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A COMPARISON OF ACTIVATION EFFECTS OF THREE DIFFERENT EXERCISES ON SUPRAHYOID MUSCLES IN HEALTHY SUBJECTS

ORIGINAL ARTICLE

ABSTRACT

Purpose: The most crucial airway protection mechanism during swallowing is adequate laryngeal elevation. Suprahyoid muscles are responsible for laryngeal elevation. Our study aimed to compare the effects of three different exercises, Shaker, resistance chin tuck (CTAR) exercise, and chin tuck exercise with theraband, on suprahyoid muscles activity responsible for laryngeal elevation.

Methods: Forty-two healthy subjects with a mean age of 27.92±5.02 years (18-40 years), of which 50% were male were included. All individuals were divided into three groups with computerized randomization. Surface Electromyography (EMG) evaluation was performed to determine electrical activity of the suprahyoid muscles (geniohyoid, mylohyoid, anterior belly of digastric, thyrohyoid, stylohyoid muscles) during maximal voluntary isometric contraction and during performing CTAR, Shaker exercise and chin tuck with theraband. Normalized suprahyoid muscle activations were calculated as the recorded maximum electrical activity during exercise (mV)/recorded maximum electrical activity during maximum isometric contraction (mV).

Results: A statistically significant difference was found between three groups regarding normalized suprahyoid muscle activation ($p<0.001$). The difference between the three groups was caused by the difference between CTAR and Shaker ($p<0.001$) and between CTAR and theraband ($p=0.040$) in favor of CTAR. No difference was found between Shaker and theraband ($p=0.104$).

Conclusion: Primarily CTAR exercise should be included in rehabilitation to increase the suprahyoid muscle activation. In addition, chin tuck exercise with theraband can also be considered as an alternative to CTAR.

Key Words: Dysphagia; Electromyography; Suprahyoid Muscles.

SAĞLIKLI OLGULARDA ÜÇ FARKLI EGZERSİZİN SUPRAHYOİD KASLAR ÜZERİNE AKTİVASYON ETKİLERİNİN KARŞILAŞTIRILMASI

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Yutma esnasında en önemli havayolu koruması, yeterli laringeal elevasyondur. Laringeal elevasyondan suprahyoid kaslar sorumludur. Çalışmamızın amacı, üç farklı egzersizin; Shaker, dirençli chin tuck (CTAR) egzersizi ve theraband ile yapılan chin tuck egzersizlerin laringeal elevasyondan sorumlu olan suprahyoid kaslarının aktivasyonu üzerine etkilerini karşılaştırmaktı.

Yöntem: Yaş ortalaması 27,92±5,02 yıl (18-40 yıl), % 50'si erkek olmak üzere 42 sağlıklı gönüllü çalışmaya dahil edildi. Maksimum istemli izometrik kontraksiyon ve CTAR, Shaker ve theraband ile chin tuck egzersizleri sırasında suprahyoid kasların elektriksel aktivitelerini belirlemek için yüzeyel elektromyografi (EMG) değerlendirilmesi yapıldı. Normalize edilmiş suprahyoid kas aktivasyonları: egzersiz esnasında kaydedilen maksimum elektriksel aktivite (mV)/maksimum izometrik kontraksiyon esnasında kaydedilen maksimum elektriksel aktivite (mV) formülü ile hesaplandı.

Sonuçlar: Üç grup arasında normalize edilmiş suprahyoid kas aktivasyonları açısından istatistiksel olarak anlamlı bir fark bulundu ($p<0,001$). Bu farkın CTAR grubu lehine, CTAR ile Shaker ($p<0,001$) ve CTAR ile Theraband grupları ($p=0,040$) arasındaki farklardan kaynaklandığı görüldü. Theraband ve Shaker arasında istatistiksel olarak anlamlı bir fark bulunamadı.

Tartışma: Suprahyoid kas aktivasyonunu artırmak için CTAR egzersizi rehabilitasyona birincil olarak dahil edilmelidir. Ayrıca, theraband ile chin tuck egzersizi de CTAR egzersizine alternatif olarak düşünülebilir.

Anahtar Kelimeler: Disfaji; Elektromyografi; Suprahyoid Kaslar.

INTRODUCTION

Swallowing is a series of sequential functions starting with oral intake of food and transferring to the pharynx, esophagus, and stomach, respectively (1). Any problem during these sequential functions is defined as swallowing impairment (dysphagia).

After food is transformed into bolus formation in the mouth, it is propelled to the pharynx by tongue movements. Swallowing reflex is triggered when the bolus passes through anterior faucial pillars. When swallowing reflex is triggered, hyolaryngeal complex move up and forward to provide airway protection with the tilt of epiglottis. The upward movement of the laryngeal complex allows relaxation of the upper esophageal sphincter, and thereby bolus enters into the esophagus with the squeezing effect of pharyngeal constrictor muscles. Namely, the most critical airway protection mechanism during swallowing function is adequate laryngeal elevation. Main structures responsible for laryngeal elevation are suprahyoid muscles (2,3).

