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The Immediate Effect of Olfactory Stimulation Using Black Pepper Oil Combined with Sour-bolus Solution on Suprahyoid Muscle Activation in Stroke Patients with Dysphagia

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ABSTRACT

The aim of this study was to investigate the immediate effect of olfactory stimulation using black pepper oil (BPO) combined with sour bolus solution on suprahyoid muscle activation in stroke patients with dysphagia. Twelve stroke patients with dysphagia participated in this study. For all subjects, the suprahyoid muscle activation was measured using surface electromyography (sEMG) during swallowing of four types. Prior to measurement, one of the following four stimulations were applied: odorless+distilled water (ODW), odorless+sour bolus (OSB), black pepper oil+distilled water (BPODW), black pepper oil+sour bolus (BPOSB). The order of swallowing of four types was random, and the subjects swallowed three times for each sensory stimulation, with a rest period of 5 min after finishing each sensory stimulation. Repeated measure ANOVA was used to calculate the mean and maximum values of suprahyoid muscle activation with four sensory stimulations from sEMG. while OSB and BPOSB had a significant effect on mean and maximum values of suprahyoid muscle activation, ODW and BPODW did not have a significant effect ($p<.05$). The olfactory stimulation using BPO combined with sour bolus solution or sensory stimulation using sour bolus solution may have a positive effect the improvement of suprahyoid muscle strength in stroke patients with dysphagia.

KEYWORDS: Stroke, Dysphagia, Suprahyoid, Black pepper oil, Sour bolus

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1. Introduction

The type of stroke depends on damaged area, and generally comes with a variety of symptoms such as motor and sensory dysfunction, agnosia, behavior dysfunction, and dysphagia [1]. Dysphagia, defined as the dysfunction in swallowing, disturbs food intake and causes delays in recovery, leading to poor quality of life with economic consequences [2-3].

Primarily, dysphagia patients with stroke suffer from weakness or paralysis of the suprahyoid muscles, which move the hyoid bone in an anterosuperior direction and elevate the larynx while swallowing [4]. This muscle contraction, which is controlled by the suprahyoid muscle, plays an important role in the opening of the upper esophageal sphincter and contributes to reduction in penetration and aspiration when dysfunctional [4-5]. Therefore, reinforcement of the suprahyoid muscle to improve hyoid and larynx elevation is necessary, and many studies with sensory stimulations, are being conducted to that end [6].

Black pepper oil (BPO), a known sensory stimulant, has been reported to be safe and effective in improving swallowing function, irrespective of patients' mental status. Previous studies showed that olfactory stimulation using BPO had a positive effect on multiple aspects of swallowing function [7-8].

Logemann et al. [9] analyzed the effect of sour bolus solution in stroke and neurologic dysphagia patients. An improvement in efficiency and low-frequency aspiration was observed in the video fluoroscopy (VFS) swallowing results. Thus, a combination of sour bolus solution and BPO olfactory stimulation could be an effective method for dysphagia patients [7-9]. There has been no study on the effect on muscle activity and the combined application of sour bolus solution and BPO olfactory stimulation. Thus, in this study, we have investigated the immediate effect of olfactory stimulation using BPO combined with sour bolus solution on suprahyoid muscle activation in stroke patients with dysphagia.

The composition of this paper is as follows. Chapter 2, Methods describes the subjects, procedures, measurement instrument, and analysis methods. Chapter 3 describes the results of the effect of olfactory stimulation using black pepper oil combined with sour-bolus solution on suprahyoid muscle activation. Chapter 4 describes the discussion and Chapter 5 concludes.

2. Methods

This study was implemented at the S rehabilitation center in Seoul with 12 stroke patients. The patients were given information about the experiment by the researchers, prior to participation in the study. Inclusion criteria were as follows: three months since confirmed diagnosis, absence of other causes for dysphagia, no issues with olfactory identification test [10], a score of 3-4 on the penetration-aspiration scale [11], and an ability to understand and follow instructions. General features of subjects are listed in Table 1.

