **Método:** foram avaliados 60 indivíduos, sendo 30 com diagnóstico definitivo de EM e 30 sem alterações neurológicas. Foram levantados os dados pessoais dos voluntários e, em seguida, coletados em prontuário tempo de diagnóstico, forma clínica da doença e escore da escala EDSS. Em seguida foi administrado o questionário DYMUS. Todos foram submetidos à realização do Protocolo de Avaliação Eletromiográfica da Deglutição. **Resultados:** na deglutição de saliva, deglutição de líquido com volume confortável e deglutição contínua, foram verificadas diferenças entre os grupos no músculo masseter, e as médias foram mais elevadas no grupo de comparação. Foram registradas diferenças entre masseter e supra-hióideo no repouso, na deglutição de saliva, na deglutição de líquido com volume confortável e na deglutição contínua, e em todas as situações as médias foram mais elevadas no supra-hióideo, sendo que a menor diferença ocorreu no repouso, e a maior na deglutição contínua. Foram registradas correlações do EDSS com a atividade do supra-hióideo na deglutição de saliva, na deglutição de líquido com volume confortável e na deglutição contínua. Com o DYMUS foram observadas correlações com a atividade do masseter e com o tempo de deglutição. As pontuações elevadas no DYMUS apresentaram correlações com o aumento da atividade elétrica do masseter. **Conclusão:** quanto pior o estado clínico do paciente, menor será a atividade elétrica do supra-hióideo, e o aumento da atividade elétrica do masseter está relacionado com a dificuldade de deglutição.

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INTRODUCTION

Multiple sclerosis (MS) is a chronic inflammatory disease that affects the central nervous system (CNS), and although its cause remains unknown, it is considered an autoimmune disease. EM results in the formation of demyelination plaques and the destruction of the myelin sheath manifested through lesions scattered in the CNS, affecting more commonly the optic nerve, brainstem, spinal cord and periventricular white matter[1]. The impairment of these regions leads to several symptoms, such as decreased visual acuity, gait alteration, numbness, fatigue, difficulties of speech articulation and swallowing[2].

Changes in swallowing seems to be commonly reported by patients with EM and are more often associated with cerebellar and brainstem impairment. The frequency of swallowing problems varies between 33% and 43%, but these values may be higher when an instrumental evaluation is performed[3]. Dysphagia is also more common in patients with more severe conditions, but it is possible to find it in patients with an Expanded Disability Status Scale (EDSS) score lower than 2.5[4]. EDSS is the most used scale for evaluation of EM. It has twenty items with scores ranging from 0 to 10 that increases half a point according to the degree of disability of the patient. It is used for the disease staging and to monitor the patient's follow-up[5]. Oropharyngeal Dysphagia can lead the patient to dehydration and aspiration pneumonia, which may decrease the quality of life and increase morbidity and mortality in these cases. Such complications can be avoided by performing an early and adequate evaluation[4,6].

Among the instrumental exams used to evaluate swallowing, surface electromyography (sEMG) has been widely used because it is a non-invasive, painless, inexpensive, and easy to reproduce method that can be repeated as needed[7]. sEMG has been an important technique to investigate the alterations of the different muscles involved in the deglutition movement, providing data on muscle physiology during voluntary contractions[8-10]. In view of the above, this study aims to characterize the electromyographic activity of swallowing muscles in MS.

METHODS

This is a descriptive observational cross-sectional study in which 60 individuals were evaluated, 30 volunteers with definitive diagnosis of SM (G1) and 30 volunteers without neurological alterations as a comparison group (G2) matched by sex and age. The age of group G1 ranged from 21 to 62 years old and G2 from 22 to 63 years old. The distributions per age range were exactly the same, with 24 women and 6 men in each group. Data was collected at the Speech-Language Pathology outpatient ward of the *Hospital da Restauração Governador Paulo Guerra* (Recife, Pernambuco, Brazil) between July and November 2015. At first, the volunteers' personal data was surveyed through an interview, followed by collection of diagnosis time, clinical form of the disease and EDSS scale score from medical records of the G1 group. Afterwards, G1 group answered the DYMUS questionnaire. DYMUS is a validated questionnaire developed by a committee of Italian neurologists with expertise in the field of MS and used as a preliminary screening method for detecting dysphagia. It consists of ten questions with dichotomous answers (yes or no) and score 1 or 0, depending on the presence or absence of the event. A single positive response was enough to indicate the presence of swallowing difficulty. The higher the score, the greater will be this difficulty[11]. Finally, all volunteers were submitted to the Protocol of Swallowing Electromyographic Evaluation[12].

