Comparison of Two Tongue Strengthening Exercises on Increasing Tongue Mobility in Healthy Young Adults: A Randomized Controlled Trial Study

Janistar Lekvichittada and Boosana Kaboosaya*

Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Chulalongkorn University, Bangkok, Thailand
*Corresponding author, E-mail: Boosana.K@chula.ac.th

Abstract

Tongue strengthening exercise (TSE) is a program to re-educate the neuromuscular pattern of the tongue muscle to improve tongue posture and swallowing function. Various TSEs have been introduced. However, most studies have been conducted on TSEs focusing on tongue strength and endurance. Only a few have focused on tongue mobility, which has yet to show which method is the best for improving tongue mobility. The prospective randomized controlled trial study aimed to investigate tongue-strengthening exercise methods that had the greatest impact on increasing tongue mobility. Thirty healthy subjects were randomly divided into 3 groups, including the control (no exercise), tongue-click and tongue-wrap groups. All subjects completed the exercise 3 times per day, every day for 4 weeks. Tongue mobility was measured in all subjects before and after the TSE using tongue range of motion deficit (TRMD). TRMD was calculated as a difference between maximal interincisal mouth opening (MIO) and mouth opening with tongue tip to maxillary incisive papillae (MOTTIP). The lower value of TRMD meant a more tongue range of motion. After 4 weeks of tongue exercises, TRMD decreased in the tongue-wrap group (15.8±7.79) but remained almost the same in the tongue-click group (17.7±8.78). An increased value of TRMD was found in the control group (19.5±9.98) after 4 weeks. However, there was no statistically significant difference in TRMD before and after exercises in all groups at p-value < 0.05. Based on our study, tongue-wrap exercise may be the most significant impact on increasing tongue range of motion in healthy young adults.

Keywords: *Tongue Movement, Tongue Range of Motion Deficit, Tongue-Strengthening Exercise*

1. Introduction

The tongue is a dynamic organ composed of extrinsic and intrinsic muscle, which functions as a digestive organ by facilitating food movement during mastication and swallowing. The extrinsic muscles of the tongue control the tongue's position within the oropharyngeal cavity. The tongue generates pressure for forming food bolus during the mastication and transports the bolus through the oropharynx during swallowing. A decreased tongue mobility could be responsible for a decreased ability to manage a bolus and transport it through the upper digestive tract, leading to lower quality of life (Potter, Nievergelt & Vandam, (2019); Van der Steen et al., (2018).

There are numerous causes of limited tongue mobility, including ankyloglossia, hypoglossal nerve damage resulting in paralysis of the tongue, inadequate tongue space, sarcopenia, and dysphagia in the elderly (Zaghi et al., 2021). Since the elderly have much less tongue strength and endurance than younger people due to physiologic changes, resulting in diminished tongue mobility (Lee JH, 2016). Since physical exercise in adult can maintain quality of life and physical function in the elderly individuals due to sustaining activity and high level of cardiorespiratory fitness, starting exercise in early life can lead to a high quality of life in elderly (Langhammer, 2018). Tongue strengthening exercise (TSE) is a neuromuscular reeducation of the tongue muscle to enhance tongue posture and swallowing function (Bendgude et al., 2021). Moreover, TSE is a therapeutic exercise designed to increase tongue strength and range of motion (Van der steen et al., 2018).

The previously reviewed article summarizes the TSE exercises used to treat tongue mobility limitation (Bendgude et al., 2021). According to Hwang et al. (2019), the TSE group underwent 20 repetitions per day, 5 days per week, for 4 weeks, with the therapist attaching gauze to the patient's tongue and extending it as far as possible for 2-3 seconds before returning it to its normal position. Patients with dysphagia following a stroke who performed tongue-stretching exercises had considerably more tongue

mobility and oro-motor function than those who did not. A tongue-strengthening device that compresses an air bulb between the tongue and the hard palate is an efficient tool for raising maximum tongue pressure (Yano et al., (2019); Van der steen et al., (2018). The exercise promotes changes in muscle physiology, such as tongue strength and thickness, by stimulating the activation of motor units (Wheeler, Chiara & Sapienza, 2007). Inconveniently, patients must visit the dental clinic in order to utilize this instrument.

