Original Article

Artigo Original

Electrical activity of masseter muscle in young adults during swallowing of liquid

Atividade elétrica do músculo masseter durante a deglutição de líquido em adultos jovens

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Keywords

Electromyography
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ABSTRACT

Purpose: To characterize the electrical activity of the masseter muscle during swallowing of liquids in healthy young adults. **Methods:** Participants were 14 volunteers considered healthy according to the inclusion and exclusion criteria established for this study. The bilateral electromyographic evaluation of the masseter muscle was conducted at rest and in swallowing tasks of 14.5 ml, 20 ml and 100 ml of liquid. The electromyographic signal was normalized by the maximum voluntary activity resisted (MVAR), considered as 100% of the muscle's electrical activity. **Results:** In the right masseter, the highest average percentage was found in the 20 ml task, and in the left masseter, in the 14.5 ml task. In the right masseter there was difference between the 14.5 ml and the 20 ml swallowing tasks. In the left masseter, no differences were found between the swallowing tasks. **Conclusion:** The electrical activity of the masseter muscle in healthy young adults during deglutition of liquids can be influenced by volume swallowed, and present different responses bilaterally.

Descritores

Eletromiografia
Músculo masséter
Deglutição/fisiologia
Transtornos de deglutição/diagnóstico
Músculos mastigatórios

RESUMO

Objetivo: Caracterizar a atividade elétrica muscular do masseter durante a deglutição de líquido em indivíduos adultos jovens saudáveis. **Métodos:** A população constou de 14 voluntários considerados saudáveis seguindo os critérios de inclusão e exclusão estabelecidos para esta pesquisa. Foi realizada avaliação eletromiográfica do músculo masseter bilateralmente, durante o repouso e nas tarefas de deglutição de 14,5 ml, 20 ml e 100 ml de líquido. O sinal eletromiográfico foi normalizado pela máxima atividade voluntária resistida (MAVR), considerada como 100% de atividade elétrica muscular. **Resultados:** No masseter direito, a maior média percentual foi encontrada na tarefa de deglutição de 20 ml e no masseter esquerdo na tarefa de 14,5 ml. No masseter direito ocorreu diferença entre as deglutições de 14,5 ml e 20 ml. No masseter esquerdo não houve diferença entre as tarefas de deglutição. **Conclusão:** A atividade elétrica muscular do masseter em adultos jovens saudáveis durante a deglutição de líquido pode ser influenciada pelo volume deglutido e apresenta diferentes respostas bilateralmente.

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INTRODUCTION

Adequate swallowing, an innate and complex function responsible for directing the bolus from the mouth to the stomach, involves the synergistic participation of many head and neck muscle groups[1,2]. The jaw elevator muscles, which include the masseter muscle, have an important role in the physiology of swallowing, especially regarding the function of jaw stabilization[2].

Although it is considered a chewing muscle, the masseter has a fundamental action during swallowing, because it acts in association with the suprahyoid muscles to clench the jaw during hyolaryngeal excursion[2]. Therefore, further knowledge of the involvement of the masseter muscle in the biomechanics of swallowing consequently involves helping to build essential clinical reasoning in diagnosis, prognosis and treatment of swallowing disorders.

Scientific literature has shown that surface electromyography (SEMG) can be used to evaluate the electrical activity of orofacial muscles, especially due to ease of use in relation to other measurement methods. It is a non-invasive method, free of discomfort and radiation, quick, inexpensive and easily understood by the patient[3].

Despite the wide use of surface electromyography in chewing muscles, the specific behavior of the masseter muscle during swallowing, although noted, has still been minimally studied, even in supposedly healthy subjects. Hence, the aim of this study was to characterize the electrical activity of the masseter muscle during swallowing of liquids in healthy young adults.

METHODS

Sample selection

The study population consisted of 14 young adult volunteers (12 men and two women, between 18 and 31 years) from the student body of a University. We included subjects with complete dentition and no swallowing complaints. To be considered young healthy individuals, volunteers were required to have full permanent dentition, no swallowing complaints, no history of orthognathic, orthopedic or orthodontic treatment, absence of signs and symptoms of DTM and no history of neurological or mechanical changes such as surgery or trauma in the head and neck regions. The study was approved by the Research Ethics Commitee of the Hospital de Câncer de Pernambuco, under protocol number 43/2009 and all volunteers signed the Free and Informed Consent Form, according to Resolution MS/CNS/CNEP nº 196/96 October 10, 1996.

