Submental Surface EMG during Dry and Wet Swallowing in Normal Women*

Young-Sun Yun · Hyang Hee Kim*** · Chung-Hwan Baek**** · Young-Ik Son*****

ABSTRACT

The aim of this study was to examine the characteristics in duration and amplitude of the submental muscle activities during dry and wet swallowing. We examined the middle suprahyoid muscle activities in 32 normal adult women during three swallowing conditions, that is, dry as well as 5 mL & 10 mL water swallowings, using a surface EMG. From the results, there were significant differences in duration: the longest in dry swallowing and shortest in 5 mL water swallowing. However, the mean amplitude per msec increased as the duration decreased. This may imply motor equivalence in swallowing stating that duration and amplitude are complementary in order to achieve a given swallowing goal.

Keywords: submental muscle, surface EMG, swallowing, motor equivalence

1. Introduction

Upon a bedside swallowing evaluation, manual examination is often conducted by asking a patient to swallow his or her own saliva (i.e., dry swallowing) or certain amount of water (i.e., wet swallowing). As the patient swallows, a clinician places his/her four fingers on the patient's neck and assesses the swallowing movements. The index finger should be lightly positioned at the sub-mandibular area immediately behind the anterior mandible, the middle finger at the hyoid bone, the ring finger at the top of the thyroid cartilage, and the little finger at the bottom of the thyroid cartilage. As the patient swallows, the clinician's index finger on the patient's neck can assess initiation of tongue movement on the basis of movement felt by the index finger. The middle finger can perceive hyoid bone movement, and the ring and little fingers can define laryngeal movements when the pharyngeal swallow triggers. By comparing the time

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* This work has been presented, in part, at the 2004 American Speech-Language-Hearing Association Convention.

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elapsed between initiation of tongue movement and that of hyoid and laryngeal movements, the clinician can estimate oral transit time and pharyngeal delay time, or the time from initiation of the swallow by the tongue until the pharyngeal swallow triggers[1].

Although this manual examination has been very useful in swallowing evaluation, it lacks in the objectivity to estimate the precise patterns of duration and amplitude of the swallowing movements. Moreover, the procedures and the results of manual examination may vary depending on clinician's experience.

Thus, such electrodiagnostic tool as electromyography(EMG) has been used in order to increase objectivity. Needle EMG with hooked-wired electrode[2] as an invasive tool is useful to evaluate the specific muscle activities[3][4][5]. Further, surface EMG as a non-invasive tool has been used not only to evaluate the muscles of swallowing but to treat with biofeedback monitoring[6][7][8]. In the investigation of swallowing disorders, surface electrodes are placed on the submental skin surface in order to measure muscle activity[9]. Due to the proximity of the floor-of-mouth musculature to the submental surface electrode, a burst in EMG activity recorded from the submental region. The burst is considered to be the result of the combined activities from individual floor-of-mouth muscles, specifically mylohyoid, geniohyoid, and anterior belly of the diagastric muscles.

In previous studies, the durations of submental muscle activities were reported in dry and wet swallowings using needle EMG[3]. Using surface EMG, the duration and amplitude of infrahyoid muscle activities were also reported in dry and wet swallowings[6]. However, the results of surface EMG activities on the submental muscles have not been reported yet in the same condition of the manual examination. The aim of this study was, thus, to examine the characteristics in duration and amplitude of the submental muscle activities of the oral phase during dry and wet swallowings with surface EMG in normal subjects.

2. Method

Thirty-two normal young adult women between 21 and 38-year-old (mean age: 26) participated in this protocol. The subjects reported no history of dysphagia or use of medicine that could cause dry mouth.