The capture of muscular electrical signal through the protocol was performed using electromyography consisting of four channels, model Miotool (MIOTEC, São Paulo, Brazil), serial number 0366, with software Miograph 1.0. Each channel was connected to an active SDS 500 sensor with a claw connection. The equipment was coupled via USB cable to an Asus X450L brand notebook with Intel Core 15-4200U processor, 16GHz, 6GB RAM memory. Filters frequencies were of 20-500 Hz. These cutoff frequencies defined the upper and lower limits of the filtration. The Notch filter frequency was also of 60Hz to decrease the probable interference of the signal in the power grid. In addition, the environment was controlled in order to minimize any interference in signal capture, with all electro-electronic appliances switched off, doors and windows closed with ambient luminosity and temperature. We used surface electrodes for children and disposable, consisting of material made of silver – Silver chloride (Ag – AgCl), immersed in conductive gel, responsible for facilitating the uptake and conduction of the sEMG signal.

The Protocol of Swallowing Electromyographic Evaluation covers[12] six stages: Preparation for the examination, Placement of the electrodes, Normalization of the signal, Rate of resting activity or basal activity (BMR), Swallowing tasks, Interpretation and analysis of the electrical signal.

First, the skin was cleaned with gauze compresses soaked in alcohol at 70%. We carried out the trichotomy of the region when necessary to ensure a better signal uptake. The cleaning started by the right elbow region, the Olecranon region of the ulna, which corresponds to the reference electrode, and then the right, left and submandibular masseter regions. The volunteer sat in a chair with back support, with hands on the lower limbs, feet supported on the ground, erect head and look directed forward, following the plan of Frankfurt. The volunteer did not look at the notebook screen to avoid visual feedback and impairment of the evaluation. Four electromyography channels were used as follows: Channel 1: Right Masseter (RM), Channel 2: Left Masseter (LM), Channel 3: Right Suprahyoid region (RSH), and Channel 4: Left Suprahyoid region (LSH). The participants received all the instructions and information necessary to carry out the records.

The electrodes placement started with the reference electrode or "earth" electrode, which minimizes the interference of external electrical noise. Then, the electrodes were placed in the regions of the masseter and suprahyoid, bilaterally, in a bipolar configuration, in the belly region of the evaluated muscles, longitudinally to the muscular fibers. To locate the region in which the electrodes of the masseter are fixed, the volunteer was asked to perform the maximum usual intercuspation for three seconds, being possible to palpate and visualize the most robust region of the masseter, that is, the median line of muscle belly. After positioning the first electrode, the second one was placed 1.5cm below. To fix the electrodes in the submandibular region, the volunteer was asked to press the tongue against the palate with the maximum possible contraction for three seconds with the mouth ajar. Then the evaluator touched the submandibular region to identify the place of electrode in the anterior belly of the digastric muscle. The second electrode was fixed at 1.5 cm in anteroposterior position, following the direction of the muscular fiber. This procedure was performed bilaterally. After fixing the electrodes, the sensors with claws were placed, obeying the same order of electrode placement. Next, we verified the configuration and habilitation of the four channels in the electromyographic signal software of analysis, obeying the aforementioned provision.

The next step was normalization of the electrical signal for converting absolute values of the record to percentages of a reference value. For normalization of the electrical signal of the masseter muscle (NMASS), we used the maintenance of the maximum normal intercuspation for five seconds, using the cotton roller bilaterally. This procedure was repeated three times, with a ten seconds interval between each activity. For the suprahyoid muscles, incomplete swallowing of saliva was requested (sucking tongue on the palate) for five seconds. Three repetitions were also requested, with intervals of ten seconds.

The fourth stage consisted of recording the resting activity or basal activity. The volunteer was asked to stay in a state of maximum relaxation, with lips tight without performing any task of speech, chewing or swallowing for one minute. Soon after, we made a single record of ten seconds. The evaluation of the electrical signal of the masseter and suprahyoid muscles during swallowing was performed by applying the following activities: natural saliva swallowing (SS); the volunteer was instructed to swallow the saliva accumulated in the mouth under the command of the evaluator. This procedure was repeated three times, with a ten seconds interval between each swallowing. Swallowing of 5ml of water at room temperature in a single sip (CVLS): The volunteer was instructed to put the volume in the mouth, hold for three seconds and swallow under the command of the evaluator. This procedure was repeated three times, with a ten-second interval between each swallowing. Finally, a continuous and habitual swallowing of 100ml of water (CS).

