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Suprahyoid Muscle Activation During Isometric Chin-Tuck Exercises in Different Body Positions

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ABSTRACT

Objective: The aim of the current study was to investigate the suprahyoid muscle activation during isometric chin-tuck exercises in different body positions.

Methods: Thirty-two healthy volunteers were enrolled. Suprahyoid muscle activation was recorded with surface EMG sensors placed under the chin. Isometric Shaker Exercise (SE) and isometric chin-tuck exercises were performed in five different body positions for 3 repetitions. Maximum voluntary isometric contraction (MVC) of the suprahyoid muscles was recorded. The normalization procedure was applied by proportioning the maximum suprahyoid muscle activation recorded during each exercise to the MVC, and recorded as a percentage (MVC%).

Results: Significantly higher suprahyoid muscle activation was detected during isometric SE compared to isometric chin-tuck exercises in supine and prone press up on elbows positions ($p < .008$). Suprahyoid muscle activation was found to be similar during isometric SE and isometric chin-tuck exercises in sitting, quadruped and prone positions ($p > .008$).

Conclusions: In conclusion, similar suprahyoid muscle activation was obtained during isometric chin-tuck exercises in sitting, quadruped and prone positions as during isometric SE. Thus, isometric chin-tuck exercises in these positions could be used as an alternative option to increase suprahyoid muscle activation with the possible potential for less fatigue and better patient compliance during dysphagia management.

Keywords: Deglutition, deglutition disorders, suprahyoid muscles, electromyography, exercise

1. INTRODUCTION

Exercise-based approaches have an important place in dysphagia management and are used to improve the functions of deglutitive muscles to maintain airway protection. The most critical parameters for airway protection are hyolaryngeal excursion and the opening of the upper esophageal sphincter (UES), facilitated by the suprahyoid muscles (1,2).

The Shaker exercise (SE) is the first defined, widely used and extensively studied exercise that focuses on the involvement of the suprahyoid muscles and includes both isometric and isotonic head lifts (3). The isotonic part of the SE involves raising the head high and forward for 30 consecutive repetitions in the supine position. The isometric portion is performed by raising the head up and forward for one minute in the supine position, which can cause muscle fatigue and affect patient compliance (4,5). To minimize these effects, the Chin Tuck Against Resistance (CTAR) exercise was developed as a less strenuous exercise to train the suprahyoid muscles. The rationale for using the chin-tuck movement as a swallowing exercise is that both head flexion and neck flexion activate suprahyoid muscle contractions (6). During the CTAR exercise, resistance is achieved through the compression of an inflatable rubber ball placed between the patient's chin and the manubrium sterni in the sitting position. The primary limitation of the CTAR exercise is the inability to control the intensity of the resistance (7).

Looking at the literature on exercise-based dysphagia management, no standard progression procedure has been established (8). However, further improvement requires a systematic increase in the load via changing such variables as volume, intensity, number of repetitions, repetition speed and rest periods. It is important to adjust these variables according to patients' needs (9). As mentioned above, the inability to control the intensity of resistance during CTAR could be a limitation for the progression of the exercise (7). It is worth nothing that one of the alterations to adjust the

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workload is adjusting body position during the exercise. Since the chin-tuck movement can be performed in several positions besides the sitting position, including the supine, prone, prone pressing up on elbows, and quadruped positions, we believe that isometric chin-tuck exercises in different body positions can be used as alternative exercises for dysphagia management.

There is no extant study evaluating the suprahyoid muscle activation during isometric chin-tuck exercises performed in different body positions. Determining the instantaneous suprahyoid muscle activation during the performance of chin-tuck exercise in different body positions will guide the creation of new exercise protocols to be used in dysphagia rehabilitation and could guide the exercise progression procedure. Therefore, the purpose of this study is to compare suprahyoid muscle activation during isometric chin-tuck exercises in different body positions with isometric SE.