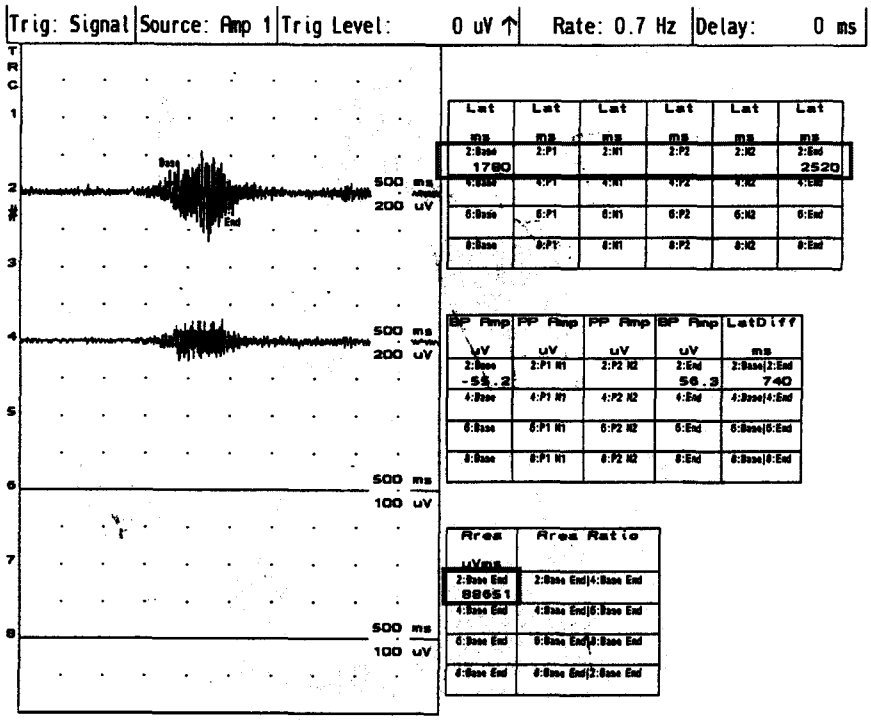
Using MMP-plus (Multi-Mode Program-plus, Viking IV, Nicolet, USA), EMG activities were recorded during three repeated swallowings on the three conditions: dry swallowing, 5 mL and 10 mL water swallowings. The target surface electrode was placed on the middle submandibular area: anterior belly of the digastric, mylohyoid, and geniohyoid muscles. The reference electrode was placed near the thyroid cartilage and the ground was placed on their wrist (Figure 1).

The target electrode was placed on the middle submandibular area (denoted as an arrow), the reference electrode was placed near the thyroid cartilage.

Figure 1. MMP-plus (Viking IV, Nicolet, USA) and the placement of surface electrodes

The subjects were asked to swallow their own saliva for dry swallowing without dry mouth. They participated at least 30 minutes later after the meal to prevent a lot of saliva due to food. Then, wet swallowing was recorded on 5 mL & 10 mL water swallowing, because 5 mL (1/2 spoon) and 10 mL (full spoon) water test were commonly used in swallowing evaluation. The subjects were asked to place a spoon of water measured 5 mL and 10 mL by a syringe in their mouth and to swallow upon cueing.

EMG activity was displayed in the screen of MMP-plus, initiation and termination of EMG activity for each swallow were marked and the duration and the amount of amplitude of the signal were measured automatically (Figure 2). Initiation was defined as the first elevation in EMG activity from baseline in the channel and termination as the point at which EMG activity returned to the baseline in the channel. The mean amplitude per msec was calculated by dividing the amount of amplitude by the duration within a single signal. Repeated ANOVA and Spearman correlation in SPSS program were used in statistical method.



EMG activity was displayed in the screen of MMP-plus, initiation and termination of EMG activity were marked and the duration and the amount of amplitude of the signal were measured automatically.

