Official Title : **Effect of Tongue-to-Palate Resistance Training on Penetration-Aspiration Scale and Suprahyoid Muscle Electrical Activity in Geriatric Patients with Oropharyngeal Dysphagia: A Randomized Control Trial**

Kuntjoro Harimurti[1], Melinda Harini[2], Bunga Saridewi Nurmansyah[2], I Wayan Murna Yonathan[3], Mohamad Yanuar Amal[3], Steven Setiono[2], Boya Nugraha[4]

[1] Department of Internal Medicine, Cipto Mangunkusumo Hospital, University of Indonesia, Jakarta, Indonesia

[2] Department of Physical Medicine and Rehabilitation, Cipto Mangunkusumo Hospital, University of Indonesia, Jakarta, Indonesia

[3] Department of Radiology, Cipto Mangunkusumo Hospital, University of Indonesia, Jakarta, Indonesia

[4] Department Rehabilitation Medicine, Hannover Medical School, Germany

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Abstract

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Background: Oropharyngeal dysphagia is a prevalent geriatric syndrome associated with malnutrition, aspiration, and increased morbidity. Tongue-to-palate resistance training (TPRT) has emerged as a simple, home-based exercise to strengthen swallowing-related musculature, yet evidence in older adults remains limited.

Objective: This study aimed to evaluate the effects of TPRT on suprahyoid muscle activity and swallowing safety, assessed by the Penetration-Aspiration Scale (PAS), in geriatric patients with oropharyngeal dysphagia.

Methods: A single-blind randomized controlled trial was conducted at Cipto Mangunkusumo Hospital, Jakarta, from July 2022 to June 2024. Twenty patients aged >60 years with videofluoroscopic-confirmed dysphagia were randomized into TPRT and control groups. The intervention group performed TPRT (30 repetitions, five sessions per week, for eight weeks), while controls received individualized dysphagia therapy (neuromuscular electrical stimulation, CTAR, or biofeedback). Suprahyoid muscle activity was measured using surface electromyography (sEMG) at baseline, week 4, and week 8; swallowing function was evaluated using PAS and videofluoroscopic parameters.

Results: Seventeen participants completed the study (intervention n=9, control n=8). Both groups demonstrated significant within-group increases in suprahyoid muscle activity over eight weeks ($p<0.001$), with larger effect sizes observed in the TPRT group, although between-group differences were not statistically significant. PAS scores improved in both groups [intervention: median 4→2; control: 4.5→2], without significant intergroup differences. Notably, anterior hyoid excursion significantly increased in the TPRT group ($p=0.038$).

Conclusion: TPRT enhanced suprahyoid muscle activity and anterior hyoid movement in older adults with oropharyngeal dysphagia, supporting its feasibility as a home-based intervention. Although no significant reduction in PAS was observed, TPRT shows promise as a safe, low-cost rehabilitation strategy warranting further investigation in larger, more homogenous cohorts.

Introduction

Oropharyngeal dysphagia is highly prevalent among older adults, affecting 30–40% of individuals over the age of 65 and over 60% of those in long-term care facilities.[1,2] This condition, characterized by impaired bolus formation and transit from the oral cavity to the esophagus, may lead to aspiration and choking[3,4], and has been classified as one of the geriatric giants by the European Union Geriatric Medicine Society (EUGMS) and the European Society for Swallowing Disorders (ESSD) due to its impact on nutritional status, functional decline, morbidity, and mortality.[4–6]

Age-related physiological changes, including reduced tongue strength, diminished laryngeal elevation, and weakened suprahyoid muscle activity, contribute to impaired swallowing efficiency.[7,8] Tongue strength is essential for effective bolus propulsion and generating adequate intraoral pressure, directly influencing the pharyngeal phase of swallowing.[9,10] Rehabilitation strategies, such as Shaker or CTAR (Chin Tuck Against Resistance) exercises and neuromuscular electrical stimulation (NMES), are frequently employed but may be unsuitable for frail elderly patients due to physical limitations or low adherence.[7,11]