The last stage was the interpretation and analysis of the signal with the analysis of the crude record, the filtration of the electromyographic signal and the Root Mean Square calculation, which represents the average electrical activity of the muscular action. In the BMR, we considered the average of the entire time interval collected. In SS and CVLS, we considered the interval of two seconds so that the swallowing activity was visibly included. In CS, we considered the average time interval corresponding to swallowing of the whole volume. It was also possible to determine the swallowing time of the volume of fluid offered and the number of swallows. For NMASS and NSH, we considered the overall mean of the three repetitions, calculated by the program used. The values found in the tasks were calculated in percentage related to the value of normalization in each muscle group.

Data were analyzed using Pearson's chi-squared, Mann-Whitney and Wilcoxon tests. The degree of association of the variables was obtained using Spearman's correlation and the hypothesis of normality of the data using the Shapiro-Wilk test. The level of significance attributed to all tests was 5%. The study was approved with the number of CAAE: 36826014.8.0000.5208, Opinion no 859,765, and all participants signed the Informed Consent Form.

RESULTS

Table 1 shows that both groups were similar regarding age range and gender. There was a higher number of individuals with MS in the age group of young adults (43.3%), most of them (80.0%) female. The frequency of swallowing difficulty was present in almost half (46.7%) of the G1 group, and the

Table 1. Age, gender, swallowing difficulty, time of diagnosis, EDSS and DYMUS according to the group

Variable	Group		P value
	G1	G2	
TOTAL	**30 (100.0)**	**30 (100.0)**	
Age (years old): Average ± DP (Median)	37.57 ± 11.37 (34.50)	37.90 ± 11.41 (35.00)	$p^{(1)} = 0.882$
Age group: n (%)			
- 21 to 29	7 (23.3)	7 (23.3)	$p^{(2)} = 1.000$
- 30 to 39	13 (43.3)	13 (43.3)	
- 40 or more	10 (33.3)	10 (33.3)	
Sex: n (%)			
- Male	6 (20.0)	6 (20.0)	$p^{(2)} = 1.000$
- Female	24 (80.0)	24 (80.0)	
Swallowing difficulty: n (%)			
- Yes	14 (46.7)		
- No	16 (53.3)		
Diagnosis time (years): Average ± DP (Median)	7.20 ± 4.53 (6.50)		
Diagnosis time: n (%)			
- Up to 4 year	10 (33.3)		
- From 5 to 9 years	12 (40.0)		
- 10 or more	8 (26.7)		
EDSS: Average ± DP (Median)	3.60 ± 1.61 (3.25)		
DYMUS: Average ± DP (Median)	1.30 ± 2.15 (0.00)		

(1): Using Mann-Whitney test; (2): Using Pearson's chi-squared test time of diagnosis was, on average, slightly higher than half a decade. The averages of EDSS and DYMUS were 3.60 and 1.30 years respectively, and the variability was very high for DYMUS, since the value of the standard deviation was higher than the average value. We found that all volunteers in group G1 presented the relapsing-remitting clinical form.

In the study of the electrical activity of the deglutition muscles contained in Table 2, we highlight that, at rest, the averages of the masseter muscle and suprahyoid musculature were correspondingly higher in the G1 group than in the G2 group. The average difference between the sides was higher in the G1 group than in G2 (9.88 x 0.47 in the masseter