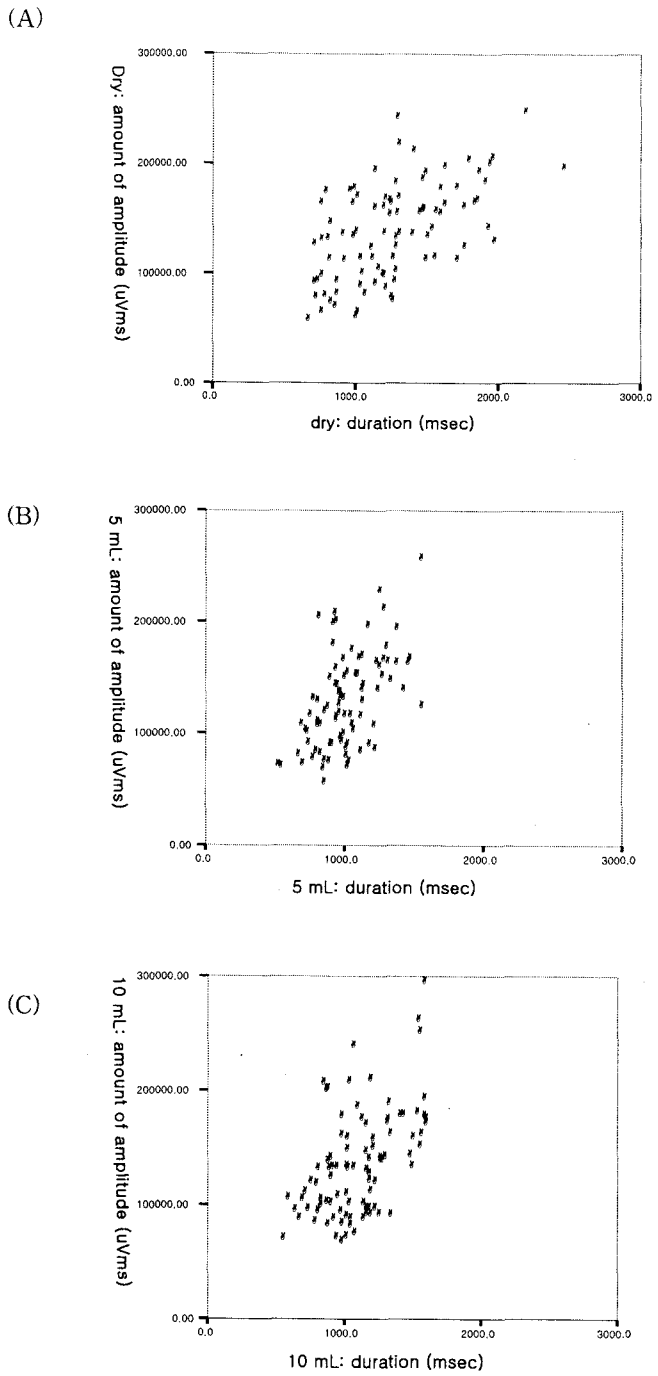
Figure 2. EMG activity and measurement of the duration and the amplitude

3. Results

The data of duration and amount of amplitude were obtained from every single signal (Figure 3.). The results indicated that the duration and the amount of amplitude of surface EMG activity varied greatly among subjects.

The duration was longer in dry swallowing than in wet swallowing. The mean value of duration was 1246.6±364.7(SD) msec in dry swallowing; 1005.3±198.1(SD) msec in 5 mL swallowing; and 1091.7±249.5(SD) msec in 10 mL swallowing. We observed significant differences in duration among the three conditions, $F(2, 62) = 17.597$, $p < .01$ (Figure 4).

However, the amounts of amplitude were not different in dry and wet swallowings. The mean value of amount of amplitude was 141740.6±46734.3(SD) μVms in dry swallowing; 129224.2±47891.6(SD) μVms in 5 mL; and 137895.1±50790.2(SD) μVms in 10 mL. There was no significant difference among the three conditions, $F(2, 62) = 3.565$, $p = .057$ (Figure 5).



(A) Dry swallowing (B) 5 mL water swallowing (C) 10 mL water swallowing.

Figure 3. The data of duration and amount of amplitude were obtained during three repeated swallowing on the three conditions: dry and 5 mL & 10 mL water swallowing.