Tongue-to-palate resistance training (TPRT), performed by pressing the tongue against the palate, offers a simple and feasible alternative that can be implemented as a home-based program.[11–13] TPRT has been shown to enhance both anterior and posterior tongue strength,[11] increase hyoid bone excursion,[11] and improve upper esophageal sphincter opening by activating the suprahyoid muscles.[11,14,15]

Several studies also report a correlation between tongue movement and suprahyoid muscle activation, with surface electromyography (sEMG) confirming greater suprahyoid activity during TPRT compared to Shaker exercises.[14,16–18]

The effects of tongue and suprahyoid muscle strengthening exercises are also supported by findings of increased geniohyoid muscle thickness from 2.3 to 2.6 cm^2 after eight weeks of training,[7] as well as increased thickness of the mylohyoid and digastric muscles following tongue-to-palate pressing exercises performed over six weeks.[9,19] A TPRT program consisting of 30 repetitions, five times per week for four weeks, also reduced PAS scores from 6 to 3.56 ($p < 0.000$).[20]

A preliminary study conducted at the Department of Physical Medicine and Rehabilitation, Cipto Mangunkusumo Hospital, showed an increase in suprahyoid muscle electrical activity from 8.56 ± 3.456 μV before TPRT to 15.26 ± 3.19 μV after one week of training, and further increased to 17.44 ± 3.922 μV after two weeks.[13] Since the strength of both the tongue and suprahyoid muscles can improve solely through tongue-strengthening exercises, TPRT has the potential to enhance swallowing function in both the oral and pharyngeal phases in patients with dysphagia, and may be suitable as a home-based training program. This study aims to evaluate the effect of tongue-to-palate resistance training in geriatric patients with oropharyngeal dysphagia over a longer observation period than typical hospital-based rehabilitation. The outcomes assessed include suprahyoid muscle electrical activity and the Penetration-Aspiration Scale (PAS) to determine the effectiveness of the training and the risk of aspiration.

Methods

Design, population, and setting

This study was an interventional, single-blind, randomized controlled trial (RCT) conducted at the Department of Medical Rehabilitation, Radiology Unit, and Integrated Geriatric Clinic of Dr. Cipto Mangunkusumo General Hospital, Jakarta, between July 2022 and June 2024.

Eligible participants were geriatric patients aged >60 years diagnosed with oropharyngeal dysphagia confirmed through videofluoroscopic swallowing study (VFSS). Inclusion criteria required that participants had not received swallowing training in the preceding two weeks, were cooperative, and had a caregiver available to support adherence to the intervention protocol. Baseline suprahyoid muscle electrical activity, measured by surface electromyography (sEMG), had to be ≤37.1 μV RMS. Exclusion criteria included significant cognitive impairment based on the MoCA-Ina test, history of radical neck dissection, malignancy of the oral cavity, recent head and neck chemoradiotherapy within three months, complete inability to move the tongue, baseline EMG = 0 μV, presence of a pacemaker, or known allergies to contrast agents or training materials.

All participants provided written informed consent prior to enrollment. Ethical approval was obtained from the Research Ethics Committee of the Faculty of Medicine, Universitas Indonesia/Dr. Cipto Mangunkusumo Hospital (No. KET-1415/UN2.F1/ETIK/PPM.00.02/2022)

Sample Size

The sample size was determined using a paired-mean difference calculation. For suprahyoid muscle electrical activity, the standard deviation of the mean difference was estimated at 3.68 with an expected mean difference of 4.0. Using a significance level of $\alpha = 0.05$ ($Z\alpha = 1.96$) and power of 80% ($Z\beta = 0.84$), the required minimum sample size was seven subjects.

For the Penetration-Aspiration Scale (PAS), the standard deviation of the mean difference was estimated at 1.03 with an expected mean difference of 1.0, yielding a minimum sample size of eight subjects under the same statistical assumptions. To ensure adequate power, the larger estimate of eight participants per group was selected.

Accounting for an anticipated 20% dropout or loss to follow-up, the final target sample size was set at 20 participants, with 10 allocated to each group.

Baseline measurement, randomization and intervention

Following consent and initial assessments, participants underwent baseline VFSS and suprahyoid sEMG evaluations. Block-permuted randomization with a block size of four was used to allocate subjects into intervention and control groups.

