Therapeutic Exercises for Strengthening Suprahyoid Muscles

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Suprahyoid muscles play an important role in normal swallowing by providing muscle contractions involved in airway protection and upper esophageal sphincter opening. However, these muscles can be weakened by neurological disease or aging, which can result in pharyngeal dysphagia. Therefore, strengthening of the suprahyoid muscles is a clinically important treatment. In addition, it is important to know exactly how and which method is optimal. Many therapeutic exercise methods have been reported to strengthen the suprahyoid muscles, and new methods related to this have recently been reported. Therefore, this study will briefly summarize the representative traditional methods and the recently reported, relatively new methods for strengthening the suprahyoid muscles. (JKDS 2018;8:8-14)

Keywords: Suprahyoid muscles, Dysphagia, Therapeutic exercise, Rehabilitation

INTRODUCTION

Swallowing involves a series of three phases, mainly oral, pharyngeal, and esophageal. All of the problems that arise in this process are collectively known as "dysphagia." Among these, pharyngeal dysphagia is the most important as it occurs most frequently after neurological disease and is directly related to aspiration1. Furthermore, aspiration pneumonia is a complication that can lead to death. In the pharyngeal phase, the suprahyoid muscles are some of the representative muscles that have an important effect on the normal swallowing mechanism. However, neurological damage, such as stroke and Parkinson's disease, causes weakening of the suprahyoid muscles1. Reduced activation of the suprahyoid muscles reduces hyolaryngeal movement and the opening of the upper esophageal sphincter (UES) and, consequently, results in pharyngeal dysphagia, leading to complications such as aspiration because of incomplete pharyngeal clearance. Therefore, the development of various therapeutic exercise methods to strengthen the suprahyoid muscles for safe swallowing and studies that demonstrate their effectiveness are of clinical importance. This review aims to summarize traditional and recent therapeutic exercise methods that can strengthen the suprahyoid muscles,
ANATOMY AND LOCATION OF THE SUPRAHYOID MUSCLES

The muscles responsible for swallowing in the pharyngeal phase are located between the mandible and hyoid bone in front of the neck and are often referred to as the suprahyoid or submental muscles. However, strictly speaking, there is a slight difference in the composition of both muscle groups. The submental muscles include three muscles: the geniohyoid, mylohyoid, and digastric anterior belly, located just below the jaw. However, the suprahyoid muscles are a group of five muscles, with the digastric posterior belly and stylohyoid muscle added to the three muscles that comprise the submental muscles. The muscle fibers of these muscles are approximately 3 to 6 cm in length and are relatively small compared with other skeletal muscles. The suprahyoid muscles are innervated by cranial nerves 5, 7, and 12.

ROLE OF THE SUPRAHYOID MUSCLES IN THE SWALLOWING MECHANISM

The suprahyoid muscles act in the pharyngeal phase with a swallowing reflex during the swallowing process. The contraction of these muscles plays a role in pulling the hyolaryngeal complex upwards; in particular, the geniohyoid and mylohyoid muscles pull the hyoid bone forward and upward, respectively. The anterior movement of the hyoid bone contributes to UES opening and the upward movement causes tilting of the epiglottis, contributing to normal swallowing through airway protection. Previous studies revealed that healthy adults anterior hyoid excursion was 1.5±0.1 cm and superior hyoid excursion was 1.3±0.3 cm, whereas in stroke patients, the average anterior hyoid excursion was 1.1±0.2 cm and average superior hyoid excursion was 1.2±0.1 cm. The reduction in hyoid bone movement may result in pharyngeal dysphagia, leading to aspiration or penetration, decreased UES opening, and pharyngeal residue. Therefore, restoring and maintaining sufficient movement of the hyoid bone, by strengthening the suprahyoid muscles, is one of the important factors for safe swallowing.

PURPOSE AND EXPECTED EFFECTS OF STRENGTHENING THE SUPRAHYOID MUSCLES

The expected effects of strengthening the suprahyoid muscles can be largely classified into kinematic (e.g., hyolaryngeal movement) and functional. The contraction of the suprahyoid muscles induces the anterior-superior movement of the hyoid bone and larynx and influences the kinematic effect through epiglottis rotation. As a result, airway protection, opening of the UES, and vocal cord closing influence the functional effect. Ultimately, this minimizes complications such as malnutrition, dehydration, and aspiration pneumonia and improves oral dietary ability.

THERAPEUTIC EXERCISES FOR STRENGTHENING THE SUPRAHYOID MUSCLES

Various therapeutic exercises for strengthening the suprahyoid muscles have been reported in many
studies over the last few years. This study summarizes typical therapeutic exercise methods aimed at strengthening the suprahypoid muscles and introduces relatively new therapeutic methods.

