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Original Article

Effect of tongue strength training using the Iowa Oral Performance Instrument in stroke patients with dysphagia

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Abstract. [Purpose] The aim of this study was to evaluate the effectiveness of a structured program of resistance training for the tongue in order to improve swallowing function in stroke patients with dysphagia. [Subjects and Methods] Twenty-seven stroke patients with dysphagia were randomly divided into two groups. The experimental group participated in a resistance-training program involving a 1-repetition maximum, with an intensity of 80%, along with 50 repetitions per day each for the anterior and posterior regions of the tongue. Both groups received conventional therapy for dysphagia for 30 min per day, 5 times per week, for 6 weeks. [Results] The experimental group showed statistically significant improvements in both, the anterior and posterior regions of the tongue. In contrast, the control group showed significant improvements only in the anterior region of the tongue. In the videofluoroscopic dysphagia scale evaluation, improvement was noted at both, the oral and pharyngeal stages in the experimental group, whereas significant improvements were only noted in the oral stage and total score in the control group. [Conclusion] Our study confirmed that tongue resistance training is an effective intervention for stroke patients with dysphagia, offering improved tongue muscle strength and overall improvement in swallowing.
Key words: Dysphagia, Stroke, Tongue

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INTRODUCTION

The tongue plays a major role in swallowing and is essential to ensure normal swallowing function. The primary functions of the tongue include food mastication, bolus formation, manipulation, and propulsion into the pharynx[1)]. Moreover, it also contributes to respiration and speech functions[2)]. During the oral stage of swallowing, the tongue squeezes food against the hard palate of the mouth, and moves the bolus from the anterior to the posterior region of the tongue for propulsion into the pharynx[3)]. Neurogenic disorders, such as a stroke or Parkinson's disease, can lead to deficits in the sensory and motor functions of the tongue. This can further lead to dysphagia in both the oral and pharyngeal stages of swallowing, such as difficulties with the mastication and manipulation of food, vallecular and pharyngeal residues, and aspiration[4, 5)]. Therefore, sufficient tongue muscle strength is a determining factor for safe swallowing.

Pushing the tongue against the hard palate or against an external resistance, such as a tongue depressor, has been described as a basic strengthening exercise for the tongue[6)]. However, in this basic approach for strength training of the tongue, the level of resistance and the volume of training stimulus—parameters necessary to optimize strength outcomes—are not systematically controlled.

The Iowa Oral Performance Instrument (IOPI Medical LLC, Redmond, WA) is a standardized portable device that can be used to quantify tongue muscle strength, thus allowing the clinician to set the level of resistance necessary to achieve optimal gains in strength, and also providing visual feedback of performance to the patients to guide training[7)]. In the present study, we aimed to evaluate the effectiveness of a resistance training program for the tongue in order to improve swallowing function in stroke patients with dysphagia.

SUBJECTS AND METHODS

Fifty stroke patients with dysphagia were eligible for this study, which was conducted from April 2015 to July 2015. The inclusion criteria for participation were as follows: 1) dysphagia from a stroke that was confirmed by a videofluoroscopic swallowing study (VFSS), 2) onset duration > 6 months, 3) Mini-Mental State Examination (MMSE) score ≥ 24. The exclusion criteria were as follows: 1) previous stroke; 2) severe orofacial pain including trigeminal neu-

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ropathy; 3) significant malocclusion or facial asymmetry; 4) severe communication disorder, such as severe aphasia. All participants provided written informed consent, and the study protocol was approved by the Institution Review Board.

This study was designed as a 6-week, single-blind, randomized controlled study. Each eligible participant was randomly allocated to the experimental training or control group using opaque envelopes that contained codes specifying his or her group membership. Both groups received traditional dysphagia therapy for 30 min per day, and the experimental group additionally received strength training for the tongue using the IOPI. Tongue muscle strength training was classified into the anterior and posterior regions. When we measured the pressure of the anterior tongue region, the bulb was positioned on the hard palate immediately behind the upper gingiva and touched the anterior 10 mm of the tongue dorsum. The subjects were instructed to press the bulb toward the hard palate with the tongue as hard as possible for 2 s. For the posterior tongue region, the bulb was placed on the anterior aspect of the posterior hard palate and the subjects were instructed to press the bulb in the same manner as described above. The instructions were as follows, "I will place the bulb in your mouth. Please press the bulb as hard as possible for 2 s. Next, I will move it backwards a little further. Now, press it in the same manner. Please do not frown too much or use your teeth."