The intervention group received TPRT home exercises consisting of 30 repetitions per session, five sessions per week, over eight weeks with video guidance and support from caregiver. Participants were monitored via logbooks and follow-up calls.

The control group received individualized dysphagia therapy, which may have included neuromuscular electrical stimulation (NMES), biofeedback swallowing therapy, and home-based chin tuck against resistance (CTAR) exercises. NMES involved placing electrodes in the submental region. Both groups received education on safe swallowing techniques, posture, and bolus modification.

Follow-up and outcomes measurement

Suprahyoid sEMG was reassessed at weeks 4 and 8. VFSS parameters (PAS score, pharyngeal transit time, hyoid movement) were evaluated again at week 8. sEMG was recorded using surface electrodes placed in the submental area after skin preparation. Electrode placement was confirmed by asking participants to press their tongue against the palate and perform a dry swallow. Each test was performed three times, with at least 10 seconds of rest between trials to prevent fatigue.

The outcomes measured were suprahyoid muscle electrical activity and the Penetration-Aspiration Scale (PAS).

Blinding

Outcome assessors were blinded to group allocation. Suprahyoid muscle electrical activity (sEMG) was evaluated before and after the intervention by a rehabilitation medicine physician, while videofluoroscopic swallowing studies (VFSS) were conducted by a radiologist and a rehabilitation medicine specialist. All assessors were unaware of participants' treatment assignment.

To ensure comparability across groups, both the intervention and control groups also received standard education on posture adjustment, swallowing maneuvers, and bolus modification for safe swallowing.

Harms

Adverse events were systematically monitored throughout the study. Participants and caregivers were instructed to report any kejadian tidak diharapkan (adverse events) via telephone during scheduled follow-up logbook checks. This approach ensured continuous surveillance during both the home-based exercise program and the hospital-based assessments. No adverse events were reported in either the intervention or control groups, whether during the training sessions or during outcome evaluations such as suprahyoid sEMG recordings and videofluoroscopic swallowing studies (VFSS)*Statistical analysis*

Data were presented using narrative summaries and tabular formats. Statistical analysis was conducted using both descriptive and inferential approaches. The normality of EMG data was tested using the Shapiro–Wilk test. If data were not normally distributed, a log transformation was applied. Repeated measures ANOVA (General Linear Model approach) was used to assess time-related effects, with Mauchly's test of sphericity applied to test variance assumptions. If sphericity was violated, corrections (Greenhouse–Geisser or Huynh–Feldt) were applied. For other outcomes, paired t-tests or Wilcoxon signed-rank tests (for within-group comparisons) and independent t-tests or Mann–Whitney U tests (for between-group comparisons) were used based on data distribution. A p-value < 0.05 was considered statistically significant.

Results

Recruitment and randomization

A total of 36 patients were screened for eligibility. Sixteen were excluded for the following reasons: suprahyoid EMG activity >37.1 μV RMS (n = 3), cognitive impairment (n = 5), history of radical neck dissection (n = 3), pacemaker implantation (n = 2), absence of a consistent caregiver (n = 1), and refusal to participate (n = 2). Twenty eligible participants were randomized using block-permuted randomization with a block size of four, resulting in 10 participants allocated to the intervention group and 10 to the control group. This sample met the minimum number required based on the a priori sample size calculation.

All participants completed the first four weeks of training and underwent the week-4 suprahyoid sEMG assessment. By week 8, three participants withdrew: one from the intervention group due to hospitalization for vascular stenting, and two from the control group (one lost to follow-up and one relocated). In total, 17 participants (intervention n = 9, control n = 8) completed the study and were included in the final analysis. The participant flow and reasons for exclusion and withdrawal are summarized in **Figure 1** (CONSORT flow diagram). The recruitment period spanned from July 2022 to June 2024.

No adverse events were reported during training sessions or during outcome evaluations, including suprahyoid sEMG and VFSS assessments.