Various self-tongue strengthening exercises that patients can perform at home have been introduced lately to encourage them to perform anywhere conveniently due to no equipment needed. For instance, the tongue-hold maneuver, holding the tongue gently between the teeth and swallowing the saliva with the tongue in this position will increase the contraction of the superior pharyngeal constriction muscle and equip it to coordinate actions between the tongue and pharynx during swallowing dynamically (Hammer et al., 2014). Placing the tip of the tongue against the front of the palate and sliding the tongue backward or forcing the tongue to suck upward against the palate develops tongue repositioning (Jones, 2010).

Several techniques had been developed to evaluate tongue mobility, including Kotlow's free tongue movement, tongue range of motion deficit (TRMD), and tongue range of motion (ROM) scale. Kotlow's free tongue movement is one of the methods that has been widely used. However, a weakness of this method is that the tongue is difficult to control and stabilize during measurement (Yoon, 2017). Lazarus C (2014) introduced a lingual range of motion assessment called the tongue range of motion (ROM) scale. This scale represents lingual ROM on the protrusion, lateralization, and elevation to the upper alveolar ridge using the Therabite measuring disc as a measurement tool which allows patients and providers to measure the mouth and jaw's opening, movement, and function (Lazarus C et al., 2014). Nevertheless, this method's reference might not be reproducible. Marchesan (2005) has proposed the use of tongue range of motion deficit (TRMD) as one of the screening tools to assess tongue mobility. TRMD is calculated as a difference between maximal interincisal mouth opening (MIO) and mouth opening with tongue tip to maxillary incisive papillae (MOTTIP). Since this method has a stable reference point and can be reproducible, it was used frequently in the comparative study.

Nevertheless, previous studies have been conducted on tongue-strengthening exercises focusing on other tongue functions. Thus, there need to be more articles focused on tongue mobility. Also, previous studies have yet to show a definitive value for improved tongue mobility after tongue strengthening exercise as to which method is the best.

2. Objectives

This study aimed to investigate tongue-strengthening exercise methods that give the most impactful for increasing tongue mobility.

3. Materials and Methods

This prospective randomized controlled trial study recruited healthy young adult participants from March to July 2022 at the Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, Chulalongkorn University. This study received approval from the ethics committee of Chulalongkorn University (HREC-DCU2022-002).

Study inclusion criteria were the following:

1) Healthy (ASA I or II), aged 18 - 25 years
2) Individuals who can do tongue wrap
3) Individuals who understood Thai language by either reading or listening

Study exclusion criteria were the following:

1) Individuals who had a gag reflex
2) Individual who had limited tongue mobility such as ankyloglossia (free tongue < 16 mm. Measure from base of lingual frenum to the tip of the tongue with Vernier caliper)
3) Individuals who had difficulty in mouth opening such as temporomandibular joint disorder.
4) Individuals who had a history of orofacial myotherapy or tongue exercise, frenectomy, or tongue surgery

5) Individuals who presented with a facial deformity, connective tissue or muscular disorders

6) Individuals who had a history of craniofacial trauma or oral and maxillofacial surgery (except extraction or surgical removal of a wisdom tooth, or supernumerary tooth)

7) Individuals who presented with mental retardation or psychiatric problem - Individuals who present with hypoglossal nerve injury or neurologic impairment

8) Individuals who did not have teeth 11,41 or 21,31

3.1 Subjects

The subjects were 30 healthy young adults (9 males and 21 females) who gave their written, informed consent prior to the study. The demographic data (gender, age, weight, height) was recorded.