There are many treatment approaches to improve laryngeal elevation in swallowing rehabilitation. The most common methods are exercises including Shaker exercises, Chin-Tuck Against Resistance (CTAR) exercise, neuromuscular electrical stimulation of suprahyoid muscles and expiratory muscle strength training (4-7). Theraband exercises as resistance training is a commonly used technique for limb strengthening in physical therapy (8,9). Shaker and CTAR exercises have some difficulties for patients. For example, Shaker exercise is positional uncomfortable, and it causes excessive fatigue in the neck muscles. Also, patients with inadequate upper limb function have limitations to perform CTAR exercise. We thought that chin tuck exercise with theraband is a more comfortable alternative for patients. Chin tuck exercise with theraband could be used to increase suprahyoid muscle activity and to improve laryngeal elevation. Therefore, we aimed to compare the effects of Shaker exercise, CTAR exercise and chin tuck with theraband exercise on suprahyoid muscles activity.

METHODS

Subjects

Forty-two healthy subjects had a score of below three from the Turkish Eating Assessment Tool-10 (T-EAT-10), (21 males, 21 females, mean age 27.92±5.02 years, aged between 18 and 40 years) were included in the study. Having any cervical pathology such as cervical disc hernia and mechanical neck pain, neurological or systemic diseases, undergoing surgery from the head and neck region, taking radiotherapy on head and neck region, and having a swallowing disorder history were the exclusion criteria of this study. All individuals were divided into three groups with computerized randomization.

This study was carried out between May and July 2018 at Hacettepe University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation. The ethical approval of this study has been obtained with the approval number of KA-180002 from the Hacettepe University Ethics Committee of Clinical Research. A written informed consent form was taken from all participants.

Measurements

All participants completed the T-EAT 10 questionnaire. It is a valid and reliable questionnaire, which contains 10 questions and assesses swallowing symptom severity (10).

Electromyographic Evaluation of Suprahyoid Muscles

Before surface electromyography (EMG), the skin was cleaned with alcohol. After drying the skin (30 sec), two silver/silver chloride (Ag/AgCl) self-adhesive, 1x2.5 cm size surface electrodes were placed on the midline of the submandibular area bilaterally. The distance between the two electrodes was adjusted to less than 20 mm. All participants were asked to sit upright in a chair during EMG evaluation. The grounding electrode was placed on the right clavicle to avoid signal from any contraction. Cables and electrodes were fixed with adhesive tape to prevent the pull artifacts that may occur during recording (11).

Dual channel surface EMG device integrated to a swallowing evaluation station named The Digital Swallowing Workstation 7200 (Kay Pentax Corporation, Lincoln Park, NJ, USA) was used. For surface EMG recording, a high filter pass was calculated as 20 Hz, a low filter pass was calculated

as 2 kHz, and the received signal was amplified 200 times. The signal transition range was set to 20 mV (12).

All EMG evaluation of suprahyoid muscles were performed by the principal investigator of the study in Hacettepe University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation.

Evaluation of Maximum Isometric Suprahyoid Muscle Activity

Surface EMG evaluation was performed to determine the electrical activity of the suprahyoid muscles during maximal voluntary isometric contraction by following the procedures mentioned above. A semirigid neck orthosis was used to allow movements of the mandible. Participants were asked to push their jaws towards the cervical neck orthosis for maximum of 10 seconds (Figure 1) (13,14). This task was repeated three times with 60 seconds of intervals between contractions. The maximum electrical muscle activity (mV) values were recorded.

Figure 1: Evaluation of Maximum Isometric Suprahyoid Muscle Activity.

Suprahyoid Muscle Activity Evaluation During Exercises

For CTAR Exercise Group, participants were asked to push the ball between the jaw and the sternum for 10 sec during the surface EMG measurement (Figure 2). In Shaker Exercise Group, the participants were asked to lift their head slightly to look at the foot tips while lying on his back for 10 sec (Figure 3). For Chin Tuck Exercise with Theraband Group, the participants were asked to sit in a vertical position in the chair while a blue colored theraband was fastened to the back of their head. The resistance of therabands varies according to their color. The theraband has eight resistance levels and, blue theraband is in the 5th place. The reason we chose the blue bands of moderate resistance was not to give excessive resistance to the participants and to prevent them from being too hard and injured (15). They were asked to bring their jaw closer to their sternum against the resistance of the theraband passed through their foreheads for 10 sec (Figure 4). All tasks were repeated three times with 60 sec of rest intervals between contractions. The maximum electrical muscle activity (mV) values were recorded (5,16,17).

Figure 2: Chin Tuck Against Resistance Exercise (CTAR).