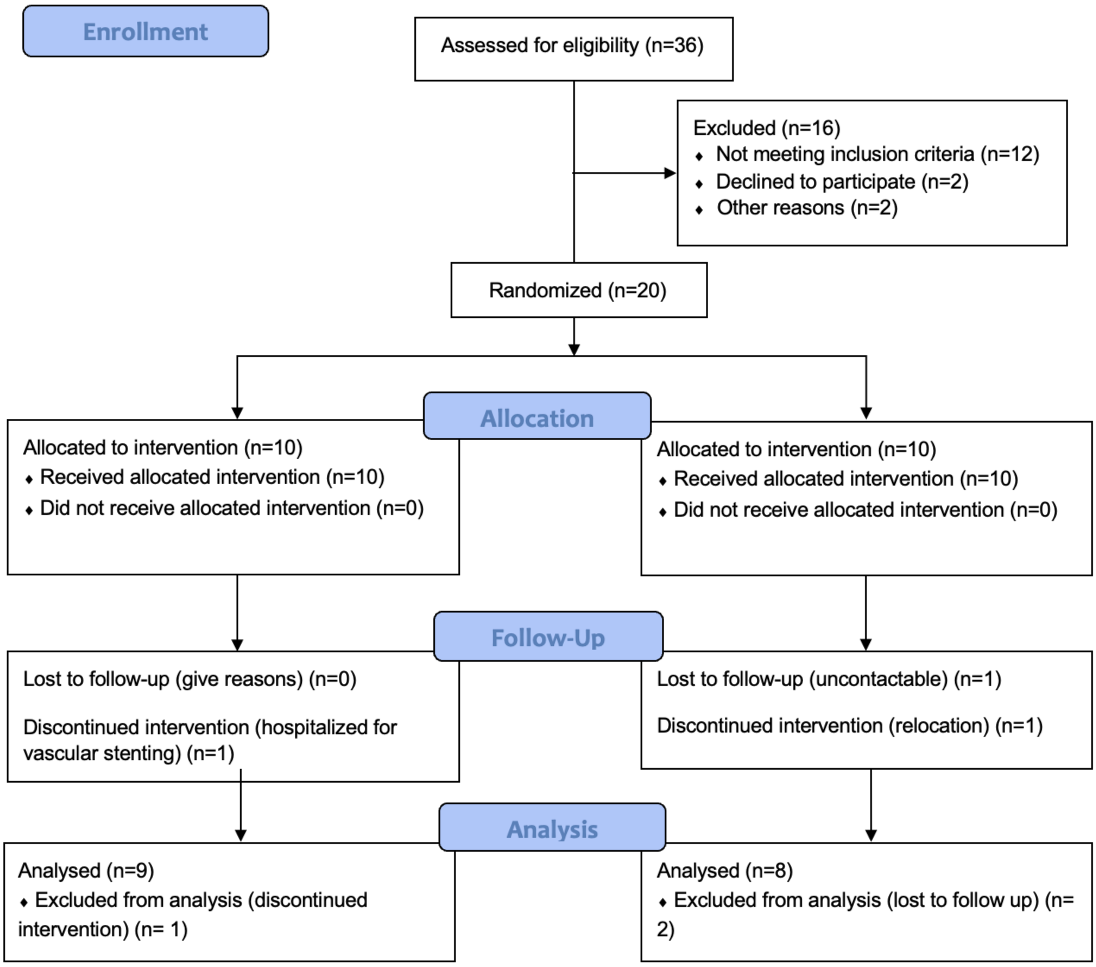

Figure 1. CONSORT 2010 flow diagram of participant recruitment, randomization, follow-up, and analysis in the TPRT trial

<u>Intervention and comparator delivery</u>

All participants in the intervention group adhered to the tongue-to-palate resistance training (TPRT) protocol, consisting of 30 repetitions per session, five sessions per week, performed at home with caregiver support, video guidance, and logbook monitoring. In the control group, participants received the standard hospital-based protocol of neuromuscular electrical stimulation (NMES) or biofeedback twice weekly, followed by unsupervised home-based chin-tuck against resistance (CTAR) exercises. Both groups were able to complete their assigned interventions as scheduled during the study period.

Concomitant care

Both groups additionally received standardized education on posture adjustment, swallowing maneuvers, and bolus modification to ensure safe swallowing.