2. METHODS

This is a cross-sectional study, which was performed at the Faculty of Physical Therapy and Rehabilitation of a university hospital. The ethical permission was received from the Non-interventional Clinical Researches Ethics Board of the university (Approval number=GO22/534, Approval Date= 31 May 2022).

2.1. Participants

Thirty-two healthy volunteers were included in the study. The inclusion criteria were as follows,

(i) Aged between 18 to 40 years,

(ii) Having a score of less than 3 on the Turkish version of the Eating Assessment Tool (T-EAT-10),

(iii) Not having any disease that could affect swallowing function,

(iv) Not having any pathology such as disc herniation or neck pain in the cervical region,

(v) Not having any temporomandibular joint problem that could affect joint biomechanics and muscle function. Written informed consent forms were signed by the participants prior to recruitment.

2.2. Evaluations

Descriptive information including age (year), gender, height (cm), weight (kg) and education level was recorded. The T-EAT-10, which measures the severity of dysphagia symptoms, was used to identify participants. It has 10 questions which are scored from 0 (no problem) to 4 (severe problem). The total score ranges from 0 to 40, with a score below 3 indicating normal swallowing function (10). Therefore, participants with a score of less than 3 on the T-EAT were included in the study.

Evaluations were performed in a quiet room at normal room temperature. Suprahyoid muscle activation was measured using the Trigno Wireless Biofeedback System (Delsys Inc., Natick, MA, USA). Prior to evaluation, the skin was cleaned with an alcohol wipe. After allowing the skin to dry for 30 seconds, two Delsys Trigno Duo dual-channel wireless superficial sensors integrated into this software were placed under the chin over the mylohyoid, geniohyoid and anterior digastric muscle complexes on either side of the midline with a distance of 1 cm between the sensors. The dual-channel Delsys Trigno Duo sensors were fixed with adhesive tape to prevent artifacts during recording. Voluntary muscle activation was measured and recorded in microvolts (mV). Surface electromyography (sEMG) signals were digitally recorded at 1500 Hz. The data were analyzed using the analysis program called Delsys EMG-Works analysis software. In the analysis, a bandpass filter was applied to the sEMG signals (high filter pass 10 Hz, low filter pass 500 Hz), with a notch filter will be applied at 60 Hz. sEMG values were presented in the microvolt root mean square (RMS) (11).

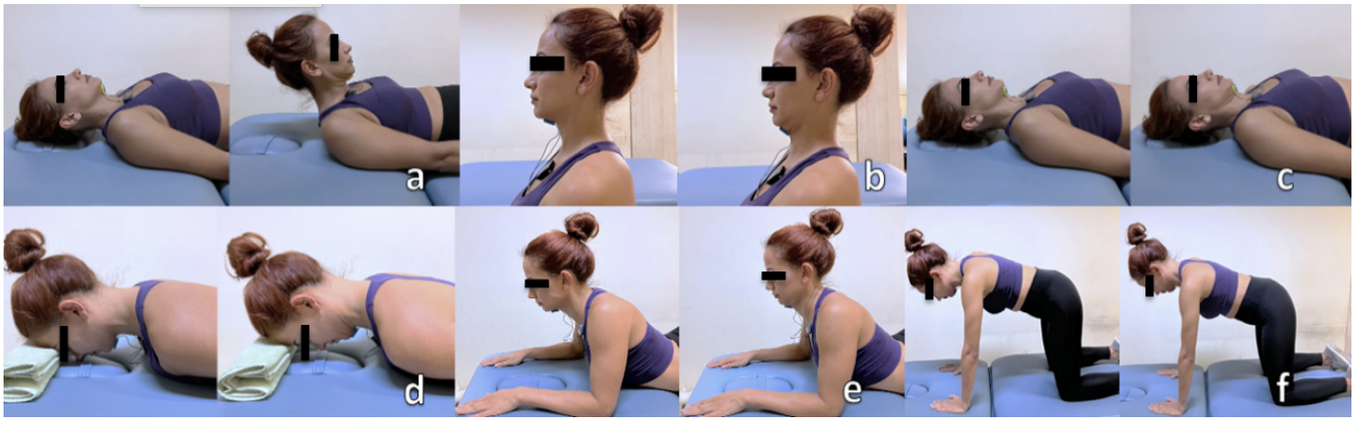

Figure 1. *Suprahyoid muscle activation measurements during isometric Shaker exercise and isometric chin-tuck exercises in sitting, supine, prone, prone press up on elbows and quadruped positions*