3.2 Method of measuring maximum tongue movement

Tongue mobility was measured in all subjects before the TSE using the tongue range of motion deficit (TRMD). TRMD calculated as a difference between maximal interincisal mouth opening (MIO) and mouth opening with tongue tip to maxillary incisive papillae (MOTTIP). For MIO measurements, patients were instructed to open their mouths. The measurement was obtained on the first mouth opening to avoid jaw protrusion or excessive translation at the temporomandibular joint. Patients were not encouraged to open their mouths as widely as possible. MIO measured the distance between the incisal edges of tooth 11 to tooth 41 or tooth 21 to tooth 31 (Figure 1a). MOTTIP measured the distance between the incisal edges of tooth 11 to tooth 41 or tooth 21 to tooth 31 when the participants opened their mouths and used the tongue to touch incisive papillae (Figure 1b).

Figure 1 a) Maximal interincisal mouth opening (MIO), b) Mouth opening with tongue tip to incisive papillae (MOTTIP).

3.3 Method of training intervention

All subjects were randomly assigned into 3 different groups using a random number table, including the control (no exercise), tongue click (TSE-C) (Figure 2), and tongue wrap (TSE-W) (Figure 3). Tongue mobility measurement was measured by recording the VDO while participants did MIO and MOTTIP. Then, the examiner replayed the recorded VDO to find the maximum MIO and MOTTIP. The examiner and the instructor were two different people to eliminate the bias. Before the participants started tongue strengthening exercises, they sat in an upright position. Participants were asked to perform TSE without other activities or distractions, such as turning off the television or talking with people during exercise. One instructor taught all the participants one-by-one and had them practice until they performed correctly. The participants received a checklist book containing TSE instruction and personal TSE record, as well as tongue exercises–animation to help them rememorize and practice at home. All TSE were performed daily three times a day, in the morning, noon and evening. After 1 month, each participant was re-measured and recorded tongue mobility to evaluate post-exercise outcomes by the same examiner.

Tongue click (TSE-C)

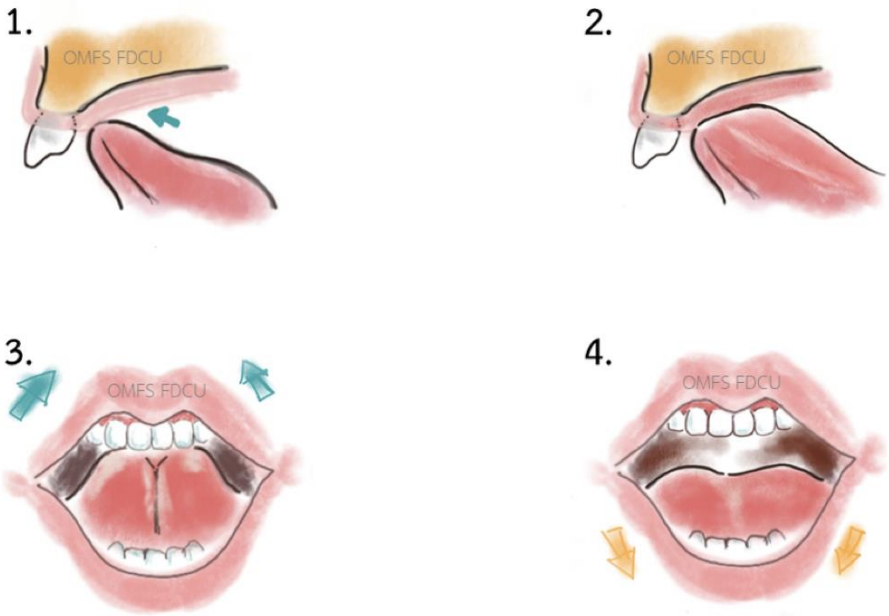

Figure 2 Demonstrated a tongue-click exercise. (2.1) Raise a tongue to touch the palate posterior to the upper anterior teeth. (2.2) Spread the tongue as close to the palate as possible. (2.3) Push the tongue to suck on the palate, similar to tapping the tongue. (2.4) Release the tongue to generate a clicking sound, then repeat step 1, 2, 3, and 4 for 5 times.