1. Shaker exercise

The Shaker exercise, also known as the head-lift exercise (HLE), enhances the strength and endurance of the suprahypoid muscles and is noninvasive, inexpensive, and safe. The Shaker exercise consists of isometric and isotonic contraction movements. In the exercise, the patient lifts the head and looks at the toes for 60 s while lying in a supine position, with a 60-s rest period between each lift (isometric contraction exercise). The next part of the exercise comprises 30 repetitive head lifts at a constant velocity, without holding the head in a fixed position (isotonic contraction exercise). Some studies reported a significant effect of the Shaker exercise on decreases in post-swallowing aspiration to a greater degree compared to other conventional swallowing therapies and demonstrated that the exercise activates the hyolaryngeal elevator in healthy adults, as assessed via electromyography, bolus clearance time, and UES opening width in healthy older adults.

The Shaker exercise is based on the anterior and superior movement of the hyoid bone by the contractions of the thyrohyoid, mylohyoid, geniothyroid, and anterior belly of the digastric muscles. Thus, its effectiveness has been reported for strengthening the suprahypoid and infrahyoid muscles and for UES opening. Most studies investigating the Shaker exercise have involved patients with UES opening difficulties and normal older adults. Recently, some studies have compared the effects of the Shaker exercise and traditional swallowing therapy, isotonic and isometric exercise methods, relationships with muscle fatigue during the Shaker exercise, and the effects of the Shaker exercise on vocal function. Mepani et al., compared the effects of a Shaker exercise group and traditional swallowing rehabilitation group for 6 weeks in patients with dysphasia. The Shaker exercise group showed significant improvement in thyrohyoid muscle shortening, which was found to be effective in improving the muscular strength of not only the suprahypoid muscles but also of the infrahyoid muscles. Easterling et al., reported that the Shaker exercise was effective for suprahypoid and infrahyoid strengthening and consequently, for UES opening in the elderly. Compared with the general adult population, elderly individuals are observed to have decreased UES relaxation, anterior and superior movement of the larynx, and increased pressure in the lower pharynx; thus, the Shaker exercise can be effectively applied for improvement of the swallowing function by facilitating anterior and superior movement of the hyoid bone and larynx through.

However, the Shaker exercise has some shortcomings. It requires considerable physical effort and can cause fatigue and temporary pain in the neck muscles because the exercise involves head-lifting against gravity in a lying position. Some studies have reported a large number of dropouts among normal adults during HLE, particularly among patients with neurological disease. Thus, an alternative therapeutic approach is needed.

Recently, the reclining exercise (RE) was reported as an alternative and less strenuous form of treatment, in which head-lifts are performed in a seated and 45° reclining position, with the head unsupported; moreover, RE retains the principles of HLE (e.g., isometric and isotonic contraction). The reclining position at 45° helps relieve neck pain and improves head and neck posture and the range of motion in healthy adults and is often used in clinical practice. This study reviewed the effectiveness of HLE and RE on submental muscle activity, tongue strength, and perceived exertion in healthy young adults; the findings indicated similar electromyographic effects regarding both exercises. Thus, RE is less strenuous than HLE, which involves high physical demands, and RE may be a new exercise that can be applied to patients with dysphagia.
2. Mendelsohn maneuver

The Mendelsohn maneuver is intended to maintain elevated hyoid and laryngeal motion during swallowing in order to increase the UES opening time and range\(^\text{19}\). In normal swallowing, the contraction time of the suprahyoid muscles is extremely short because the anterior-superior movement of the hyoid bone is within about 1-2 seconds. Hyoid movement pulls on the thyroid and cricoid cartilages; thereby, UES is allowed about a 6-mm opening. Maximal hyoid excursion occurs at the time of the first cricopharyngeal opening and, thereafter, the bolus passes through the esophagus. However, the Mendelsohn maneuver can intentionally prolong the contraction time of the suprahyoid muscles by holding the hyoid bone up to its maximum when the suprahyoid muscles are contracted during swallowing. A previous study has reported that the Mendelsohn maneuver has a longer activation time than spontaneous swallowing, such as wet or saliva swallowing\(^\text{20}\), because the person can intentionally control the muscle contraction time for activation. These results suggest that the Mendelsohn maneuver is effective for opening the UES and increasing hyoid movement in patients with dysphagia after stroke\(^\text{20,21}\). However, it is challenging to apply the Mendelsohn maneuver to patients with dysphagia. Because the Mendelsohn maneuver depends on voluntary swallowing, it is challenging to perform in patients who have a significantly reduced ability to swallow. In addition, it is difficult for patients to understand and perform the correct method.

3. Effortful swallowing

Effortful swallowing training (EST) involves all the muscles associated with swallowing and is aimed at increasing the pressure of the oropharynx. EST increases the posterior motion of the tongue base toward the posterior pharyngeal wall. As a result, a compensatory technique was initially introduced to improve the clearance of vallecular residues in the pharyngeal phase\(^\text{22}\). Recently, EST was reported as a remedial method for the treatment of oropharyngeal dysphagia. This method involves pushing the tongue firmly against the palate while swallowing as forcefully as possible. EST is known to have a positive effect on the function of the oral and pharyngeal phases. It uses a variety of muscles involved in the oropharyngeal phase to enable strong swallowing; thus, it activates muscles such as the tongue and suprahyoid muscles\(^\text{23,24}\). Several studies have reported that EST induces a greater activation of the suprahyoid muscles compared with normal swallowing and is more effective for the anterior-superior movements of the hyolaryngeal muscles compared with normal swallowing\(^\text{25,26}\). Therefore, EST can be applied to enhance the movement of the hyolaryngeal complex by strengthening the suprahyoid muscles and can also act as a compensatory method.

