Electromyographic Comparison of the Suprahyoid Muscles During Seated Mandible and Capital Resistance

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Abstract

[Purpose] To clarify the relationship between the difference of resistance site and the activity of suprahyoid muscle group. [Subjects] Healthy 11 subject were studied, 6 male and 5 female (average age 20.8 ± 0.55 years old, average body weight 60.7 kg ± 6.14). [Methods] To determine the effects of the swallowing muscles exercise during seated, we measured the surface EMG of the suprahyoid, the sternocleidomastoid and the trapezius (upper fiber) muscle with isometric contraction. [Results] Our examination showed that the muscle activity of suprahyoid muscles, resistance of mandible (condition 1) was more than about two times higher forehead (condition 2). [Discussion] The exercise by resistance of mandible is more effective in swallowing therapy for functional recovery of the suprahyoid muscles.

Key words: swallowing rehabilitation, suprahyoid muscles, EMG

Introduction

The history of the swallowing therapy is a relatively new rehabilitation technique, since recognition as a claimable insurance item according the Japanese Ministry of Health, Lobor & Welfare in 1994[1].

Swallowing is divided into three phases, the "oral phase" where food is sent from the oral cavity to the pharynx by movement of the tongue, the "pharyngeal phase" where food is delivered from the pharynx to the esophagus by the swallowing reflex and the "esophageal phase" which carries food to the stomach by peristaltic movement of the esophagus[2~4]. For smooth and safe swallowing, many organ functions are involved. Dysphagia occurs due to various factors including aging and disability of these organs. Rehabilitation of the swallowing function is a localized treatment around the oral cavity by a speech therapist (ST), while whole body rehabilitation is provided by physical therapists (PT)[5~6]. Recently, the number of deaths due to aspiration pneumonia is increasing, and rehabilitation of eating dysphagia

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has become an important treatment. One treatment for swallowing disorders is muscle strength training targeting the small muscles of the neck centering on the superior hyoid bone muscle group. In clinical practice, there are typically two methods for strengthening this muscle group, application of load (1) under lower jaw and (2) directly on the forehead. We analyzed electromyographic data to identify differences in muscle activity of these two muscle strengthening methods.

Subjects and Methods

The subjects of this experiment were 6 males and 5 females (11 subjects), age [SD] = 20.8 [0.55] years, height =155.2 [6.92] cm, weight 60.7 [6.14] kg. Our subjects received an explanation of this research and the guidelines by a medical attendant, and provided informed consent. This study is approved by the ethics committee of Okubo Hospital (Ethics Committee Approval No-2703).

Condition 1 applies resistance to the lower jaw (Mandible), and Condition 2 applies resistance to the center of the forehead, both with the subject's own thumb or palm. Subjects are seated on a chair to prevent compensatory action due to flexion of the back and trunk during EMG measurement.In condition 1, both elbows are placed under the lower jaw on a table in front of the body at the height of the chest.

The neck is in the neutral position without lateral flexion or rotation, and is flexed forward into the applied pressure to between 5 and 10 degrees.The wrist joints are slightly dorsiflexed, the 2nd to 5th fingers are interlocked, the first finger extends from the MP joint and the IP joint is slightly flexed for resistive load to the bottom of the tip of the lower jaw (Fig 1).

In Condition 2, while maintaining the same sitting posture as Condition 1, both hands are coupled by the subject (Fig 2). The hands are press against the center of forehead. Resistance is applied by pushing of both hands against the center of the forehead.

Muscle activity was analyzed by integrated electromyography (IEMG), (MyoTrace400 produced by Norxon EMG & Sensor Systems). The surface electrodes used were Blue

Fig 1. Condition 1 Resistance on Mandible

Fig 2. Condition 2 Resistance on Forehead

sensors M-00-S/25 (on suprahyoid muscles) and M-00-S/50 (on sternocleidomastoid and the upper fiber of trapezius muscle) produced by Mets Ltd. The sampling frequency of EMG was 1000Hz, with A / D conversion, the computer OS used was the Windows 7.

The skin of the target muscles were cleaned with Nihon Koden Skin pure. We set the electrodes to the appropriate positions on suprahyoid muscles, Sternocleidomastoid and trapezius upper fiber in accordance with the method and location indicated by Shimono[7]. We examined the muscles activity for 15 seconds or more, and recorded data by IEMG for 10 seconds.

As statistical processing, comparison of IEMG ratio was determined using Kruskal-Wallis test followed by the Bonferroni post hoc test. Differences between resistance methods for each muscle were determined using a paired t-test. The effect size was used to estimate the magnitude of an effect in statistical analyses. The statistical significance threshold was set at 5%. And we calculated using the statistical processing software in Excel 2013 for Windows.

Results

Collected data of activity of the muscles in Conditions 1 and 2. The resultant integrated myoelectric value of the suprahyoid muscle group was divided by the value of condition 2. It was greater than 1.0 (AVG 2.180, SD 1.264) in all samples. Similarly, the ratio of the sternocleidomastoid muscle in 10 samples was less than 1.0 (average 0.588, SD 0.359). The ratio for trapezius upper fibers was less than 1.0 (average 0.6241, SD 0.377) in 9 subjects (Table 1, 2, 3).

Table 1. IEMG divided for each resistance.