Jaw opening was used to measure the maximum voluntary isometric contraction (MVC) of the suprahyoid muscles. All participants were seated in an upright position in a chair during the MVC assessment. A semirigid cervical neck orthosis allowing only jaw opening was used, as described by Kılınç et al. (12). Participants were asked to open their mouth as wide as possible against the orthosis for a period of 10 seconds. Three repetitions were performed with a 1 minute rest period to eliminate fatigue. The maximum electrical muscle activity obtained during each measurement was recorded, and the highest value obtained from the measurements was used for statistical analysis.

Five minutes after the MVC assessment, suprahyoid muscle activations were evaluated during isometric SE and isometric chin-tuck exercises in the sitting, supine, prone, prone press up on elbows and quadruped positions. To control for order effects, the sEMG measurements during different positions were performed in a randomized order by using a random number generator. For isometric SE, the participants were asked to lift their head high and forward enough to see their own feet without lifting their shoulders for 10 seconds in the supine position during suprahyoid muscle activation recordings (Figure 1a). This was repeated for 3 times with a 1 minute rest break. Each participant was asked to perform an isometric chin-tuck exercise for 10 seconds for 3 times with a 1 minute rest break in the sitting (Figure 1b), supine (Figure 1c), prone (Figure 1d), prone press up on elbows (Figure 1e) and quadruped (Figure 1f) positions during suprahyoid muscle activation recordings. There was a 5 minute rest period between each position to eliminate fatigue. The maximum electrical activities obtained in each measurement were recorded in mV, and the highest value was used for statistical analysis.

For the normalization procedure, the calculation including the recorded maximum electrical activity during each movement / MVC of the suprahyoid muscles was used. The results were recorded as a percentage (MVC%).

2.3. Statistical Analysis

Statistical power analysis was performed by using G*Power version 3.1. A total of 32 participants gives an effect size of 0.5, a type I error margin of 5%, and 81% statistical power conditions to detect the significant changes between six different exercises as statistically significant.

The IBM-SPSS for Windows version 20 (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Descriptive statistics were calculated as a number/percent for qualitative data and mean, standard deviation for quantitative data. Normality tests were performed using the visual (histograms, probability plots) and analytical (Kolmogorov-Simirnov/Shapiro-Wilk's test) methods.

The Friedman test was conducted to test whether there was a significant change between exercises. If there was a significant difference, pairwise comparisons were conducted using the Bonferroni adjusted Wilcoxon test. A p-value of less than .008 was considered to show a statistically significant result.

3. RESULTS

A total of 32 participants were included in the study, of whom 87.5% (n=28) were female. The mean age, height and weight were 22.80±3.16 (min=19, max=33) years, 165.59±6.28 (min=155, max=182) cm and 62.40±12.33 (min=42, max=108) kg, respectively. A percentage of 84.4 (n=27) had a bachelor's degree and 18.6% (n=5) had a postgraduate degree.

Mean suprahyoid muscle activations during isometric SE and isometric chin-tuck exercises in the sitting, supine, prone, prone press up on elbows and quadruped positions are presented in Table 1.