Table 2. Masseter and suprahyoid musculature measurements

Variable	Side	Group G1 Average ± DP (Median)	Group G2 Average ± DP (Median)	P value
Rest				
- Masseter	Right	10.86 ± 8.92 (6.36)	5.32 ± 5.62 (3.33)	$p^{(1)} = 0.001$*
	Left	20.74 ± 22.80 (10.18)	5.80 ± 6.01 (3.58)	$p^{(1)} < 0.001$*
	Absolute diff. average	9.88	0.47	$p^{(1)} = 0.012$*
	P value	**$p^{(2)} = 0.007$***	**$p^{(2)} = 0.289$**	
- Suprahyoid	Right	27.26 ± 20.76 (24.58)	17.35 ± 9.96 (13.95)	$p^{(1)} = 0.041$*
	Left	31.30 ± 21.32 (23.93)	20.02 ± 13.36 (15.21)	$p^{(1)} = 0.032$*
	Absolute diff. average	4.04	2.68	$p^{(1)} = 0.615$
	P value	**$p^{(2)} = 0.478$**	**$p^{(2)} = 0.019$***	
	P value	**$p^{(3)} < 0.001$***	**$p^{(3)} < 0.001$***	
	P value	**$p^{(4)} = 0.012$***	**$p^{(4)} < 0.001$***	
Saliva swallowing				
- Masseter	Right	24.80 ± 22.73 (18.35)	12.26 ± 12.61 (6.61)	$p^{(1)} = 0.003$*
	Left	50.20 ± 81.82 (21.99)	11.19 ± 10.51 (6.99)	$p^{(1)} < 0.001$*
	Absolute diff. average	25.40	-1.07	$p^{(1)} < 0.001$*
	P value	**$p^{(2)} = 0.001$***	**$p^{(2)} = 0.781$**	
- Suprahyoid	Right	102.46 ± 98.38 (75.03)	102.29 ± 62.07 (89.36)	$p^{(1)} = 0.506$
	Left	101.89 ± 68.87 (89.26)	105.05 ± 67.86 (90.31)	$p^{(1)} = 0.802$
	Absolute diff. average	-0.57	2.76	$p^{(1)} = 0.802$
	P value	**$p^{(2)} = 0.959$**	**$p^{(2)} = 0.845$**	
	P value	**$p^{(3)} < 0.001$***	**$p^{(3)} < 0.001$***	
	P value	**$p^{(4)} = 0.003$***	**$p^{(4)} < 0.001$***	
Liquid swallowing (5mL)				
- Masseter	Right	25.41 ± 24.97 (13.05)	9.93 ± 10.56 (5.35)	$p^{(1)} < 0.001$*
	Left	50.06 ± 82.18 (24.90)	10.45 ± 12.09 (6.81)	$p^{(1)} < 0.001$*
	Absolute diff. average	24.65	0.52	$p^{(1)} = 0.014$*
	P value	**$p^{(2)} = 0.007$***	**$p^{(2)} = 0.762$**	
- Suprahyoid	Right	94.40 ± 117.38 (60.69)	95.21 ± 58.33 (85.66)	$p^{(1)} = 0.231$
	Left	86.38 ± 57.34 (78.94)	99.27 ± 72.61 (79.43)	$p^{(1)} = 0.554$
	Absolute diff. average	-8.03	4.06	$p^{(1)} = 1.000$
	P value	**$p^{(2)} = 0.813$**	**$p^{(2)} = 0.845$**	
	P value	**$p^{(3)} < 0.001$***	**$p^{(3)} < 0.001$***	
	P value	**$p^{(4)} = 0.005$***	**$p^{(4)} < 0.001$***	
Continuous swallowing (100mL)				
- Masseter	Right	24.45 ± 27.41 (14.20)	10.22 ± 12.20 (5.57)	$p^{(1)} = 0.001$*
	Left	49.10 ± 81.10 (17.88)	10.14 ± 10.16 (6.17)	$p^{(1)} < 0.001$*
	Absolute diff. average	24.64	-0.08	$p^{(1)} = 0.033$*
	Valor de p	**$p^{(2)} = 0.009$***	**$p^{(2)} = 0.230$**	
- Suprahyoid	Right	96.50 ± 86.42 (75.73)	103.38 ± 60.29 (84.94)	$p^{(1)} = 0.301$
	Left	95.74 ± 57.30 (88.31)	111.97 ± 76.72 (95.11)	$p^{(1)} = 0.595$
	Absolute diff. average	-0.76	8.59	$p^{(1)} = 0.668$
	P value	**$p^{(2)} = 0.861$**	**$p^{(2)} = 0.371$**	
	P value	**$p^{(3)} < 0.001$***	**$p^{(3)} < 0.001$***	
	P value	**$p^{(4)} = 0.002$***	**$p^{(4)} < 0.001$***	