Tongue wrap (TSE-W)

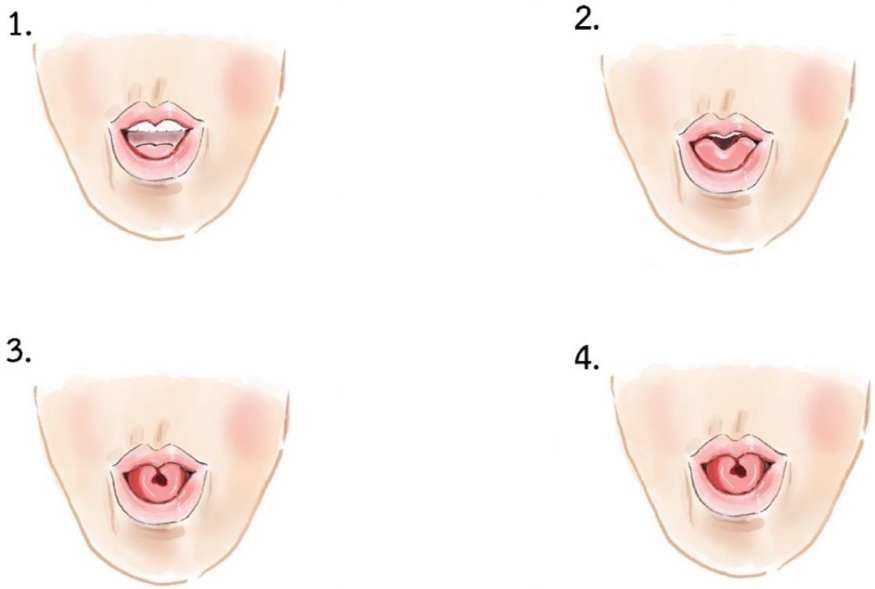

Figure 3 Demonstrated tongue-wrap exercise. (3.1) In a comfortable position, slightly open the mouth. (3.2) Folding the lateral side of the tongue gently. (3.3) Try to fold the tongue as much as possible (3.4) Holding the tongue for 5 seconds, then repeat step 1, 2 ,3, and 4 for 5 times.

3.4 Statistical analysis

The descriptive statistics consisted of frequencies and percentages. The normality of the data distribution was assessed by the Shapiro-Wilks test. Gender distribution among 3 groups was assessed by the Chi-square test. Comparison of BMI and age between 3 groups was assessed by the Kruskal Wallis test. Wilcoxon Sign Rank test was used to compare tongue mobility (TRMD) before and after receiving the treatment within each group. Kruskal Wallis test was used to compare the improvement of tongue mobility (TRMD) after the treatment between each group. All statistical analyses will be considered statistically significant at the P-value below 0.05, performed using the SPSS. program.

4. Results and Discussion

4.1 Results

All 30 subjects completed the experiments without dropping out. The general characteristics of all subjects were summarized in Table 1. The demographic data and inferential analysis revealed no significant differences in gender, BMI, pre-exercise TRMD (T1 TRMD), and post-exercise TRMD (T2 TRMD). However, there was a statistically significant difference in age between 3 groups.

Table 1 Patient characteristics of 3 different groups

	Control group (n = 10)	**TSE-C** (n = 10)	**TSE-W** (n = 10)	***p-value***
Age (years) (mean±SD)	22.1 ± 0.74	20.8 ± 0.79	22.3 ± 1.89	0.018*
Gender (n, %)				
Male	1 (11.1%)	4 (28.6%)	4 (28.6%)	0.24
Female	9 (42.9%)	6 (44.4%)	6 (44.4%)	
BMI (kg/m^2) (mean±SD)	21.35 ± 5.6	21.63 ±5.45	19.06 ± 1.8	0.188
T1 TRMD (mm) (mean±SD)	15.2 ± 8.52	17.5 ± 6.04	18.6 ± 9.49	0.678
T2 TRMD (mm) (mean±SD)	19.5 ± 9.98	17.7 ± 8.78	15.8 ± 7.79	0.549

kg/m^2 = kilogram per meter square, mm = millimeter

BMI = body mass index, T1 TRMD = Pre-exercise tongue range of motion deficit, T2 TRMD = Post-exercise tongue range of motion deficit