Table 1. *The mean suprahyoid muscle activation (MVC%) during isometric Shaker exercise and isometric chin-tuck in sitting, supine, prone, prone press up on elbows and quadruped positions*

	Suprahyoid MVC%	
	X (SD)	Min-Max
Isometric Shaker exercise	29.94 (18.20)	4.84-82.23
Isometric chin-tuck in sitting	21.27 (19.07)	3.95-81.57
Isometric chin-tuck in supine	20.48 (14.58)	5.19-56.22
Isometric chin-tuck in prone	24.60 (18.56)	6.78-87.11
Isometric chin-tuck in prone press up on elbows	18.96 (12.38)	5.63-60.83
Isometric chin-tuck in quadruped	23.44 (12.78)	7.41-53.59

Isometric SE caused significantly higher suprahyoid muscle activation than isometric chin-tuck exercise in prone press up on elbows and supine positions (p< .008). Suprahyoid muscle activation was similar for isometric SE and isometric chin-tuck exercise in the sitting, prone and quadruped positions (p> .008) (Table 2).

Table 2. *Comparison mean activation (%MVC) of isometric Shaker exercise and isometric chin-tuck in sitting, supine, prone, prone press up on elbows and quadruped positions*

	iSE-Csitting	iSE-Csupine	iSE-Cprone	iSE-Cquadruped	iSE-Celbows	Csitting-Csupine	Csitting-Cprone	Csitting-Cquadruped	Csitting-Celbows	Csupine-Cprone	Csupine-Cquadruped	Csupine-Celbows	Cprone-Cquadruped	Cprone-Celbows	Cquadruped-Celbows
p	.018	.005*	.161	.043	.003*	.911	.278	.217	.400	.104	.308	.940	.852	.070	.003*

Abbreviations: isometric Shaker: iSE, isometric chin-tuck in sitting: Csitting, isometric chin-tuck in supine: Csupine, isometric chin-tuck in prone: C-prone, isometric chin-tuck in quadruped: Cquadruped, isometric chin-tuck in prone press up on elbows: Celbows
**p< .008 (Bonferroni's correction for multiple comparisons)*

4. DISCUSSION

This study was performed to determine the suprahyoid muscle activation during isometric chin-tuck exercises in different body positions by comparing the isometric SE. Suprahyoid muscle activation was found to be similar for isometric SE and isometric chin-tuck exercise in the sitting, prone and quadruped positions, whereas isometric SE produced significantly higher suprahyoid muscle activation than isometric chin-tuck exercise in the prone press up on elbows and supine positions.

The isometric part of the SE has been reported to be more challenging than the isotonic part, and the supine position is not always well tolerated (5,13,14). Thus, it is clinically important to develop new therapeutic exercises that specifically compensate for the limitations of the isometric part of the SE. As an alternative option to the isometric part of SE, we thought that the chin-tuck exercise could be used as a swallowing exercise to activate suprahyoid muscle contractions. In addition, to achieve improvements in exercise training, it is necessary to systematically increase the load by varying variables such as volume, intensity, number of repetitions, repetition speed and rest periods according to the patients' needs (9). The CTAR exercise, which was developed as an alternative to the SE, also has shortcomings in this respect. The inability to control the intensity of the resistance during the exercise and its use in a seated position can limit the progress of the exercise. (6, 7, 15, 16). It is worth noting that one of the changes that can be made to adjust the workload is to adjust the position of the body during the exercise. In physical therapy for neck and shoulder problems, chin-tuck exercises could be performed in different body positions (17-19). Therefore, the effect of chin-tuck exercise on suprahyoid muscle activation in different body positions could be investigated to provide new exercise options for clinical practice. In this study, it was aimed to compare isometric SE with isometric chin-tuck exercises in different body positions in terms of the suprahyoid muscle activation. According to the results of the current study, the isometric chin-tuck exercises in the sitting, prone and quadruped positions were found to be as effective as the isometric SE in increasing the suprahyoid muscle activation. Thus, isometric chin-tuck exercises in sitting, prone and quadruped positions could be used as alternative exercises to isometric SE. While the chin-tuck movement in the prone and quadruped positions is performed in the horizontal plane, the movement in the sitting position is performed in the sagittal plane. Thus, the possible reasons for activation of the suprahyoid muscles in these positions may be different, as they involve the realization of movement in different planes. Sitting position during isometric chin-tuck exercises may not require an effort against gravity, but the similar activation to SE may be due to the fact that people can focus more easily on the submental area, and their orientation is easier in this position due to the wider field of vision. Therefore, more loading to the suprahyoid muscles can be provided voluntarily in sitting position. The possible reason for maintaining similar suprahyoid muscle activation during isometric chin-tuck exercises in the quadruped and prone positions may be related to (i) gravity and (ii) the extra effort required to perform the isometric chin-tuck exercise while trying to maintain the body in the quadruped and prone positions.