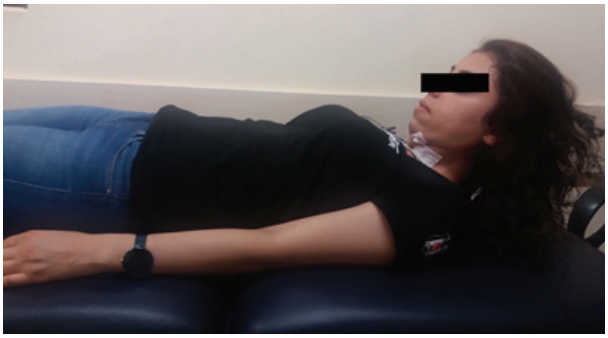

Figure 3: Shaker Exercise.

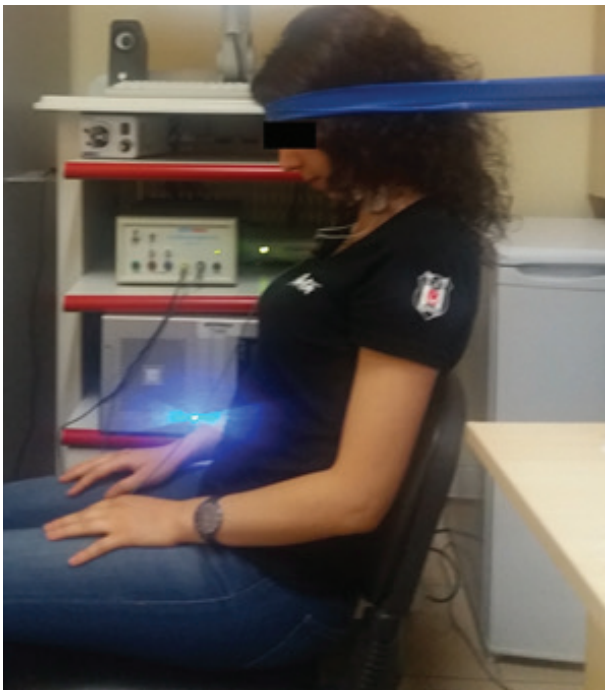

Figure 4: Chin Tuck Exercise with Theraband.

Normalization Procedure

Normalized suprahyoid muscle activations were calculated as the recorded maximum electrical activity during exercise (mV)/recorded maximum electrical activation during maximum isometric contraction (mV). This normalization process was performed to determine what percentage of the maximal suprahyoid muscle activations the exercises were activating. The results were recorded as a percentage (18,19).

Statistical Analysis

The statistical data of the study were analyzed SPSS 18.0 software package (SPSS Inc., Chicago, IL, USA). For the power of the study is at 80%, type 1 error at 5%, it was necessary to include 14 participants for each group. The Kruskal Wallis test was used to determine the difference between normalized muscle activations of the three groups participating in the study. Bonferroni correction was performed to determine which groups the statistical difference between all groups originated. A p-value of less than 0.05 was considered to be statistically significant.

RESULTS

Forty-two healthy subjects, including 14 participants from each group, were included in the study. The demographic data of the subjects are shown in Table 1. There was no statistical difference between groups in terms of age, height and body weight ($p>0.05$).

A statistically significant difference was found between the three groups in terms of normalized suprahyoid muscle activities ($p<0.05$, Table 2). It was found that the difference among three groups was caused by the differences between CTAR and Shaker ($p<0.001$) and between CTAR and Chin Tuck exercise with theraband in favor of CTAR ($p=0.040$). No statistically significant difference was found between Shaker and Chin Tuck exercise with theraband ($p=0.107$).

DISCUSSION

The CTAR exercise was found to be more effective on suprahyoid muscle activity than both Shaker and Chin Tuck exercise with theraband. Although there was no statistically significant difference between the Chin Tuck exercise with theraband and Shaker exercise, there was a clinically significant difference in favor of the theraband group.

Previous studies primarily focused on the participants' electrical suprahyoid muscle activation (7,20). It can be misleading to interpret the results according to electrical muscle activation because the same exercise modality can cause different degrees of muscle activation in different people. Therefore, we used the maximum activation potential of a muscle as percentages instead of electrical muscle activation. The normalized suprahyoid muscle activity of CTAR exercise was higher than Shaker exercise and chin tuck exercise with theraband. Although no statistical difference

Table 1: Characteristics of the Participants.

Variable	CTAR (n=14)	Shaker (n=14)	Theraband (n=14)	p
	Mean±SD	Mean±SD	Mean±SD	
Age (years)	28.75±5.17	26.72±3.95	28.25±5.78	0.678
Height (cm)	168.69±7.26	169.18±10.12	171.16±6.46	0.115
Weight (kg)	64.07±16.07	62.81±14.62	74.75±16.09	0.572

was found in the normalized suprahyoid muscle activations between Shaker exercise and chin tuck exercise with theraband, the normalized suprahyoid muscle activity of chin tuck exercise with theraband was higher than Shaker exercise which was clinically significant.

