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Effect of the head extension swallowing exercise on suprahyoid muscle activity in elderly individuals

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ABSTRACT

Aging causes motor function deterioration in the elderly population, which in turn can cause weakness in the muscles associated with swallowing. Swallowing-related problems in elderly individuals can be prevented or their symptoms can be improved with strengthening exercises for the muscles involved in swallowing. The existing strengthening exercises for the suprahyoid muscle have their limitations. Therefore, it is necessary to find another exercise that can be performed by individuals whose personal characteristics make it difficult for them to perform the existing exercises. In this study, we investigated the changes in suprahyoid muscle activation, tongue strength, and thickness of the suprahyoid muscle after 8 weeks of the head extension swallowing exercise (HESE). A total of 23 healthy elderly individuals participated in an 8-week exercise program (20 min/session, 2 times/week for 8 weeks). Suprahyoid muscle activation during effortful swallowing and the effortful-normal ratio were significantly increased at 8 weeks compared to the baseline values ($p = 0.002$, and 0.033, respectively). Tongue tip pressure, tongue base pressure, normal swallowing pressure, effortful swallowing pressure, and tongue tip endurance were significantly increased at 8 weeks compared with baseline ($p = 0.014$, 0.004, 0.046, 0.009, and 0.004, respectively). The thickness of the digastric muscle and that of the mylohyoid muscle were significantly increased at 8 weeks compared with baseline ($p = 0.000$ and 0.004, respectively). This study showed that HESE can be a good option for improving the suprahyoid muscle and tongue strength in the elderly population. Additionally, this exercise does not require any additional equipment and has the advantage of being able to be performed anytime and anywhere. A variety of exercise options tailored according to individual characteristics may be helpful in choosing the most appropriate exercise.

1. Introduction

Aging causes deterioration of sensation and the motor swallowing mechanism in elderly individuals (Aslam and Vaezi, 2013). Deterioration of motor function cause weakness in the muscles associated with swallowing. In turn, muscle weakness associated with swallowing can lead to decreased hyoid movement (Logemann et al., 2000), decreased isometric tongue pressure (Robbins et al., 1995), reduced pharyngeal contraction (Tracy et al., 1989), and decreased diameter of the upper esophageal sphincter opening (Shaw et al., 1995). These changes related to aging can affect the efficiency of swallowing, leading to different complications, such as dysphagia and aspiration pneumonia (Di Pede et al., 2016).

These problems caused by aging can be prevented or their symptoms can be improved with strengthening exercises for the muscles involved in swallowing. Robbins et al. (2005) found that the tongue isometric pressure, the pressure of the tongue during swallowing, and the volume of the tongue were significantly increased by tongue strengthening exercise for 8 weeks in healthy elderly subjects. Kraaijenga et al. (2015) showed that suprahyoid muscle mass and tongue strength were significantly increased compared with the pre-exercise levels by applying 3 types of strengthening exercise (jaw opening against resistance, chin tuck against resistance, and effortful swallowing) for 6 weeks in healthy elderly individuals.

Decreased extent of hyoid movement is one of the aging-related phenomena observed in normal elderly people (Logemann et al., 2000). Hyolaryngeal excursion is mainly caused by contraction of the suprahyoid muscles (mylohyoid, geniohyoid, digastric, and stylohyoid muscles) (Pearson et al., 2013; Pearson et al., 2012), and can be improved with the Shaker exercise, Mendelsohn maneuver, jaw opening exercise, and chin tuck against resistance exercise (Kraaijenga et al., 2015; Antunes and Lunet, 2012; McCullough and Kim, 2013; Park et al., 2018). These exercises have limitations, such as the indications of each exercise and the need for special equipment, making them difficult to apply in all elderly individuals (Yoon et al., 2014; Oh, 2016). The Shaker exercise is the most commonly used method for strengthening

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the suprahyoid muscle, and its effect has been verified in various studies. However, this exercise is difficult to perform for an individual with difficulty in postural control because the exercise is performed while lying down. In addition, the action of lying down then lifting the head itself requires considerable effort, resulting in a high dropout rate and an excessive burden on the sternocleidomastoid and abdominal muscles (Park et al., 2018). The Mendelsohn maneuver is a method of deliberately increasing the duration of hyolaryngeal elevation during swallowing, and it is usually applied in patients with limitation in upper esophageal sphincter opening. However, in a study conducted on normal subjects, some subjects did not maintain the motion required by the exercise (Wheeler-Hegland et al., 2008). Moreover, in a study of patients with dysphagia due to stroke, some subjects complained of dizziness during the exercise and stopped the exercise (Bogaardt et al., 2009). To perform the chin tuck versus resistance and jaw opening exercises, a special tool is needed to provide resistance during the performance of the exercise (Kraaijenga et al., 2015). Therefore, it is necessary to find another exercise that can be performed by individuals whose personal characteristics make it difficult for them to perform the existing exercise.