In this study, it was detected that performing isometric chin-tuck exercise in the supine and prone press up on elbows positions resulted in less suprahyoid muscle activation compared to isometric SE. In a study evaluating suprahyoid muscle activations during water swallowing in terms of study design, it was reported that chin tuck movement in the supine position caused less electrical activation in the suprahyoid muscles compared to the neutral position (20). Supine position may provide a more stable position that may cause less electrical activation of the suprahyoid muscles during the same movement. However, there is no study evaluating chin-tuck exercise in the prone press up on elbows in terms of swallowing related muscles. We thought that the elbow support may have resulted in the exercise being performed with less activation by providing comfort against gravity and body weight. These findings are also important for clinical practice. The literature underscores the importance of a structured and gradually progressive exercise program to enhance exercise compliance and effectiveness (4). Therefore, especially for individuals who could not successfully perform isometric head lift in the supine position, the rehabilitation program could be started with chin-tuck exercises in these positions.

There are also some limitations in this study. Fatigue and/or compliance of participants could be questioned for each exercise for comparison, however these were not evaluated. These parameters are very important for clinicians for attainment of the exercise goals (5,13). Future studies could be design to investigate fatigue and/or exercise compliance during isometric chin-tuck in various positions. In addition, the long-term effects of isometric chin-tuck exercises in different positions could also be investigated to increase our understanding of their impact on swallowing function before replication of these studies with older adults and patients with dysphagia.

5. CONCLUSION

In conclusion, isometric chin-tuck exercises in sitting, quadruped and prone positions provide suprahyoid muscle activation similar to that of isometric SE. Therefore, isometric chin-tuck exercises in these positions could serve as alternative options to target suprahyoid muscles with the potential for less fatigue and greater patient compliance during dysphagia management.

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Acquisition of data for the study: RA, EC
Analysis of data for the study: SSA, RA, EC
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REFERENCES

[1] Molfenter SM, Steele CM. Physiological variability in the deglutition literature: Hyoid and laryngeal kinematics. Dysphagia 2011;26(1):67-74. DOI:10.1007/s00455.010.9309-x.

[2] Krekeler BN, Rowe LM, Connor NP. Dose in exercise-based dysphagia therapies: A scoping review. Dysphagia 2021;36(1):1-32. DOI:10.1007/s00455.020.10104-3.

[3] Shaker R, Kern M, Bardan E, Taylor A, Stewart ET, Hoffmann RG, Arndorfer RC, Hofmann C, Bonnevier J. Augmentation of deglutitive upper esophageal sphincter opening in the elderly by exercise. Am J Physiol. 1997;272(6):1518-1522. DOI:10.1152/ajpgi.1997.272.6.G1518.

[4] Easterling C, Grande B, Kern M, Sears K, Shaker R. Attaining and maintaining isometric and isokinetic goals of the Shaker exercise. Dysphagia 2005;20(2):133-138. DOI:10.1007/s00455.005.0004-2.

[5] White KT, Easterling C, Roberts N, Wertsch J, Shaker R. Fatigue analysis before and after shaker exercise: physiologic tool for exercise design. Dysphagia 2008;23(4):385-391. DOI:10.1007/s00455.008.9155-2.