4. Expiratory muscle strength training

Expiratory muscle strength training (EMST) has recently been reported as a remedial treatment for exercising the suprahyoid muscles\(^\text{1,26}\). EMST consists of blowing with force to generate high expiratory pressures, against adjustable resistance with the use of an EMST device. The expiratory pressure required to perform EMST is generated and transferred through the upper airway into the EMST device through the recruitment of the suprahyoid muscles. Furthermore, this training has been shown to be effective for improving cough capacity by exerting a strong expiratory effect, which could decrease the risk of aspiration/penetration\(^\text{1,27}\). Because respiratory and swallowing functions share many anatomical structures, such as the airway and muscles, they play an important role in airway protection.

Although EMST is recommended as an exercise for strengthening the suprahyoid muscles in patients with dysphagia and can be performed with an EMST device, balloon-blowing or straw-blowing can also be employed as easily available alternatives. However, regarding EMST, clinical considerations should include repeatedly strong exhalation against resistance through the mouth. Therefore, it is maybe necessary to perform EMST in patients with unstable respiration.
and hypertension and patients should be aware of the applicability.

5. Chin-tuck-against-resistance exercise

The Chin-tuck-against-resistance exercise (CTAR) addresses the limitations of HLE and has been applied for the same purpose. The exercise is performed by tucking the chin to compress an inflatable rubber ball in a sitting position. Recently, therapeutic devices (e.g., a resistance bar) have been introduced that provide resistance to tucking the chin in a sitting position. In a study involving healthy adults, CTAR was performed for suprahyoid muscles strengthening by placing an elastic rubber ball with resistance on the chin and sternum, and then tucking the chin against the resistance. Increased activation of the suprahyoid muscles occurred during CTAR compared with HLE, and participants reported that CTAR was subjectively less strict than HLE\(^{16}\). Other studies have reported that CTAR was more specific in targeting the suprahyoid muscles compared with HLE based on surface electromyography recordings and that the sternocleidomastoid muscles were significantly less activated and fatigued during CTAR than during HLE in stroke patients with dysphagia\(^{28}\). Gao et al. reported that CTAR had similar effects to HLE on reduced aspiration/penetration and psychological states, such as depression, by improving swallowing function in stroke patients with dysphagia\(^{29}\).

However, CTAR has its limitations as the exercise is not suitable for patients who have severe cognitive decline or are unable to sit up. In contrast, the Shaker exercise can be performed with a therapist’s assistance in such patients. Thus, each exercise method can be applied differently to improve swallowing function depending on the physical and cognitive potential of patients.

6. Jaw-opening exercise

The jaw-opening exercise is usually performed by opening the jaw to its maximal extent and sustaining the position or via isometric movement with other resistance tools applied. Maximal jaw-opening and sustenance of this position are associated with the mandibular adductor and depressor, which contain the mylohyoid, geniohyoid, and anterior gastric muscles. Previous studies have demonstrated that the jaw-opening exercise is an effective exercise for suprahyoid muscle strengthening\(^{30,31}\). The isometric jaw-opening exercise for suprahyoid strengthening was performed by maximally opening the jaw and holding the motion for 10 s, as suggested by Watts et al.\(^{31}\). This study demonstrated the effect of the exercise on improvement of the upward movement of the hyoid bone, UES opening width, and pharynx passage time\(^{32}\). Resistance exercise is known to increase muscular strength and endurance, which prevents the problems associated with dysfunctional skeletal muscles and particularly alters muscle fiber type distribution. Resistive jaw-opening exercise is an isometric jaw-opening exercise where the chin brace is positioned below the jaw to provide resistance. In a comparative study of the activation of the hyolaryngeal muscles in a resistive jaw-opening exercise and HLE, the former showed a greater activation of the hyolaryngeal muscles for elevating the larynx than did HLE\(^{31}\).

The jaw-opening exercise, like CTAR, can be a schema for rehabilitation in dysphagia for patients who cannot perform HLE because of posture and compliance problems. In addition, if the patients perform the correct movement to achieve the desired effect for the jaw-opening exercise, they can self-apply the exercise without a therapist or other supervision. Thus, this exercise can be used as an additional exercise for swallowing disorders, regardless of circumstances.

CONCLUSION

This review paper briefly summarizes traditional and relatively recent therapeutic exercises for strengthening the suprahyoid muscles. Future studies should develop and investigate new therapeutic methods and demonstrate their efficacy. Moreover, a systematic review should provide a more objective
summary of these methods.

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