The head extension swallowing exercise (HESE) is an exercise for strengthening the suprahyoid muscles. Subjects sit in an erect posture, look at the ceiling with their head extended, and swallow a small amount of saliva. A previous study reported that the HESE significantly improved the suprahyoid muscle activation and the tongue strength of healthy adults compared with before exercise (Oh, 2016). Originally, head extension swallowing is a compensatory method that is applied in patients with head and neck cancer who generally have problems with the oral transfer of food because of tongue resection or the effects of radiation/chemotherapy (Pauloski, 2008). However, Oh (2016) used the idea of reinforcing the suprahyoid muscle by using this posture to apply resistance, based on the report by Sakuma and Kida, who demonstrated that suprahyoid muscle activation increased significantly when the subjects attempted to swallow with the head extended (Sakuma and Kida, 2010).

Previous study has confirmed the effect of strengthening the suprahyoid muscle and tongue muscles; however, this study was conducted in young healthy adults and that result is difficult to apply to the elderly population. Therefore, in the present study, we investigated the changes in the suprahyoid muscle activation, tongue strength, and thickness of the suprahyoid muscle after 8 weeks of HESE. We hypothesized that the suprahyoid muscle activation, thickness of suprahyoid muscle, and tongue strength would increase as a result of 8 weeks of muscle strengthening exercise.

2. Materials and methods

2.1. Participants

This study included 23 volunteers (mean age, 76.22 ± 4.64 years; range, 66–83 years) without a reported history of speech or swallowing deficits and who could perform the HESE (Table 1). A total of 25 participants were initially recruited; however 2 were excluded from the analysis because they could not attend the final measurement (week 8): 1 subject (female, 74 years) was lost to the final measurement and another subject (female, 70 years) dropped out because of a long overseas trip. Therefore, 23 of 25 participants completed the exercise program. No participant reported drug use that could affect swallowing or neurological function, or having engaged in any type of swallowing-related strength training program for at least 1 year before this study. Before the start of the study, all participants received a complete explanation of the purpose, risks, and procedures, and provided written informed consent. The procedures were in accordance with the ethical standards of the committee on human experimentation at the institution at which the work was conducted. This study was approved by our Institutional Review Board.

Table 1
Demographic characteristics of the participants.

		Number (*n*)	Percent (%)
Sex	Male	6	26.1
	Female	17	73.9
Age group (years)	65–69	1	4.4
	70–74	7	30.4
	75–79	10	43.5
	80–84	5	21.7

2.2. Experimental procedures

This study was carried out in the following order:

1. Baseline measurement (muscle activation of the suprahyoid muscle during normal and effortful swallowing measured using surface electromyography [sEMG], isometric/swallowing tongue pressure and tongue endurance determined using a tongue pressure measurement system, and muscle thickness of the suprahyoid muscles evaluated using ultrasound);
2. Eight-week exercise program (20 min/session, 2 times/week for a total of 8 weeks);
3. Re-evaluation after 8 weeks (sEMG, tongue pressure, muscle thickness).

Measurements at baseline and at 8 weeks were conducted in the same place, at the same time, and by the same examiner.

2.2.1. Electrophysiological evaluation

Before the measurements, the skin under the chin was wiped with alcohol cotton and dried for 30 s. During the examination, the subjects sat on a chair with armrests and a backrest, maintaining a neutral upright posture. sEMG data were collected using Noraxon TeleMyo-DTS (Noraxon, Inc., Scottsdale, AZ, USA) and analyzed using Noraxon MyoResearch 1.07 XP software (Noraxon Inc.). The sEMG signals were amplified, band-pass filtered (10 and 500 Hz), and notch filtered (60 Hz) before being digitally recorded at 1000 Hz and processed into the root mean square. For recording the activity of the suprahyoid muscle complex (mylohyoid, geniohyoid, and anterior digastric muscles), wireless sEMG electrodes were placed at a distance of 1 cm on the skin on both sides of the midline under the chin (Beckmann et al., 2015). The isometric reference voluntary contraction (RVC) was used to normalize the EMG data. RVCs were used instead of maximum voluntary contraction to decrease the risk of injury. To measure the RVC, the subjects were required to lift their head and look at their feet for 5 s from the supine position. The suprahyoid muscle activity during the first and last seconds was excluded from the measurement of RVC. Therefore, data of the middle 3 s of the 5 s contraction were used for analysis (Hiramatsu et al., 2015). Measurements were preceded by a familiarization session to exclude the effects of a learning curve and improve the reliability of the measurements. The measurements were then repeated 3 times, with a 120-s rest period between the trials. During normal swallowing, the participants were given 10 mL water in the mouth by using a syringe and instructed to swallow comfortably. During effortful swallowing, the participants were given 10 mL water in the mouth by using a syringe and instructed as follows: “As you swallow, push really hard with your tongue” (Huckabee and Steele, 2006). The order of measurements was the same for all participants and during all measurements (baseline and 8 weeks). The onset and offset signals representing the effort applied by the participant for each task were identified, and the signals in-between the onset and offset signals were analyzed to obtain the peak values (peak amplitude) for each participant. For each task, the mean values of the 3 trials were used to analyze the peak value. For each subject, the mean value of the sEMG