Electromyographic evaluation

The MIOTOOL 200 device (MIOTEC®, São Paulo, Brazil), composed of four channels and linked to a computer, was used to capture the electromyographic signal. The electromyographic signal was processed through a data acquisition system provided by the possible selection of eight independent gains per channel in which the gain of 1000 was used; low pass filter of 20 Hz and high-pass filter of 500 Hz, two SDS500 Sensors with clamp connections, a reference cable (earth) and a calibrator (MIOTEC®).

The recordings were performed at the Electromyography Laboratory of the UFPE Postgraduate Pathology Course.

We used children's disposable surface electrodes (MEDI-TRACE®, São Paulo, Brazil), consisting of material composed of silver-silver chloride (Ag-AgCl), immersed in a conductive gel, responsible for obtaining and conducting the SEMG signal.

Before placing the electrodes, the skin was cleaned with gauze soaked in alcohol 70° to remove any material that could impede the signal acquisition. We removed any existing hairs with a razor blade, ensuring better signal quality and decreased impedance, increasing the contact surface. This procedure occurred only after the volunteer´s consent.

The electrode placement followed a standard procedure, starting with the reference electrode or "earth", followed by placement of electrodes on the right side and then on the left side. The reference electrode was used to minimize interference from external electrical noise. It was placed at a point distal to the registered location of the evaluated muscles, agreed as the volunteer´s right ulnar styloid process.

The other electrodes were placed in a bipolar configuration, in the belly of the masseter muscles, arranged longitudinally to the muscle fibers. To locate the masseter muscle region, the evaluator asked the volunteer to maintain active voluntary oral occlusion with maximum resistance for a duration of three seconds, with the possible visualization and palpation of the more robust masseter region, the midline of the muscle belly. The second electrode was positioned 1.5 cm below the first, also longitudinally following the muscle fiber. The two unused channels were disabled.

During SEMG recording, the environment was quiet, with artificial light and temperature surroundings. The volunteer sat comfortably in a chair with back support and no head support, with the hands over the femur, the soles of the feet flat on the floor, head erect and eyes focused straight ahead, following the Frankfurt plane. The volunteer was unable to see the computer screen in order prevent visual feedback, and compromising the assessment. Before each experiment, each subject underwent training, and during each training session received all necessary instruction and information.

The electromyographic evaluation was then commenced, which consisted of the following steps:

1. Maximum voluntary activity resisted (MAVR)[4,5]: was requested, clenching of the MAVR for five seconds. The task was repeated three times, with an interval of ten seconds between each contraction.
2. Swallowing of a comfortable liquid volume (DLVC)[3]: swallowing of water at room temperature in a single gulp of 14.5 ml. The volunteer was instructed to put the volume in the mouth, hold for three seconds and swallow on the evaluator´s command.
3. Swallowing of an uncomfortable liquid volume (DLVD)[3]: swallowing of water in one gulp of 20 ml (test to assess the volunteers' ability to adapt, using a large water volume). The

volunteer was instructed to put the water in the mouth, hold for three seconds and swallow on the evaluator´s command.

4. Continuous swallowing (DC)[3]: The volunteer was instructed by the evaluator to swallow 100 ml of water, in a continuous and regular way.

It is noteworthy that the tooth contact, muscle symmetry, occlusion strength and breathing pattern and occlusion were not controlled in this study.

For presentation and interpretation of the signal, we used the software Miograph 2.0 (MIOTEC®, São Paulo, Brazil), which provides the numerical data in RMS (Root Mean Square), representing a digitalized signal, the result of the root square of the mean square of the instantaneous of the amplitudes of the electromyographic signal trace recorded , with units expressed in microvolts (μV).