[6] Yoon WL, Khoo JK, Rickard Liow SJ. Chin tuck against resistance (CTAR): New method for enhancing suprahyoid muscle activity using a Shaker-type exercise. Dysphagia 2014;29(2):243-248. DOI:10.1007/s00455.013.9502-9.

[7] Park JS, Lee G, Jung YJ. Effects of game-based chin tuck against resistance exercise vs head-lift exercise in patients with dysphagia after stroke: An assessor-blind, randomized controlled trial. J Rehabil Med. 2019;51(10):749-754. DOI:10.2340/16501.977.2603.

[8] Félix-Lusterman CC, Joseph ME, Daniels SK. Update on exercise-based rehabilitation approaches for neurogenic dysphagia. Curr Phys Med Rehabil Rep. 2021;9(4):252-266. DOI:10.1007/s40141.021.00333-4.

[9] American College of Sports Medicine. American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. Med Sci Sports Exerc. 2009;41(3):687-708. DOI:10.1249/MSS.0b013e318.191.5670.

[10] Demir N, Serel Arslan S, Inal O, Karaduman AA. Reliability and validity of the Turkish Eating Assessment Tool (T-EAT-10). Dysphagia 2016;31(5):644-649. DOI:10.1007/s00455.016.9723-9.

[11] Park JS, Jung YJ, Kim HH, Lee G. A novel method using kinesiology taping for the activation of suprahyoid muscles in healthy adults: A preliminary research. Dysphagia 2020;35(4):636-642. DOI:10.1007/s00455.019.10071-4.

[12] Kılınç HE, Arslan SS, Demir N, Karaduman A. The effects of different exercise trainings on suprahyoid muscle activation, tongue pressure force and dysphagia limit in healthy subjects. Dysphagia 2020;35(4):717-724. DOI:10.1007/s00455.019.10079-w.

[13] Ferdjallah M, Wertsch J, Shaker R. Spectral analysis of surface EMG of upper esophageal sphincter opening muscles during head lift exercise. JRRD. 2000;37(3):335-340.

[14] Alfonso M, Ferdjallah M, Shaker R, Wertsch JJ. Electrophysiologic validation of deglutitive UES opening head lift exercise. Gastroenterology 1998;114(4):711. DOI:10.1016/S0016-5085(98)82919-3.

[15] Moon JH, Jung JH, Hahm SC, Jung KS, Suh HR, Cho HY. Effects of chin tuck exercise using neckline slimmer device on suprahyoid and sternocleidomastoid muscle activation in healthy adults. J Phys Ther Sci. 2018;30(3):454-456. DOI:10.1589/jpts.30.454.

[16] Kılınç HE, Yaşaroğlu ÖF, Serel Arslan S, Demir N, Topçuoglu MA, Karaduman A. Comparison of muscle activation effects of three different exercises on suprahyoid muscles in healthy subjects. Turk J Physiother Rehabil. 2019;30(1):48–57. DOI:10.21653/tfrd.450812.

[17] Ahn SH, Yang JH, Lee SK, Park JS. Effect of chin tuck exercises on various postures and muscle activity of the neck and shoulder. PNF and Movement. 2020;18(3):403-414. DOI:10.21598/JKPNFA.2020.18.3.403.

[18] Beneka A, Malliou P, Gioftsidou A. Neck pain and office workers: An exercise program for the workplace. ACSM's Health & Fitness. 2014;18(3):18-24. DOI:10.1249/FIT.000.000.0000000034.

[19] Jeon J, Ju S, Jeong H. The effect of cervical stabilizing exercises in the standing position and the supine position on deep neck muscle strength and endurance. J Phys Ther Sci. 2012;24(5):423-425. DOI:10.1589/jpts.24.423.

[20] Woo HS, Park SH, Jung MY, Yoo EY, Park JH. The effects of cranio-cervical flexion on activation of swallowing-related muscles. J Oral Rehabil. 2012;39(11):805–811. DOI:10.1111/j.1365-2842.2012.02338.x.

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