	Suprahyoid muscle		ratio	Sternocleidomastoid		ratio	Trapezius upper		ratio
No	Mandible	Fronral bone		Mandible	Fronral bone		Mandible	Fronral bone	
1	203.7	127.0	1.603937	243.0	593.0	0.409781	74.4	169.0	0.440237
2	99.4	68.9	1.442671	110.0	307.0	0.358306	95.0	177.4	0.535513
3	258.0	147.0	1.755102	365.0	626.0	0.583067	126.0	301.0	0.418605
4	179.0	110.0	1.627273	207.0	407.0	0.5086	61.5	142.0	0.433099
5	841.0	356.0	2.36236	579.0	709.0	0.816643	92.3	170.0	0.542941
6	592.0	311.0	1.903537	488.0	878.0	0.555809	104.0	325.0	0.32
7	299.0	49.2	6.077236	70.2	266.0	0.26391	40.1	53.1	0.755179
8	465.0	225.0	2.066667	300.0	718.0	0.417827	227.0	477.0	0.475891
9	336.0	226.0	1.486726	131.0	359.0	0.364903	97.6	374.0	0.260963
10	376.0	177.0	2.124294	195.0	352.0	0.553977	56.1	52.4	1.070611
11	297.0	193.0	1.53886	768.0	471.0	1.630573	143.0	88.7	1.612176
AVG			2.180787			0.587581			0.62411
SD			1.263736			0.358791			0.377324

Table 2. T-test.

resistance	Mandible	Forebone	P.value	effect size (r)
Suprahyoid	358.7 (209.8)	180.9 (95.2)	0.00117	0.82
Sternocleidomastoid	314.2 (217.9)	516.9 (199.7)	0.00552	0.74
Trapzuius upper	101.5 (51.4)	211.8 (138.8)	0.00685	0.73

AVG (SD)

Table 3. The Bonferroni post hoc test. Multiple comparison with suprahyoid muscles.

	Suprahyoid	Sternocleidomastoid	Trapzuius upper	p value	Cramer's V
MVCratio(mandible/forebone)	2.2 (1.3)	0.6 (0.4)**	0.6 (0.4)**	0.0001064	1.29

** Significant difference

Discussion

Eating and swallowing are some of the most important and fundamental functions for people to conduct daily life. However, swallowing function can decrease with swallowing muscle dysfunction or mastication, stroke and central nervous system disorders such a Parkinson's disease and aging. In addition, declining swallowing function is a major cause of aspiration pneumonia[8~9].

According to a report by the Ministry of Health, Labor and Welfare in 2011, pneumonia surpassed cerebrovascular disorder and became the third leading cause of death in Japan.

Pneumonia is the second leading cause of death in elderly people over 90 years of age and more than 90% of those who die of pneumonia are elderly people aged 65 years or older, mostly due to aspiration pneumonia. Also, among elderly people who die of pneumonia, more than 70% are reported to be due to aspiration pneumonia.Many elderly people who repeatedly suffer pneumonia are thought to be inspiring oral bacteria into the trachea and lungs due to subclinical aspiration function[10~11].

There are methods for maintaining and improving the swallow function, such as the swallow reflex and the cough reflex for preventing inhalation of food, by medication therapy, and by methods for improving muscle function related to swallowing. The treatment method used by PTs and STs to improve swallow function involves strengthening of the deglutition muscle function.

The suprahyoid muscle group is critical for swallowing. The muscles are from the temporal area to the mandible bone, then connect to the hyoid bone, and are located proximally to the hyoid bone. The muscle group consists of the Digastric, Mylohyoid, Geniohyoid and Stylohyoid muscles, and controlled by the Mandibular nerve (V_3) (Trigeminal (V) nerve branch), Facial nerve (Ⅶ) and Hypoglossal nerve (XⅡ)[12].

Deglutition is typically divided into three phases: oral, pharyngeal, and esophageal phase. In the pharyngeal phase, many nerves and muscles in the oral cavity work in conjunction with each other. Before the food is sent from oral cavity into the pharynx, the soft palate blocks the nasal and pharyngeal cavities, the upper pharygeal muscle contracting close the nasopharynx.

In order to pass the food from the oral cavity further downwards, the tongue base contracts rearward and the muscles in the middle of the pharynx contract. Following that, the pharyngeal muscles cause a guiding movement from proximal to distal and pushes the food downward. Before food reaches the hypopharynx, suprahyoid and thyrohyoid muscle contraction causes the hyoid bone and the larynx to lift up and forward. The epiglottis closes the larynx by moving the larynx forward and upward and contracts the tongue base. During swallowing, incomplete larynx elevation or tongue contraction increase the risk of food aspiration. For food to enter the esophagus, expansion of the upper esophageal sphincter (UES) is necessary. The cricopharyngeal muscles, which make up the majority of the UES, are constantly contracting and only relax during swallowing. In sync with the relaxation of the cricopharyngeal muscles, the suprahyoid muscles and the thyrohyoid muscle contract. Furthermore, the UES expands by lifting the hyoid bone and the larynx. The contraction lifts the hyoid bone and the larynx repeatedly during swallowing as the UES expansion occurs. Thus, maintaining and improving the function of the suprahyoid muscles is critical for swallow function.

In our results of the muscle activity of the suprahyoid muscles, condition 1 was about 2.18 times higher than condition 2. It is considered that the cause of the increase in the muscle activity in condition 1 is higher than that of condition 2 because of activation of the suprahyoid bone muscles during resistance directly to the jaw. Condition 2 is a load to the forehead. The sternocleidomastoid muscle is primarily activated during neck flexion. The trapezius upper fibers are located backside the neck, and act as the antagonist of sternocleidomastoid, increasing in co-contraction as sternocleidomastoid contraction increases. For this reason, the dual-muscle activities in Condition 2 increased more than Condition 1.

In the future in the case of seated exercises, as a functional exercise to enhance the activity of the suprahyoid bone muscles, it is suggested that resistance to the tip of mandible increases the activity of the suprahyoid muscles more than to the forehead.

Acknowledgements

We wish to thank Mr.Takayoshi Otani in our university for gave the appropriate advice and statistical processing.

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