Patients' characteristics

A total of 17 participants completed the full 8-week protocol, including suprahyoid surface electromyography (sEMG) and videofluoroscopic swallowing study (VFSS) assessments. Due to non-normal distribution of sEMG data, natural log transformation was applied, and repeated measures ANOVA (GLM approach) was used for analysis. Baseline characteristics are summarized in Table 1. The mean age of all subjects was 70.18 ± 6.24 years, with no significant age difference between the intervention group (69.67 ± 4.67 years) and the control group (70.75 ± 7.97 years). Male participants accounted for 58.8% of the sample, with a slightly higher proportion in the control group (62.5%) than in the intervention group.

Body mass index (BMI) was non-normally distributed and showed no significant difference between groups, with a median of 22.14 (19.22–30.41) kg/m² in the intervention group and 21.14 (16.9–29.4) kg/m² in the control group. The Charlson Comorbidity Index (CCI) was slightly higher in the intervention group [median 6 (3–8)] compared to the control group [median 5 (3–8)]. The proportion of frailty was marginally higher in the control group (62.5%) than in the intervention group (55.6%).

The most common etiology of dysphagia was stroke (47.1%), followed by laryngopharyngeal reflux (LPR, 41.2%) and nasopharyngeal malignancy (11.8%). The baseline PAS score was 4 (2–8) in the intervention group and 4.5 (2–8) in the control group. Penetration (70.6%) was more prevalent than aspiration (29.4%) across both groups.

Table 1 Patients' characteristics

Characteristics	Total	Group	
		Intervention (n=9)	**Control (n=8)**
Age (years)	70,18 ±6,24	69,67 ±4,67	70,75 ±7,97
60-69	10 (58,8%)	6 (66,7%)	4 (50%)
70-79	6 (35,3%)	3 (33,3%)	3 (37,5)
>80	1 (5,9%)	0 (0%)	1 (12,5%)
Gender			
Male	10 (58,8%)	5 (55,6%)	5 (62,5%)
Female	7 (41,2%)	4 (244,4%)	3 (37,5%)
BMI (kg/m^2)	21,6(16,9-30,41)	22,14(19,22-30,41)	21,14(16,9-29,4)
CCI	5(3-8)	6(3-8)	5(3-8)
Mild	0 (0%)	0 (0%)	0 (0%)
Moderate	6 (35,3%)	3 (33,3%)	3 (37,5%)
Severe	11 (64,7%)	6 (66,6%)	5 (62,5%)
Frailty			
Yes	10 (58,8%)	5 (55,6%)	5 (62,5%)
No	7 (41,2%)	4 (44,4%)	3 (37,5%)
Etiology			
Stroke	8 (47,1%)	4 (44,4%)	4 (50%)
***Laryngopharyngeal Reflux* (LPR)**	6 (35,3%)	4 (44,4%)	2 (25%)
Nasopharyngeal	3 (17,6%)	1 (11,1%)	2 (25%)

cancer			
Dysphagia severity (PAS)	5(2-8)	4(2-8)	4,5(2-8)
Penetration	12 (70,6%)	7 (77,8%)	5 (62,5%)
Aspiration	5 (29,4%)	2 (22,2%)	3 (37,5%)

Suprahyoid Muscle Electrical Activity

Baseline measurements showed comparable activity between the intervention and control groups in both tongue-pressed and dry swallowing conditions. At week 4 and week 8, the intervention group showed an increase in median electrical activity during tongue-pressed movements from 34.54 (24.32–36.91) µV RMS to 49.12 (31.28–58.42) µV and 60.87 (28.84–95.79) µV respectively. The control group exhibited a smaller increase from 32.26 (23.42–34.89) µV to 33.13 (30.13–54.38) µV and 42.99 (25.55–89.04) µV. During dry swallowing, the intervention group improved from 35.38 (25.95–36.99) µV RMS at baseline to 50.06 (29.75–69.85) µV at week 4 and 63.91 (27.32–91.99) µVat week 8. The control group increased from 33 (21.43–35.80) µV to 32.14 (24.7–59.15) µV and 54.04 (31.13–85.37) µV. Table 2 describes the increase in suprahyoid muscle electrical activity in both the intervention and control groups during tongue-pressed and dry swallowing movements. Both groups had similar baseline values in tongue-pressed movement as well as in dry swallowing.