The electromyography signal analysis was performed through normalization, considering (100%) the average of the three repetitions required in the task of MAVR as a reference value, when the masseter muscle is at the height of its muscular activity. All other data was analyzed in terms of reference value percentage. In each channel, from the first two swallowing tasks, the average was taken from each of the three repetitions and a final average was calculated, to be compared with the maximum value. In the natural swallowing, the first five seconds were considered and the average was calculated, which was compared to the maximum value in each channel.

As such, the percentage of electrical activity used by the masseter muscle in the different tasks evaluated was defined in relation to the maximum electrical activity that this muscle produces in MAVR.

Initially, we performed descriptive statistical analysis, by calculating the mean, standard deviation and variation coefficient. To check whether there was significant difference between the tasks (DLVC, DLVD and DC) the nonparametric Friedman test was applied, and the significance level of 5% was considered.

RESULTS

The data was shown in tables and was expressed in percentage according to the MAVR (100%), on each side. In the right masseter muscle, the highest average percentage was found in the swallowing of 20 ml task, and the left masseter muscle was found in the swallowing of 14.5 ml task. Among all volumes offered, the lowest averages on both sides were found at the 100 ml volume (Table 1). It is worth mentioning that the result can experience interference from the standard deviation, which presented elevated values in all the volumes, bilaterally.

The comparison between the different tasks required by the volunteer, using the nonparametric Friedman test, can be analyzed in Table 2.

In the right masseter muscle there was only statistically significant difference between the volumes of 14.5 ml and 20 ml, the largest volume of liquid in the oral cavity resulted in more intense electrical muscle activity. In the left masseter muscle there was no difference between the different liquid volumes.

Table 1. Distribution of masseter electrical activity during swallowing of different volumes in healthy young adults

	Tasks	n	Mean (%)	SD
RMM	Swallowing 14.5 ml	14	13.53	7.26
	Swallowing 20 ml	14	14.33	7.02
	Swallowing 100 ml	14	12.86	6.69
LMM	Swallowing 14.5 ml	14	15.63	6.98
	Swallowing 20 ml	14	15.08	5.68
	Swallowing 100 ml	14	14.22	4.09

Note: RMM = right masseter muscle; LMM = left masseter muscle; SD = standard deviation

Table 2. Comparison of the masseter electrical activity (%) during swallowing between the tasks performed by healthy young adults

Muscle	n	Swallowing 14.5 ml	Swallowing 20 ml	Swallowing 100 ml
Right masseter	14	13.53^{AC}	14.33^{BC}	12.86^{C}
Left masseter	14	15.63^{EFG}	15.08^{FG}	14.22^{G}

The groups of letters above the averages represent the multiple Friedman tests comparisons. Means or average pairs with different letters indicate significant differences ($p<0.05$) between the corresponding mean values

DISCUSSION

It has been established in the literature that the masseter muscle exhibits electrical activity at the moment of swallowing, due to its antagonist action in relation to the jaw depressant action, characterized by an increase in electrical activity at the beginning of swallowing, followed by a decrease when carrying out this function[2].

The data about percentage of masseter electrical activity during swallowing is consistent with previous studies, which also showed low levels of masseter muscle electrical activity during swallowing in relation to MAVR, since its participation is restricted to jaw stabilization[6]. On the other hand, the data differs from previous study results, in which the electrical activity of the masseter muscle during water swallowing without informed volume was reported in approximately 5% of MAVR, a lesser value than the value found in this study[7].

There is controversy about the commencement of masseter muscle activation in swallowing, however, different facial types, different occlusal types, jaw position changes and the methods used for acquisition and analysis of the electromyographic signal can appear to influence this parameter, therefore depending on individual differences[6,7].

In addition, studies of surface electromyography are exposed to several variables that may influence the signal acquisition, such as skin impedance, depth and muscle location, crosstalk, electrode placement, muscles and individual temperature variations[3].

The properties of the material to be swallowed (food or saliva), such as their consistency, viscosity, temperature and volume, as well as the subject palate and the taste intensity of food, modulate the swallowing patterns[6-8].