(*): Significant difference at 5.0% level; (1): Using Mann-Whitney test entre between groups G1 e G2; (2): Using Wilcoxon test for paired data between right and left sides; (3): Using Wilcoxon test for paired data between masseter and suprahyoid muscles on the right side; (4): Using Wilcoxon test for paired data between masseter and suprahyoid muscles on the left side and 4.04 x 2.68 in the suprahyoid) with significant differences in the masseter muscle. It was also observed a difference between the sides of the masseter muscle in the G1 group, with higher averages on the left side. In saliva swallowing, swallowing of liquid with comfortable volume (5ml) and continuous swallowing (100ml), there were differences between the two groups in the masseter muscle and in these situations, with correspondingly higher averages in group G1 than in G2. We also found differences between the sides in G1 group, with higher averages on the left side. We also observed differences between the masseter and suprahyoid muscles in each group, at rest, in saliva swallowing, in swallowing liquid with comfortable volume (5ml) and in continuous swallowing (100ml). In all situations, the averages were correspondingly higher in the suprahyoid than in the masseter, and the smallest difference between the two muscles occurred at rest and the highest in continuous swallowing (100ml) in the G1 group. We found that the median was lower than the average value, due to the occurrence of an asymmetry of the data found. Moreover, the data showed a high variability, since the standard deviation was higher than half of the average. This situation can be justified by the condition of instability of the studied pathology.

Table 3 presents the results of Spearman correlations between each of the variables: time of diagnosis, score of EDSS scale and score of the DYMUS questionnaire, with the percentage measurements of the electrical activity of the deglutition muscles. This table shows no correlations with the time of diagnosis. Statistically different correlations were recorded between EDSS score and the suprahyoid activity in saliva swallowing, swallowing of fluid with comfortable volume and continuous swallowing, and all the correlations cited were negative, which indicates an inverse relationship between the variables. The values ranged from -0.376 to -0.441. With the DYMUS questionnaire score, we observed correlations with masseter activity and swallowing time, and these significant correlations were all positive. The values ranged from 0.401 to 0.470 on the right side, and from 0.502 to 0.633 on the left. The correlation between DYMUS and swallowing time was 0.370. We emphasize that the data were not correlated with the clinical forms of the pathology, since all volunteers with MS presented the relapsing-remitting clinical form.

Table 4 shows a comparison between patients with and without swallowing alterations, and it was observed that patients with a higher score in the DYMUS questionnaire also had higher measurements in the electrical activity of masseter muscle.

Table 3. Spearman correlation between the time of diagnosis, EDSS and DYMUS with the percentage measurements of the electrical activity of the swallowing muscles in the group of cases

Muscle	Side	Diagnosis time	EDSS	DYMUS
		s (p)	s (p)	s (p)
Rest				
- Masseter	Right	-0.069 (0.718)	0.154 (0.416)	0.470 (0.009)*
	Left	-0.105 (0.581)	0.168 (0.374)	0.633 (< 0.000)*
- Suprahyoid	Right	-0.031 (0.869)	-0.005 (0.980)	0.160 (0.398)
	Left	-0.116 (0.542)	0.100 (0.600)	-0.012 (0.952)
Saliva swallowing				
- Masseter	Right	-0.139 (0.465)	0.140 (0.461)	0.404 (0.027)*
	Left	-0.163 (0.390)	0.241 (0.199)	0.568 (0.001)*
- Suprahyoid	Right	0.019 (0.923)	-0.407 (0.026)*	-0.349 (0.059)
	Left	-0.197 (0.296)	-0.340 (0.066)	-0.306 (0.100)
Liquid swallowing (5mL)				
- Masseter	Right	-0.137 (0.471)	0.246 (0.191)	0.401 (0.028)*
	Left	-0.061 (0.750)	0.317 (0.088)	0.502 (0.005)*
- Suprahyoid	Right	-0.085 (0.655)	-0.441 (0.015)*	-0.329 (0.076)
	Left	-0.133 (0.484)	-0.379 (0.039)*	-0.302 (0.105)
Continuous swallowing (100mL)				
- Masseter	Right	-0.274 (0.143)	0.161 (0.395)	0.447 (0.013)*
	Left	-0.155 (0.415)	0.146 (0.442)	0.531 (0.003)*
- Suprahyoid	Right	-0.138 (0.466)	-0.396 (0.030)*	-0.299 (0.109)
	Left	-0.230 (0.221)	-0.290 (0.119)	-0.323 (0.082)
Swallowing time		-0.174 (0.357)	0.020 (0.919)	0.370 (0.044)*
Number of swallows		-0.081 (0.672)	0.041 (0.831)	0.149 (0.432)