Table 2. Suprahyoid Muscle Activity Before and After Training in the Intervention and Control Groups

Suprahyoid muscle electrical activity	*Baseline*	Week 4	Week 8
Tongue pressed **(µVRMS)**			
Intervention	34,54(24,32-36,91)	49,12(31,28-58,42)	60,87(28,84-95,79)
Control	32,26(23,42-34,89)	33,13(30,13-54,38)	42,99(25,55-89,04)
Dry swallowing **(µVRMS)**			
Intervention	35,38(25,95-36,99)	50,06(29,75-69,85)	63,91(27,32-91,99)
Control	33(21,43-35,80)	32,14(24,7-59,15)	54,04(31,13-85,37)

Repeated Measures ANOVA (GLM approach) was performed after log transformation of non-normally distributed data. Mauchly's test of sphericity indicated violation of the assumption ($p < 0.05$), requiring Greenhouse-Geisser correction. The results indicated a significant time effect for both tongue-pressed ($p = 0.000$, $\eta^2 = 0.693$) and dry swallowing ($p = 0.000$, $\eta^2 = 0.669$), while time*group interaction was not significant, indicating similar patterns of change in both groups. Between-group effects analysis did not yield statistically significant results ($p > 0.05$), though effect sizes were moderate to large ($\eta^2 = 0.164$ for tongue pressed, $\eta^2 = 0.123$ for dry swallow), suggesting a potential clinical impact. Figure 1 illustrates the trend of mean log-transformed suprahyoid muscle activity during tongue-pressed and dry swallowing tasks across baseline, week 4, and week 8, showing a consistent increase in both the intervention and control groups, with greater improvement observed in the intervention group.

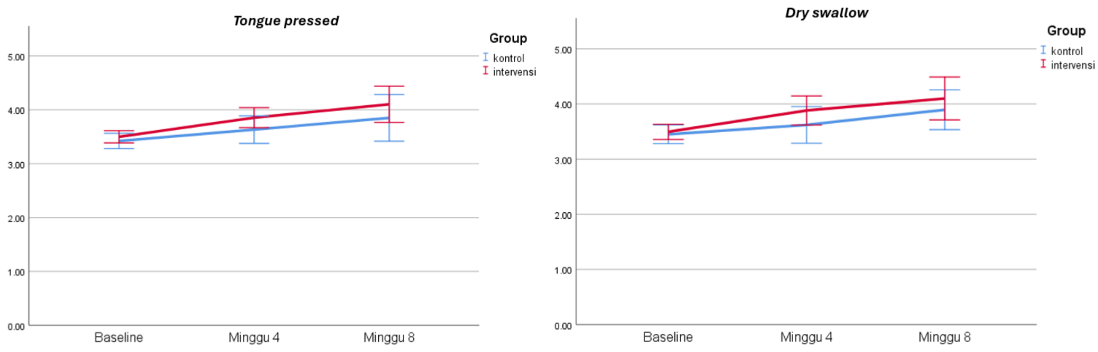

Figure 1. General Linear Model of Suprahyoid Muscle Electrical Activity

Penetration-Aspiration Scale (PAS)

VFSS evaluation prior to the intervention showed similar PAS scores between groups: median (min–max) PAS was 4 (2–8) in the intervention group and 4.5 (2–8) in the control group, with no statistically significant difference ($p > 0.05$). After completing the training protocol, both groups demonstrated a reduction in PAS at week 8: 2 (1–8) in the intervention group and 2 (1–8) in the control group. However, the difference between groups remained statistically non-significant ($p > 0.05$). Table 3 presents the comparison of Penetration-Aspiration Scale (PAS) scores between the intervention and control groups at baseline and after 8 weeks of training. While both groups showed a reduction in median PAS scores following the intervention period, no statistically significant differences were observed either within or between groups.