Studies on the therapeutic effects of exercises to increase suprahyoid muscle activity are very limited. In one of these studies, Gao and Zhang (21) showed that CTAR exercise is more effective in protecting the airway than Shaker exercise on patients who have/had a cerebral infarction. Similarly to our study results, previous studies reported that CTAR exercises activate suprahyoid muscles more than Shaker exercise (7,20,21). The possible reasons regarding this difference were reported that Shaker exercise is not specific to the suprahyoid muscles, and activates the superficial neck flexor muscles such as the anterior scalene and sternocleidomastoideus (7) primarily. Sze and colleagues (20) reported that Shaker exercise produces more muscular fatigue, especially on sternocleidomastoideus than CTAR exercise. Another possible reason for this difference may be this muscular fatigue.

The Shaker exercise involves raising the head against gravity in the prone position. This positional difference causes various biomechanical adjustments. In order to active deeper anterior neck muscles, such as deep cervical flexors (longus capitis and longus colli) and suprahyoid muscles, the movement should occur between the Occiput-C1-C2 segments. While this movement is called craniocervical flexion, the movements occur, and lower cervical segment, performed by sternocleidomastoideus and anterior scalene muscles are called cervical flexion (22,23). While, in Shaker exercise lifting head and looking at the toe tip have cervical flexion movement features, CTAR exercise and chin tuck exercise with theraband have craniocervical flexion features more. Less activation of Shaker exercise on suprahyoid muscles than activations of chin tuck exercise with theraband and CTAR exercise may be associated with these biomechanical differences. In addition, superficial cervical flexor muscles, which are stronger than deep cervical muscles, may be overactive to lifting the weight of the head. If an adult human head is thought to be 4-6 kg, this overactivation seems more likely. In this case, it may have caused less activation of the suprahyoid muscles that are located behind sternocleidomastoideus and anterior scalene muscles.

CTAR exercise has activated the suprahyoid muscles more than chin tuck exercise with theraband. One of the possible causes of this difference between these exercises, which have similar biomechanical features may be the direct contact of the ball with the suprahyoid muscles in CTAR exercise. This contact may provide proprioceptive input

Table 2: Comparison of Normalized Suprahyoid Muscle Activation among the Groups.

Normalized Suprahyoid Muscle Activation (%)	Mean±SD	Median (25-75% IQR)	p
CTAR	0.79±0.38	0.74 (0.44-0.89)	**<0.001***
Shaker	0.30±0.11	0.33 (0.21-0.40)	
Theraband	0.47±0.28	0.48 (0.38-0.53)	

*p<0.05, Kruskal Wallis Test. CTAR: Resistance chin tuck (CTAR) exercise.

and biofeedback. In some surface EMG studies, proprioceptive input and biofeedback increase muscle activation have been reported (24,25). However, in order to be performed CTAR exercise, a sufficient upper extremity function is needed to keep the ball under the jaw. Therefore, we believe that individuals with poor upper extremity function may prefer chin tuck exercise with theraband. In addition, in chin tuck exercise with theraband, the strength of the exercise can be increased by increasing the resistance of the band. In CTAR exercise, the ball is fixed between the jaw and the manubrium sterni, so some difficulties can be encountered when performing an exercise in patients with tracheostomy. We thought that this is one of the disadvantages of the CTAR exercise.

Although there was no statistically significant difference between Chin Tuck exercise with theraband and Shaker exercise, we believed that the 17% normalized muscle activation difference was clinically valuable. This difference was calculated as normalized suprahyoid muscle activations of theraband Group-normalized suprahyoid muscle activations of Shaker group. In addition, chin tuck exercise with theraband is more comfortable than Shaker exercise positionally, and chin tuck exercise with theraband can be preferred as the second choice for increasing suprahyoid muscle activity.

One of the limitations of the study was not performed to participant any fatigue questionnaire about exercises. Furthermore, we could not evaluate the activation of sternocleidomastoid muscle during EMG measurements due to technical requirements.

In conclusion, these study results suggest that CTAR exercise should be included in rehabilitation as a primary in order to increase the suprahyoid muscle activation. In inadequate upper extremity functioning individuals and patients with tracheostomy, we believe that chin tuck exercise with theraband can be considered as an alternative exercise to CTAR exercise.

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Conflict of Interest: The authors have no conflicts of interest to disclose.

Ethical Approval: The ethical approval of this study has been obtained with the approval number of KA-180002 from the Hacettepe University Ethics Committee of Clinical Research, Date: 18.05.2018

Informed Consent: A written informed consent was obtained from each subject.

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