The intensity of training was based on previous research by Robbins et al.[4]. The 1-repeated maximum contraction (i.e., 1 RM) for anterior and posterior elevation of the tongue was measured using the IOPI. The training protocol of the experimental group was similar to that for the measurement of tongue strength, and resistance was set at the 80% level of maximal isometric tongue pressure. Training was performed for 6 weeks at a frequency of 5 times per week and an intensity of 5 sets of 10 trials per day, amounting to a total daily volume of 50 repetitions each for the anterior and posterior regions of the tongue. A minimum rest period of 30 s was provided between sets, with longer durations considered to accommodate patients' fatigue. Trials in which the target training level was not reached were repeated to standardize the volume of resistance training. The training was directed by two experienced occupational therapists.

The effectiveness of the training was evaluated by comparing pre- and post-training measures. The IOPI was used to determine baseline 1 RMs of the anterior and posterior regions of the tongue for patients in both the experimental and control groups. The 1 RMs were re-evaluated at the end of the 6-week training program. Swallowing function was also evaluated at baseline and following the 6-week training intervention using the videofluoroscopic dysphagia scale (VDS) based on videofluoroscopic swallowing study (VFSS). VFSSs were conduct based on a previous study[8]. The VDS consists of 14 items, which can largely be categorized into an oral phase (7 items: lip closure, bolus formation, mastication, apraxia, tongue to palate contact premature bolus loss, and oral transit time) and a pharyngeal phase (7 items: pharyngeal triggering, vallecular residues, pyriform sinus resides, laryngeal elevation, pharyngeal wall coating, pharyngeal transit time, and aspiration). The score ranges from 0 to 100, and a higher score indicates a higher severity of dysphasia[9].

Table 1. Characteristics of participants

Characteristics	Experimental Group (n=15)	Control group (n=14)
Age (years) mean±SD (range)	67.3±10.6 (51–82)	65.8±11.5 (52–80)
Gender, male/female	6/9	7/7
Etiology		
Hemorrhage	8	6
Infarction	7	8
Time since onset of stroke, weeks, mean ± SD (range)	25.37±7.43 (19–45)	26.38±6.81 (17–43)

SD: standard deviation

Participant characteristics were analyzed using a statistical software program (SPSS Statistics 20, IBM, Armonk, NY), and descriptive statistics are presented as mean ± standard deviation. The Shapiro-Wilk test was used to check the normality of the outcome variables. To evaluate the effects of training, paired t-test was used to compare measures before and after the intervention in each group. Independent t-test was used to compare the changes in outcome measures between the two groups. The significance level was set at $p < 0.05$.

RESULTS

There were no significant differences between the baseline characteristics in the two groups (Table 1). The experimental group showed significant improvements from 18.93 ± 6.75 to 20.73 ± 6.61 for the anterior region, and from 16.2 ± 4.69 to 18.47 ± 4.09 for the posterior region. On the other hand, the control group showed improvements from 22 ± 5.74 to 22.86 ± 5.36 for the anterior region, and from 17.29 ± 4.3 to 17.71 ± 4.36 for the posterior region. However, the change in the control group was only statistically significant for the anterior region. No statistically significant difference in either the anterior or the posterior region scores was observed between the two groups after the intervention (Table 2).

Regarding the VDS evaluation based on VFSS, the experimental group showed statistically significant differences in both the oral and pharyngeal stages, as well as in the total score. On the other hand, the control group showed significant improvements in the VDS score for the oral stage of swallowing and in the total score. No statistically significant difference in VDS scores was observed between the two groups after the intervention (Table 3).