Table 1. General characteristics

	Subjects (n=12)	
Sex	Male	Female
	n=7	n=5
Age (years)	75.0 ± 7.4	
Lesion side	Right	Left
	n=6	n=6
Onset duration (months)	18.5 ± 11.9	

In all the subjects, a surface electromyography (sEMG) electrode was attached to the suprahyoid muscle and one of the following four sensory stimulations were applied: distilled water swallowing (ODW) after odorless olfactory stimulation, sour bolus solution swallowing (OSB) after odorless olfactory stimulation, distilled water (BPODW) after BPO olfactory stimulation, and sour bolus solution swallowing (BPOSB) after BPO olfactory stimulation. The order of swallowing of four types was random, and the subjects swallowed three times for each sensory stimulation. For BPO olfactory stimulation, the BPO (Absolute Aromas CO., England) similar to that used in study of Ebihara et al. was used [7]. For sour bolus solution, 100% real lemon juice (Real lemon, USA) was used. For olfactory stimulation, a drop of BPO on a cotton swab was placed 3-5 cm away from the nose, for the subjects to inhale. For distilled water and sour bolus stimulations, 5 ml of the solution was injected into the nose using a needle. All subjects were fasted for 1 h prior to start of the experiment and rested for 5 min after completion of each sensory stimulation. In cases where aspiration came up during the experiment, the experiment was terminated immediately.

To measure muscle activation and sEMG signal, a Noraxon Telemyo 15770N (NORAXON, USA), which is an eight-channel wireless sEMG system, and a disposable electrocardiography electrode (T246H) with a band pass filter of 50-350 Hz were used. One channel was used for measurements while a part of sEMG was attached to the suprahyoid muscle.

Data were analyzed using SPSS 21.0. Using a statistical level of significance α as 0.05, descriptive statistics was carried out for the subjects' general characteristics and repeated measure ANOVA was used to calculate the mean and maximum values of suprahyoid muscle activation with four sensory stimulations from sEMG.

3. Results

The results of suprahyoid muscle activation

Table 2. Comparison of suprahyoid muscle activation during 4 swallowing task

	Odorless + distilled water (Task 1)	Odorless + sour bolus (Task 2)	Black pepper oil + distilled water (Task 3)	Black pepper oil + sour bolus (Task 4)	p
Mean (mA)	25.62 ± 2.32	46.90 ± 4.66[a,b]	23.51 ± 9.14	52.17 ± 8.92[a,b]	.001
Maximum (mA)	100.74 ± 7.04	125.39 ± 21.39[a,b]	106.27 ± 11.03	143.34 ± 18.23[a,b]	<.001

[a]p<.05, significant differences on odorless+distilled water

[b]p<.05, significant differences on black pepper oil+distilled water

with four sensory stimulations are listed in Table 2. The mean and maximum values of OSB and BPOSB had higher significant differences than those of ODW and BPODW ($p<.05$).

4. Discussion

In our study investigating the immediate effect of olfactory stimulation using black pepper oil combined with sour bolus solution on suprahyoid muscle activation in stroke with dysphagia, we found that there was a significant difference in the mean and maximum values of suprahyoid muscle with four different sensory stimulations. We infer that sensory stimulation has an effect on the activation of suprahyoid muscle. In the difference of each sensory stimulation, the results of mean value and maximum value are equal. As compared to ODW and BPODW, the muscle activation in OSB and BPOSB was significantly greater.

In a previous study, the effect of sour bolus on swallowing was observed. Leow et al. [12] reported an increase in the contraction of suprahyoid muscle by sour bolus, thus facilitating swallowing function in normal subjects, using sEMG. Ding et al. [13] reported that sour bolus enhanced the start time of contraction of suprahyoid muscle in older, normal subjects, using sEMG. In an intramuscular EMG study, Parmer et al. [14] reported that sour bolus had a greater effect than water, on swallowing and speed of activation of suprahyoid muscle in normal adults. Agreeing with the results of these studies, we found that sensory stimulations that had sour bolus solution had a greater significant effect on muscle activation.