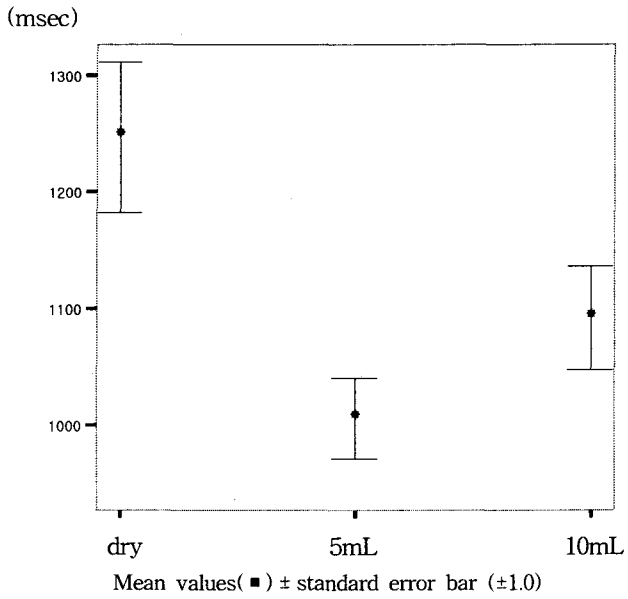


Figure 4. Mean values of duration on three swallowing conditions

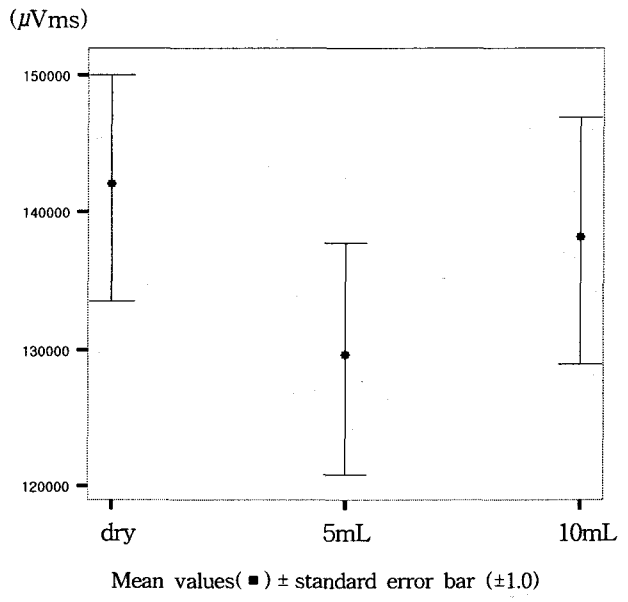
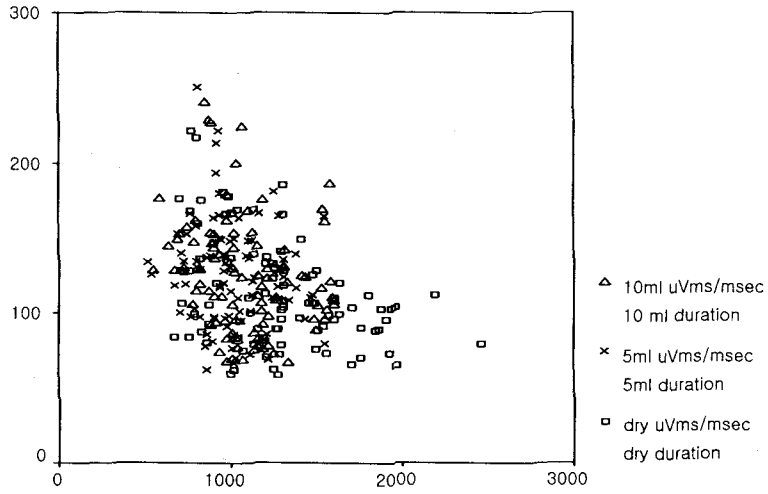


Figure 5. Mean values of amount of amplitude on three swallowing conditions.



: Y axis indicates mean amplitude per msec (μVms/msec). X axis refers duration(msec). Dry swallowing(□); 5mL wet swallowing(×); 10mL wet swallowing(△).

Figure 6. Negative relationship between the mean amplitude per msec and duration in all signals.

We obtained the mean amplitude per msec that was calculated by dividing the amount of amplitude by the duration within a single signal. The mean value of mean amplitude per msec was 123.2±66.5(SD) μVms/msec in dry swallowing; 132.8±54.4(SD) μVms/msec in 5 mL; and 129.6±51.5(SD) μVms/msec in 10 mL. There were significant differences among the three conditions, $F(2, 190) = 5.285$, $p < .01$, especially between dry swallowing and 5 mL swallowing.