DISCUSSION

Tongue resistance training can improve tongue muscle strength in stroke patients with dysphagia. Consequently, it has been considered as a remedial approach for improving swallowing functions. In this study, we aimed to confirm the effects of tongue resistance training on tongue muscle strength and overall swallowing function.

Table 2. Comparison of results between experimental group and control group

Region	Experimental group		Control group	
	Before treatment	After 4-week treatment	Before treatment	After 4-week treatment
Anterior region	18.93 ± 6.75	20.73 ± 6.61**	22 ± 5.74	22.86 ± 5.36*
Posterior region	16.2 ± 4.69	18.47 ± 4.09**	17.29 ± 4.3	17.71 ± 4.36

The values are mean ± standard deviation. Unit: pressure
*p<0.05, **p<0.01 by paired t test between initial and final scores in the group

Table 3. Comparison of results between experimental group and control group

Items	Experimental group		Control group	
	Before treatment	After 4-week treatment	Before treatment	After 4-week treatment
Oral phase	16.27±4.72	14.67±4.45**	16.82±4.11	16.64±4.13*
Pharyngeal phase	42.87±6.85	40.77±6.12*	41.75±6.8	41.5±6.84
Total score	59.13±10.74	55.43±9.35**	58.57±9.75	58.14±9.83*

The values are mean ± standard deviation.
*p<0.05, **p<0.01 by paired t test between initial and final scores in the group

Our 6-week protocol involved a training resistance of 80% 1 RM and a volume of 50 repetitions each for the anterior and posterior regions of the tongue. The protocol yielded significant gains in strength in the anterior and posterior regions of the tongue, and improved function in both the oral and pharyngeal stages of swallowing. In general, the functional recovery of skeletal muscle increases rapidly within the first 6 months after a stroke[10]. A training intensity of 60–80% 1 RM has been shown to be effective in improving the strength of skeletal muscles[11]. A very low resistance intensity will not provide sufficient loading of the muscle to stimulate increases in strength, whereas a very high resistance intensity will lead to fatigue and an inability to complete the volume of repetitions that is necessary to optimize strength gains. Robbins et al.[4] reported increases in tongue strength and volume/area in stroke patients following an 8-week resistance training program for the tongue, involving a training resistance between 60% and 80% 1 RM. Based on these results, we assumed that a training stimulus of 80% 1 RM would be adequate when designing the present study.

The effectiveness of the resistance-training program in improving the oral and pharyngeal stages of swallowing is an important and novel finding of our study. In the oral stage of swallowing, tongue strength and function play essential roles in mastication and bolus formation. Further, tongue strength and function are essential to squeeze food against the hard palate, both for movement of the bolus from the anterior to the posterior regions of the tongue and for propulsion into the pharynx. Tongue strength is also important for creating a sufficiently high pressure within the oral cavity, to reduce the oral and pharyngeal transit time, vallecular residues, and risk of aspiration as a result of improved airway protection. Steele et al.[12] also suggested that tongue resistance training is an effective method for reducing aspiration and penetration. Thus, increased tongue strength has a positive effect on the swallowing-related quality of life of stroke survivors.

The effectiveness of resistance training for the tongue results from both a central (neural) and peripheral (muscle mass) effect[13]. In the present study, we confirmed that a structured resistance-training program was effective for producing gains in strength (1 RM) in the tongue. However, we did not specifically evaluate the central effects of resistance training. Robbins et al.[4] proposed that improvements in swallowing function with resistance training are the result of both the direct effects of training on strength and the effects of resistance training on the neuroplasticity of the neural circuits for swallowing, including collateral sprouting to areas affected by the stroke.

This study has several limitations. First, the sample size was small; future studies with larger sample sizes are therefore needed to generalize the results. Second, the recruited participants included patients with relatively mild dysphagia who actively cooperated during training. Finally, a follow-up was not performed after the intervention.

In conclusion, our study provides evidence supporting the inclusion of resistance training of the tongue muscle in rehabilitation programs for stroke patients with dysphagia. The administration of this resistance training can improve tongue strength and general swallowing function.

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