(*): Statistically different from zero

Table 4. Comparison of electrical activity of masseter and suprahyoid muscles with DYMUS results comparing patients with and without swallowing disorders

Muscle	Side	Dymus ≥ 1	Dymus = 0	s (p)
		s (p)	s (p)	
Rest				
- Masseter	Right	0.36 ± 0.28	0.16 ± 0.11	0.071
	Left	-0.105 (0.581)	0.168 (0.374)	0.633 (< 0.000)
- Suprahyoid	Right	-0.031 (0.869)	-0.005 (0.980)	0.160 (0.398)
	Left	-0.116 (0.542)	0.100 (0.600)	-0.012 (0.952)
Saliva swallowing				
- Masseter	Right	0.36 ± 0.28	0.16 ± 0.11	0.071
	Left	0.87 ± 1.10	0.18 ±0.13	0.002
- Suprahyoid	Right	1.04 ±1.39	1.01± 0.44	0.980
	Left	0.86 ± 0.74	1.16 ± 0.63	0.110
5ml swallowing				
- Masseter	Right	0.35 ± 0.29	0.17 ± 0.18	0.109
	Left	0.82 ± 1.10	0.22± 0.27	0.007
- Suprahyoid	Right	1.04 ± 1.70	0.86 ± 0.39	0.064
	Left	0.78 ± 0.76	0.93 ± 0.39	0.140
100ml swallowing				
- Masseter	Right	0.34± 0.33	0.16 ± 0.18	0.039
	Left	0.82 ± 1.08	0.20 ± 0.27	0.002
- Suprahyoid	Right	0.92 ± 1.14	1.00 ± 0.56	0.096
	Left	0.85 ± 0.69	1.05 ± 0.45	0.146

DISCUSSION

Swallowing is a complex sensory-motor function that associates the activity of several muscular groups of the air and digestive tract, regulated by the brainstem, and receives information from the cerebral cortex. It is characterized by three phases (oral, pharyngeal and esophageal) that always occur in the same sequence. The difficulty of swallowing or dysphagia is common in severe neurological disorders, such as MS, and may lead to complications that increase morbidity and mortality in the final phase of the disease. Although dysphagia increases the risk of life, there are still studies of this pathology[6,13-15]. Therefore, it is important to perform an early and adequate evaluation of this symptom in patients with MS.

The age range of the patients evaluated is in agreement with the literature that highlights a highest prevalence in females from 20 to 50 years old in[16,17]. MS affects mostly young adults, who are at a productive age and with the possibility of contributing to the development of the country, and therefore, generates a public health problem with great family, social and economic impact.

The study by Calcagno et al.[18] found a frequency of 34.3% of the 143 patients evaluated with swallowing difficulty. Fernandes et al.[19] reported that 90% of the 120 patients evaluated presented dysphagia conditions at various stages of the disease. Guan et al.[20] found, in a systematic review study, a variation of 36% to 81% prevalence of dysphagia, and believe this difference is because the heterogeneity of the studies, including the use of subjective and objective evaluations of swallowing. In this study, we found a frequency of 46.7% of patients with swallowing difficulties, and this finding is in agreement with the researches by Calcagno et al.[18] and Guan et al.[20]. The difficulty of swallowing may vary in the stages of the disease, and sometimes it is not detected in the initial phase, but with its evolution, we found it is a symptom with important characteristics in the pathology general picture. We should be attentive to this aspect, and studies with clinical and instrumental resources to investigate this function are necessary, as this study, which investigates the electrical activity of the musculature through the sEMG.

In this study, we observed that during rest, the average percentage of the electrical activity of the masseter and suprahyoid muscles were higher in the group of patients. This finding suggests that there is a greater activation of these muscles in an attempt to maintain the synergistic balance of the mandible when at rest, because muscular weakness in these patients is common.

The higher measures on one side may reinforce the hypothesis of a possible asymmetry of the musculature. This may be due to a preferential side during habitual chewing, or, as we have seen in a study with Parkinson, which also affects the CNS, the possibility of a lower recruitment of motor fibers resulting from the disease, leading to a decrease in electrical activity on one side[21,22]. We believe that the imbalance in the recruitment of motor fibers may be present in the SM, because it is a demyelinating disease, which lead to the muscular asymmetry found in this study.