Therefore, we observed the negative relationship between the mean amplitude per msec and duration in all signals, $r = -.359$, $p < .01$ (Figure 6). Especially, the subjects with longer duration in dry swallowing showed smaller mean amplitude per msec.

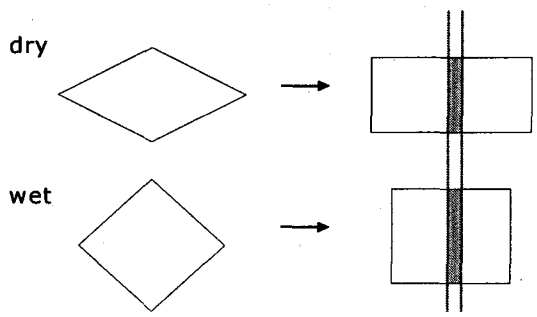
4. Discussion

From the results of the study, the submental muscle activities during dry swallowing took longer time comparing to those during wet swallowing. This finding was corresponding to the results of the study by Hrycyhryn et al[3]. stating that the mean time of needle EMG activity in 20 normal subjects was longer during dry swallowing as opposed to wet swallowing in the suprahyoid muscles, i.e., geniohyoid, diagastric, mylohyoid, and genioglossus.

This finding might have attributed to the following reasons. In dry swallowing, a subject tends not to get ready for swallowing behavior until a verbal command to swallowing is given.

In consequence, dry swallowing ends up taking longer duration. Upon providing with a certain amount of water, on the other hand, a subject is already geared up for swallowing resulting in rather shorter swallowing duration. In a similar fashion, lack of lubricant in oral cavity during dry swallowing might have resulted in longer swallowing time.

On the contrary to the swallowing duration, the total amounts of amplitude of submental activities for a given swallowing activity did not differ between dry and wet swallowing. In other words, the mean square of amplitude per msec of dry swallowing was smaller as the duration of dry swallowing took longer time, and vice versa, as shown in Figure 7. Therefore, there was a negative relationship between the mean square of amplitude per msec and duration in all signals. This may imply motor equivalence[10] stating two activities are complementary to achieve a given motor goal. In our study, duration and amplitude are balanced each other in duration and amount of amplitude in order to accomplish a given swallowing goal.



The square of amplitude (denoted as shadow bar) of dry swallowing was smaller than that of wet swallowing.

Figure 7. Simple figures of EMG activities on dry and wet swallowing

Relationship between swallowing duration and amplitude measures was also reported in a study on patients with brain stem stroke[11]. Crary et al. found that swallowing attempts from the dysphagic patients revealed higher muscle activities over a shorter duration and with less coordination than normal control. However, the underlying mechanism for this finding might different from that of the normal control. They explained that patients had anxiety and/or hypertonicity both at rest and during swallowing. They also explained that the shorter duration was due to 'incomplete' swallowing and/or an acceleration of the oral component of swallow attempts. But they did not explain why more muscle activities over a shorter duration are needed.

Whereas we observed submental activities in the oral stage in this study, Gupta[6] has reported the results of pharyngeal stage stating that the duration of surface EMG on the

infrahyoid muscle activities was same comparing dry swallowing with wet swallowing. However, the higher power during wet swallowing could be attributed to higher energy required to swallow fluids. From his results, we can explain that the muscle activities in wet swallowing in pharyngeal stage need more powerful energy to prevent liquid aspiration in the same duration.

From the results of Gupta and this study, the mean amplitude per msec in wet swallowing increased not only in oral stage but also in pharyngeal stage. This may imply that wet swallowing with some water bolus needs more power of activities per time in all swallowing stage comparing with dry swallowing.

In conclusion, submental surface EMG may be very useful as a non-invasive tool to examine the duration and the amplitude in oral stage swallowing. In dry swallowing, slightly longer duration in oral stage might be a normal pattern.

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received: January 30, 2006
accepted: March 12, 2006

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