Some authors believe that saliva is the best option for swallowing electromyography assessment, being easy to use and avoiding the variability of food characteristics involved in the swallow, in addition to being a good stimulus to trigger the swallowing reflex[6]. Other authors[4,6] use water swallowing for electromyographic evaluation, due to the ability to control the offered volume, and the lack of interference in relation to the differences inherent in the food preparation among other consistencies and allows acquisition of a differential diagnosis in several cases of swallowing changes[3].

The authors of this study agree that water is a good evaluation parameter, especially as it does not suffer variations in consistency and offers the possibility of volume control, which is important for both clinical practice and research. In addition, using water allows the possibility of undertaking assessment of volumes and controlled procedures, also soliciting a natural swallow .

In the scientific literature, few authors have evaluated the electrical activity of muscles involved in deglutition with different volumes, so it is necessary to emphasize the differences between them. In swallows with 14.5 ml and 20 ml, the subject is asked to put the volume in the mouth, maintain and swallow on the evaluator´s command. These are, therefore, voluntary swallows but are unnatural and different from physiological swallowing. In 100 ml swallows, the neuromuscular control mechanisms are distinct from previous tasks, being more natural and therefore more physiological[3]. In this study, the data suggests that in a situation with closer resemblance to normal swallowing, there is a more discreet recruitment of muscle action, while in swallowing on command in an unusual situation, the muscular action can be more intense.

As in the right masseter muscle the 20 ml deglutition had the highest average percentage in relation to MAVR, it is assumed that the individual requires more muscle effort to reach the ideal state of jaw balance to perform the swallow properly. Thus, to achieve the jaw stability needed during this function, the muscle recruits more motor units, generating more electrical activity.

A previous study with healthy subjects also showed a higher electrical activity average of the masseter muscle with a 20 ml volume, however, the electromyographic signal was not submitted to normalization and the results were only shown in microvolts[3]. In the same study saliva swallowing was evaluated , but water swallowing showed a higher electrical activity average. Another study conducted with users of dental prostheses[9] found a higher increase in electrical activity of the masseter muscle in saliva swallowing when compared to 5 ml water swallowing. According to the authors, the result was due to the greater volume of water swallowed in relation to the saliva volume, which could not be controlled, but which they believe to be around one or two ml.

These results may also have been influenced by issues related to occlusal contact and occlusal vertical dimension (DVO). In a study that evaluated occlusal force during swallowing, they observed increases in strength with an increase of the DVO. The authors suggest that one possible explanation for this result is that the high DVO impedes the tongue action in the food bolus propulsion and therefore the activity of the chewing muscles may also increase[10].

This may explain the higher activity of the right masseter muscle in the 20 ml deglutition showed in this study. By putting this volume in the oral cavity, the individual needs more DVO to keep it in the mouth, generates more tongue effort to swallow, and recruits more masseter muscle activity in an attempt to stabilize the jaw. With 14.5 ml of water, swallowing becomes more comfortable as the lesser volume allows a lower DVO during swallowing and reduced effort in the tongue action. Despite the higher total volume in 100ml swallowing, in this task the individual swallows in a natural way, voluntarily controlling the volume of each gulp. It should be noted, however, that our study did not evaluate occlusal contact and DVO.

Other authors, however, have a different viewpoint. In cases of increased DVO, a decrease of occlusal contact occurs, essential for the best prognosis for occlusal development, jaw stability and activation of the stomatognathic system muscles[11] and therefore the electrical activity can be decreased. Previous research found higher electrical activity of the masseter muscle in subjects who swallowed with tooth contact than in individuals who swallowed without tooth contact[12].

In adults, there is a correlation during swallowing between the vertical face dimension, elevators activity, and extent of tooth contact. The activity during swallowing is negatively correlated with the vertical dimension and positively correlated with tooth contact[13,14].

Other authors claim that there is more activity in the masseter muscle during swallowing in the intercuspidal position than in other jaw positions. In this situation, the maximum number of antagonist parts makes contact, there is less pressure in the periodontal ligament, less stimulation in periodontal mechanoreceptors, less inhibition of jaw elevation activity and more electromyography activity, which implies greater jaw stability[6].Another study corroborates only in part to the impact of tooth contact in swallowing. In the population studied, only 75% of the volunteers fit this profile, 25% showed no significant changes of the masseter muscle electromyographic signal due to poor tooth contact[15], suggesting that other factors may be involved in this muscle activation.