* significant at *p-value* < 0.05

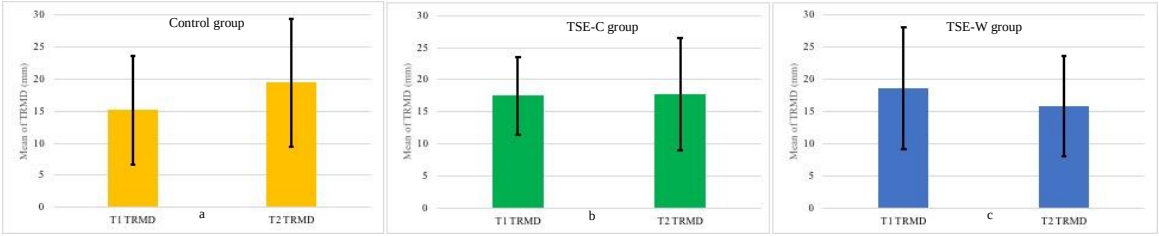

Figure 4. Comparison of TRMD before and after 4 weeks of TSE in 3 different groups; a. Control group, b. TSE-C group, c. TSE-W group (Wilcoxon Signed Ranks test, significant at *p-value* < 0.05)
TSE-C = tongue-click exercise, TSE-W = tongue-wrap exercise
T1 TRMD = Pre-exercise tongue range of motion deficit
T2 TRMD = Post-exercise tongue range of motion deficit

There was no significant difference in T1 TRMD among groups. After 4 weeks of TSE, T2 TRMD increased in the control and the TSE-C groups while decreasing in the TSE-W group. However, there is no statistically significant difference at *p-value* < 0.05. (Figure 4)

4.2 Discussion

This study developed tongue strengthening exercises, including tongue click and tongue wrap exercises, based on previous self-tongue strengthening exercises (Hammer et al., 2014), which mimic the function of intrinsic and extrinsic tongue muscles in tongue mobility. Tongue clicks exercises involve touching the palate behind the upper anterior teeth with the tongue, then spreading the tongue as close to the palate as possible, pressing the tongue to suck on the palate, and then releasing the tongue to produce a clicking sound, adapted from the study of Yano et al. (2019) which mimic the function of tongue muscle during food bolus formation. Tongue wrap exercise involves gently folding the tongue and holding it for 5 seconds which mimics the function of tongue muscle during speech, eating, and swallowing by using transverse muscle to change the shape of the tongue (Kayalioglu M, 2007).

The data showed that post-exercise TRMD decreased in the TSE-W group, while there were no changes in the TSE-C group and increased in control group. Although there is no significant difference among groups, this can be implied that TSE-W can increase tongue range of motion while TSE-C can maintain tongue range of motion. A lack of physical exercise can lead to loss of mobility as adult aging especially with adults with sedentary behaviour (McGowan et al., 2020). Exercise interventions can reduce the risk of developing mobility limitations and improve mobility-limited older adults' walking capacity (Brahms et al.,2021). Daily exercise was recommended in older adults to prevent joint stiffness which led to limit in body mobility. (Pahor M, Blair SN, Espeland M, 2006). These can also be implied to tongue muscle which if there is no exercise, tongue range of motion may decrease according to our study that TRMD was increased in control group. TSE may reduce muscular stiffness which cause muscle fiber shortening, resulting in increased muscle fiber length and improved tongue mobility (Phil P, 2012). Our study used a 4 week-exercise protocol that was used in previous studies (Lazarus C, 2003) because muscle fiber started to physiologically change in size and function (strength and endurance) after 4 weeks of resistance exercises in adults (Del Vecchio A, 2019). However, some studies used 6 to 8 week-exercise protocol (Schuler and Cosgrove, 2013).

Limitations of this study included the small sample size and no guarantee to reassure that patients can exercise properly. Further studies should increase the sample size and use interactive media to verify that the participants are able to do TSE correctly and completely at the specified time.

5. Conclusion

Based on our study, tongue-wrap exercise may increase tongue mobility in healthy young adults compared to tongue-click or no exercise.

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