Table 3. Comparison of Parameters Before and After Training in the Intervention and Control Groups

Parameter	*Group*	Baseline	*Week 8*	*p-value*
Anterior hyoid movement (% C2–C4)	Intervention	15.75 (3.21–24.43)	28.26 (3.5–45.18)	0.038[w]
	Control	14.09 (0.96–17.54)	**14.48 (1.07–23.69)**	**0.161[w]**
	p-value between groups	0.178[m]	0.021[m]	
Superior hyoid movement (% C2–C4)	Intervention	14.52 (5.54–38.85)	22.07 (4.83–38.33)	0.086[w]
	Control	16.56 (10.68–34.62)	19.50 (1.77–48.93)	0.327[w]
	p-value between groups	0.441[m]	0.564[m]	

PTT (seconds)	Intervention	0.63 (0.1–1)	0.73 (0.23–0.83)	0.859[w]
	Control	0.68 (0.5–1)	0.74 (0.33–5.6)	0.327[w]
	p-value between groups	0.923[m]	0.310[m]	
PAS	Intervention	4 (2–8)	2 (1–8)	0.232[w]
	Control	4.5 (2–8)	2 (1–8)	0.753[w]
	p-value between groups	1.000[m]	0.797[m]	

<u>*Pharyngeal transit time (PTT)*</u>

Other parameters assessed using VFSS in this study included Pharyngeal Transit Time (PTT) and anterior and superior hyoid movement. As shown in Table 3, PTT evaluation revealed no significant differences within or between the intervention and control groups before and after training ($p > 0.05$).

<u>*Effects of TPRT to hyoid movement*</u>

Hyoid movement in the anterior and superior directions was expressed as a percentage of the C2–C4 distance, normalized by dividing each measurement by the length of a straight line connecting the inferior borders of C2 and C4 on the y-axis. Table 3 displays the changes in anterior and superior hyoid excursion. No significant differences were observed between groups at baseline for either direction ($p > 0.05$). However, in the intervention group, a statistically significant increase was found in anterior hyoid movement between baseline and week 8 ($p = 0.038$). Additionally, an intergroup comparison at week 8 showed a significant difference in anterior hyoid movement ($p = 0.021$)

Discussion

This study aimed to evaluate changes in swallowing function in geriatric patients with oropharyngeal dysphagia by analyzing suprahyoid muscle activity and the Penetration-Aspiration Scale (PAS). Participants were assigned to either a home-based TPRT group using video guidance and logbook monitoring or a control group receiving standard care, including NMES or biofeedback sessions and unsupervised CTAR exercises.

Findings showed that both groups experienced significant increases in suprahyoid muscle activity from baseline to weeks 4 and 8 during tongue-pressed and dry swallowing tasks. While between-group differences were not statistically significant, the large effect sizes observed in the intervention group suggest potential clinical relevance. These results align with previous studies showing improved tongue strength after TPRT or similar resistance training protocols. A more recent study by Kim et al. demonstrated that home-based tongue-to-palate training in stroke patients was as effective as hospital-based programs, with both groups showing significant improvement in tongue muscle strength and volume without differences between the two delivery modes.[41]

Previous studies by Kim et al. reported that the positive effects of TPRT could be observed as early as after 4 weeks of training in tongue muscle strength.[10] Similarly, Plaza et al. found a statistically significant increase in suprahyoid muscle sEMG values by the 4th week of combined tongue-to-palate pressing and strengthening exercises using IOPI, reaching 57.3±13.6 %MVC by the 8th week with tongue-to-palate pressing alone.[21] Resistance training improves muscle performance through neural mechanisms such as increased motor unit recruitment and hypertrophy mediated by muscle IGF and myogenic factors.[22–24] Robbins et al. further emphasize post-stroke swallowing recovery may involve neuroplasticity.[25–27]

TPRT targets oral and pharyngeal phases of swallowing by strengthening muscles responsible for bolus formation and palatal contact.[15,28,29] The activation of genioglossus and hyoglossus muscles indirectly enhances geniohyoid and suprahyoid activity.[9,17,28,29] Although sEMG reference values vary due to age and normalization methods, a consistent upward trend in sEMG across this study indicates positive training effects.[30–32]