In subjects without teeth, dental prosthesis users, it has been observed that the electrical activity of the masseter muscle during swallowing did not show significant changes with or without the dental prosthesis in the mouth, indicating that this muscle is less sensitive to changes relating to the maxillo-mandibular[16].

On the other hand, they also state that the absence of teeth contributes to an increase in the electromyographic potential of elevator and depressor jaw muscles[16], demonstrating that there is still no consensus in the literature about this subject.

A recent study compared the electrical activity of the submental muscles, masseter muscle, anterior temporal muscle and sternocleidomastoid muscle during spontaneous saliva swallowing in a group of 54 patients who swallowed with occlusal contact and 57 patients who swallowed without occlusal contact. Despite finding an increase in electrical activity in the masseter muscle in the group that swallowed with occlusal contact, the authors showed that in normal subjects, without objective or subjective signs of altered swallowing, the occurrence of swallowing is possible in both conditions studied. This indicated that swallowing without occlusal contact can be a pattern often found in this population and not necessarily an incorrect swallowing pattern. The same authors also point out in a previous study that swallowing with occlusal contact seems to be more related to subjects who received some type of prosthetic treatment or had lost a tooth[17].

Our group believes in the paramount importance of the stabilizing action that occlusal contact exerts on the masseter muscle during swallowing, however, we agree that it should not be considered as the only interference with this process, since the stimulation and the return generated by the sensory information arising from oral cavity proprioceptors, muscles and ligaments have an influence on patterns of central origin[16], which can change the muscle's electrical activity patterns. We also agree that in future studies, the occlusal contact should be controlled and correlated with other data.

In the left masseter muscle, the same profile found on the opposite side was not observed, however, parameters to analyze asymmetry were not considered in this study, had they been applied, perhaps they could have justified this result.

In populations of healthy subjects it is possible to observe a certain degree of muscle imbalance, which can be considered as physiological and compatible with normal function[18]. Studies with surface electromyography has verified the existence of a preferred chewing side, which can lead to different stimulus between the working and balancing sides during chewing and contribute to the asymmetric development of the facial skeleton and, consequently, the muscles of this region. In our results, it is noteworthy that one of the possible explanations for the asymmetry found between the masseter muscle electrical activity may be related to masticatory preference side in the volunteers[19].

Note, however, that in relation to natural 100 ml swallowing, the results are consistent with a previous study by other researchers[3], which is possibly due to the fact that this task is the most natural and therefore the most spontaneous. In this case, there are different patterns of neurological and peripheral muscle controls that differ from spontaneous swallowing activity from a more voluntary-type activity, as occurs in the swallowing of 20 ml and 14.5 ml[20].

It is important to remember that the oral phase of swallowing is a moment of adjustment to position the food bolus for its subsequent passage into the pharynx. These adjustments involve individual variability and morphology which seems to exert an important role on swallowing motor control[10]. Therefore, in surface electromyography studies it is necessary to use normalization in order to minimize this individual variability[7,21].

The results of this study showed that the masseter muscle exhibits electrical activity during swallowing in healthy young adult subjects and that this activity can vary with the swallowed volume. This plasticity indicates that this muscle group is compliant to adaptation, considering the morphological and neurological individual variables. Therefore, it is likely that subjects with changes at the central nervous system level as well as individuals with mechanical changes induced by resection in the head and neck region may present different patterns of masseter muscle activation during swallowing. Thus, it is important that future research includes this population group.

The results of this study indicate the involvement of the masseter muscle in swallowing biomechanics. The knowledge of muscle physiology in healthy subjects contributes to clinical reasoning in assessments of swallowing disorders and provides the appropriate theoretical support for planning for rehabilitation or for speech therapy readaptation.

It is suggested that future research proposes parameters to standardize electromyographic swallowing evaluation, includes a larger number of subjects and controls more variables such as tooth contact, muscle symmetry, occlusion strength and respiratory pattern.

CONCLUSION

The masseter muscle demonstrates electrical activity during swallowing in healthy young adult subjects. This activity varies with the volume swallowed and presents different responses bilaterally.

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