Ebihara et al. [7] reported an improvement in the swallowing function with a reduced latency with BPO olfactory stimulation, in dysphagia patients after stroke. Park et al. [8] reported that the experimental group receiving BPO olfactory stimulation, showed an improved effect on swallowing as compared to the control group that received odorless olfactory stimulation. In the latter group, a reduction in swallowing function was observed instead. To summarize the previous studies, there were statistically significant differences on swallowing reflex time, laryngeal elevation and epiglottis closure, vallecula residue, and larynx pass time with BPO stimulation. However, the results of our study differed from the previous one in that there were no significant differences between ODW and BPODW observed in our study. Neither were there significant differences in the mean and maximum values between OSB and BPOSB. Thus, BPO stimulation had no effect on the activation of suprahyoid muscle and it seems like only sour bolus solution can cause a change in the sEMG value. This difference in our results may be attributed to our focus on short-term effect, unlike the previous ones, which demonstrate long-term effects [15]. Besides, sour taste stimulation seems to be stronger than BPO stimulation; thus, if BPO olfactory stimulation could not have an effect on the activity of suprahyoid muscle, then we should determine which part of swallowing is positively affected by BPO olfactory stimulation.

The limitations of this study are as follows:

only immediate effect results could be determined, and the sample size is small. Hence, our hypothesis-theory remains to be confirmed in a large sample size [16]. In the previous study, although a reduced latency of swallowing was demonstrated, it could not be analyzed. Therefore, we recommend a future studies that analyze timing in this context.

5. Conclusions

The aim of this study was to investigate the immediate effect of olfactory stimulation using BPO ombined with sour bolus solution on suprahyoid muscle activation in stroke patients with dysphagia. While OSB and BPOSB had a significant effect on mean and maximum values of suprahyoid muscle activation, ODW and BPODW did not have a significant effect. The olfactory stimulation using BPO combined with sour bolus solution or sensory stimulation using sour bolus solution may have a positive effect on stroke patients with dysphagia.

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블랙페퍼오일을 이용한 후각자극과 신맛의 병행이 삼킴장애가 있는 뇌졸중 환자의 목뿔위근 활성에 미치는 즉각적인 효과

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요 약

본 연구는 블랙페퍼오일을 이용한 후각자극과 신맛의 병행이 삼킴장애가 있는 뇌졸중 환자의 목뿔위근 활성에 미치는 즉각적인 효과를 규명하고자 하였다. 현재 연구에 삼킴장애를 가진 뇌졸중 환자 12명이 참여하였다. 모든 대상자는 4가지 유형의 삼킴 동안 표면근전도를 이용하여 목뿔위근의 활성을 측정하였다. 4가지 유형은 무취+증류수, 무취+신맛, 블랙페퍼오일+증류수, 블랙페퍼오일+신맛으로 구분하였다. 4가지 삼킴유형의 순서는 무작위로 하였으며, 각 감각자극은 3번씩 삼키도록 요청되었다. 각 감각자극 사이에 5분간의 휴식이 제공되었다. 반복측정 분산분석은 4가지 감각자극 사이에 목뿔위근의 평균 및 최대값의 차이를 규명하기 위하여 사용하였다. 4가지 감각자극 비교결과, 무취+신맛과 블랙페퍼오일+신맛은 무취+증류수와 블랙페퍼오일+증류수보다 목뿔위근 평균 및 최대값에서 유의하게 더 강했다($p<.05$). 블랙페퍼오일을 이용한 후각자극과 신맛의 병행 또는 신맛을 이용한 감각자극은 삼킴장애를 가진 뇌졸중 환자의 목뿔위근 강화에 긍정적인 중재방법이 될 수 있다.

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