We observed differences between both groups for the masseter muscle, with regard to swallowing tests of saliva, swallowing of liquid with comfortable volume (5ml) and continuous swallowing (100ml). In all cases, the averages were higher in the patients' group. The masseter muscle has an important role in the oral phase of swallowing, aiding the suprahyoid musculature in the stabilization of the mandible. This stabilization allows the contraction of the suprahyoid muscles and, consequently, traction of the hyoid bone and larynx in the rearward direction, guaranteeing a safe swallowing[14,23]. Therefore, these findings may mean greater activation of this musculature in an attempt to assist in the swallowing chain, such as compensation, adaptation or a precursor sign of dysphagia. This happens because, as we have seen in Calcagno et al.[18], the patients with MS presented impairment of the oral and pharyngeal phases of swallowing, and Vieira et al.[24] reported that even patients without complaints of swallowing alterations also presented dysphagia in the oral and/or pharyngeal phases.

The highest averages of the suprahyoid muscles were in the group of patients during rest, but in swallowing tests, they tended to decline. It is probable that fatigability can intervene in the decline of electrical activity of this musculature, since this is a symptom found in SM[25]. Muscular fatigue can lead to another form of compensation in swallowing process, which is swallowing with exertion, and perhaps this compensation is associated with increased electrical activity of the masseter. During the oral phase of swallowing, the activation of a series of muscles occurs, including the suprahyoid muscles that act pushing the bolus to the hypopharynx. In patients with oropharyngeal dysphagia associated with MS, this coordination may be impaired due to the involvement of corticobulbar tract. Studies with videofluoroscopy demonstrated the occurrence of delay, prolongation or even absence of the pharyngeal phase. Laryngeal excursion movements may also be impaired in MS, leading to a process of swallowing incoordination[26,27]. These alterations associated with the evolution of the disease can lead the patient to develop compensatory and adaptive movements that facilitate swallowing. These alterations and findings in the above studies reinforce the use of sEMG as a complementary resource that can help to understand these clinical characteristics of swallowing in MS.

In our study, the time of diagnosis did not influence the percentage measurements of the electrical activity of the muscles investigated during saliva swallowing and 5ml and 100ml volumes. The study by Wiesner et al.[28] states no correlation between the degree of swallowing abnormality and length, severity of the disease, or age of patients. It reinforces the need for researches that investigate the possibility of relating the time of diagnosis with swallowing difficulty. It is probable that to deep these investigations it is also necessary to tie to the studies a survey of the brain areas affected by the MS.

The inverse relationship between EDSS variable and the suprahyoid muscle activity in saliva swallowing, 5ml swallowing and 100ml swallowing in our findings may indicate that, the higher the EDSS score, the lower the activity of this musculature. Fernandes et al.[19] observed this relationship. Their data indicate that the greater the difficulty of swallowing, the higher the EDSS score.

In the literature, as well as in our results, there were no correlation with the amount of swallows. Clinic of patients with MS has shown the presence of multiple swallows, even for small volumes or volumes in which a single swallowing is expected, but we did not found this data in this research.

There is a significant positive correlation between the DYMUS questionnaire score and the masseter muscle activity, i.e., the greater the swallowing difficulty, the greater the masseter activity. The study by Alfonsi et al.[27] mentions a low relation of their findings with the DYMUS score, but the study by Bergamaschi et al.[29] refers to a strong relationship of the DYMUS score with the findings of the clinical evaluation of dysphagia in MS. We also found a direct relationship between swallowing difficulties and the increase in swallowing time. We believe that this relationship is due to the swallowing process becoming slower, as already described in other neurological alterations, such as Parkinson's disease[30].

CONCLUSION

We conclude that the more severe the clinical status of the patient with MS, according to the EDSS scale score, the lower the electrical activity of the suprahyoid musculature; the increase in the electrical activity of the masseter muscle is related to the increase on swallowing difficulty, according to the DYMUS questionnaire score. The increase in the electrical activity of the masseter muscle seems to be related to compensatory mechanisms that seek the best possible muscular synergism during saliva and fluid swallowing. Future studies should advance in the search for the relationship between the electrical activity of this musculature and other clinical and instrumental data associated with swallowing in MS. Our findings highlight differences in the behavior of the swallowing muscles in patients compared with a healthy population.

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Author contributions

VAS: participated in the idealization of the study, collection, analysis and interpretation of the data and writing the article; ACCV: participated as joint supervisor, in the idealization of the study and writing the article; HJS: participated as supervisor, in the idealization of the study and writing the article.