The PAS decreased in both groups by week 8, but without significant between-group differences. Similar findings have been reported in older adults receiving tongue resistance training.[20,33,34] One possible explanation is the "floor effect" in participants with initially low PAS scores, limiting the ability to detect statistical improvements. Additionally, PAS is affected by multiple physiological factors such as pharyngeal timing and hyoid displacement.[35–37] Bingjie et al. identified increased pharyngeal delay time, prolonged pharyngeal transit time, and reduced maximal vertical displacement of the larynx and hyoid bone as independent predictors of aspiration in older adults.[42] Similarly, Zhang et al. demonstrated in a large cohort that anterior hyoid displacement was the most reliable predictor of penetration–aspiration risk, highlighting the critical biomechanical role of hyoid excursion in swallowing safety.[43]

Furthermore, no significant change in PTT was observed, possibly due to participant heterogeneity and age-related physiological changes.[38] In contrast, Namiki et al. reported shortened PTT post-TPRT in a healthier cohort.[11] This study observed statistically significant improvements in anterior hyoid movement among intervention participants. Anterior hyoid displacement is essential for upper esophageal sphincter

(UES) opening and airway protection. Increased anterior hyoid movement suggests neuromuscular adaptations from TPRT, even though PAS scores remained unchanged. These results indicate potential for improving biomechanical aspects of swallowing.[39,40]

In summary, TPRT may enhance suprahyoid muscle activity and anterior hyoid excursion in older adults with oropharyngeal dysphagia. Though PAS and PTT changes were not statistically significant, the observed physiological improvements highlight TPRT as a feasible and promising home-based intervention.

Strengths and limitations

This is the first randomized controlled trial in Indonesia to evaluate tongue-to-palate resistance training (TPRT) in geriatric patients with oropharyngeal dysphagia. Its simple, equipment-free protocol supports feasibility for home-based use. However, the heterogeneous sample, small sample size, and high data variability may have limited statistical significance despite moderate-to-large effect sizes. A floor effect in PAS scores and use of only thin-liquid consistency for VFSS may also limit generalizability.

Conclusion

Tongue-to-palate resistance training (TPRT) has the potential to enhance suprahyoid muscle electrical activity in geriatric patients with oropharyngeal phase dysphagia. However, this intervention did not result in a statistically significant reduction in Penetration-Aspiration Scale (PAS) scores in the studied population. This study supports the feasibility of implementing home-based TPRT as a clinical intervention for geriatric patients with oropharyngeal dysphagia. The training protocol may serve as a reference for rehabilitation programs targeting swallowing function in this population. Future studies should involve larger and more homogenous sample populations to increase statistical power and generalizability. Additionally, longer training durations or combined exercise protocols are recommended to further explore the potential therapeutic effects of TPRT in this patient group.

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Conflict of Interest

The author declares no conflict of interest.

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Table 3. Comparison of Parameters Before and After Training in the Intervention and Control Groups

Parameter	*Group*	Baseline	*Week 8*	*p-value*
Anterior hyoid movement (%C2–C4)	Intervention	15.75 (3.21–24.43)	28.26 (3.5–45.18)	0.038[w]
	Control	14.09 (0.96–17.54)	**14.48 (1.07–23.69)**	**0.161[w]**
	p-value between groups	0.178[m]	0.021[m]	
Superior hyoid movement (%C2–C4)	Intervention	14.52 (5.54–38.85)	22.07 (4.83–38.33)	0.086[w]
	Control	16.56 (10.68–34.62)	19.50 (1.77–48.93)	0.327[w]
	p-value between groups	0.441[m]	0.564[m]	
PTT (seconds)	Intervention	0.63 (0.1–1)	0.73 (0.23–0.83)	0.859[w]
	Control	0.68 (0.5–1)	0.74 (0.33–5.6)	0.327[w]
	p-value between groups	0.923[m]	0.310[m]	
PAS	Intervention	4 (2–8)	2 (1–8)	0.232[w]
	Control	4.5 (2–8)	2 (1–8)	0.753[w]
	p-value between groups	1.000[m]	0.797[m]	

m) Mann-Whitney Test; w) Wilcoxon Test