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Original Article

Effects of lingual strength training on lingual strength and articulator function in stroke patients with dysarthria

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Abstract. [Purpose] This study investigated the effects of lingual strength training (LST) on lingual strength and articulator function in stroke patients with dysarthria. [Subjects and Methods] 16 stroke patients with dysarthria were randomly assigned into two groups: the experimental group (n=8) or the control group (n=8). Both groups received the conventional rehabilitation therapy at 30 min/day, 5 times for week, and during 4 weeks, and the experimental group received an additional 30 min of LST using the Iowa Oral Performance Instrument (IOPI). The Maximum Isometric Tongue Pressures (MIPs) was used to assess the lingual strength and the Alternating-Motion Rate (AMR) and Sequential-Motion Rate (SMR) were used to measure the articulator function. [Results] After the intervention, the experimental group showed a significant improvement in MIPs and AMR (/tə/) than the control group. [Conclusion] Findings of this study suggest that LST provides positive effects on lingual strength and articulator function, and thus can be used as an interventional method in stroke patients with dysarthria.

Key words: Dysarthria, Articulator function, Lingual strength training

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INTRODUCTION

Dysarthria following stroke has been reported to occur in 20–30% of cases[1)]. Stroke patients with dysarthria generally experience difficulty in articulating or performing appropriate gestures[2)]. Production of articulation is a complex and precise process that is accomplished by sophisticated control and proper integration of about 70–80 palatal and facial muscles, including the respiratory system, pharynx, larynx, and articulator[3)]. It reduces their relationships with family members and

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likely results in a decrease of quality of life[4].

Intervention methods for improvement of articulator function include interactions such as orofacial exercise, articulator relaxation, and tongue strengthening. Among the behavioral approach of speech disorder treatment, non-articulation oromotor training reported an improvement of articulator function through previous studies[5].

Lingual exercise is effective in improving the oromotor function by increasing the strength and range of motion of tongue; this improvement is also important in articulation production[6]. In addition, it has been reported to have positive effects on patients with dysarthria due to its positive effect on pronunciation clearness[7]. In previous studies, tongue was an important articulator and was closely related to the production of articulation and accuracy of pronunciation[8].

Lingual strength training (LST) has been reported to improve not only articulator function, but also to improve oromotor movement of stroke patients. Robbins et al. reported an increase in tongue strength and improved oromotor function in stroke patients through LST using the Iowa Oral Performance Instrument (IOPI)[9].

According to the meta-analysis of Adams et al., although IOPI may be a reliable method to measure the strength and endurance of the tongue, its effect on neurological groups, such as stroke, was poor[10]. In addition, previous studies on LST using IOPI have mostly focused on swallowing function, and studies related to LST articulator function using IOPI are very limited in the literature.

Therefore, to demonstrated the effect of LST for improvement of dysarthria, this study investigated the effect of LST on lingual strength and articulator function of stroke patients with dysarthria.

SUBJECTS AND METHODS

A total of 16 patients with dysarthria receiving rehabilitation therapy at a hospital in Seoul were recruited. The criteria for selection were as follows: (1) the onset period of stroke was more than 3 months, (2) the diagnosis of paralytic dysfunction was given by a rehabilitation medicine doctor, (3) the MMSE score was 24 or more, and (4) maximum isometric tongue pressures (MIPs) using IOPI were less than 40 kPa. The exclusion criteria were: (1) difficult to evaluate using IOPI and (2) pain during lingual strength exercise. All participants were informed of the contents and procedure of the experiment. This study was approved by the Gachon University Institutional Review Board (1044396-201606-HR-046-01).

Sixteen stroke patients were randomly assigned to two groups: the experimental group (n=8) and the control group (n=8). Both groups received conventional rehabilitation therapy for 30 min a day, five times a week, for a period of four weeks, and the experimental group received an additional 30 min of LST using IOPI. Conventional rehabilitation therapy has received physical and occupational therapy.

LST was performed in the experimental group in the following manner[9]. LST was performed 30 times in the anterior portion of the tongue based on the target value set in IOPI. Training was repeated 10 times, with 10 seconds of rest in between each repetition. Regarding the position of the bulb during LST, the evaluator fixed the bulb directly to the alveolar ridge of the hard palate so that it could be in contact with the tongue tip by for about 10 mm. Then, the bulb was pressed against the hard palate for 2 seconds with the maximum pressure of the tongue.

IOPI was used to measure MIPs in the two groups, and the alternating motion rate (AMR) and sequential motion rate (SMR) were measured to evaluate the articulation function. All measurements were performed by an occupational therapist with six years of clinical experience.

IOPI was used to measure MIPs of subjects. IOPI consists of the tongue bulb, connecting tube, data output jack, and input terminal. MIPs were measured three times in a row, and the average value was recorded. The intra-rater reliability of IOPI was 0.76–0.99, suggesting high reliability[11].

AMR and SMR were performed to evaluate the articulator function. The syllable task (/pə/, /tə/, /cə/) is described to perform AMR. The experiments were performed by repeating one syllable of /pə/, /tə/, and /cə/ for 5 seconds quickly and accurately to measure the number of single syllables. The mean score of the syllable was calculated for 5 seconds, and the mean value was calculated 3-times[12].

SMR measured the number of sequential syllables by alternately repeating /pə tə cə/ for exactly 5 seconds at the highest possible speed. For test standardization, the mean value was calculated by taking three measurements[13].

An analysis of collected data was performed using SPSS 22.0. In this study, the normality of variables was tested using Shapiro-Wilk test and all data did not assume the normality. Thus, we used non-parametric statistical methods to analyze our data. Mann-Whitney U test and χ^2 test were used to analyze the general characteristics of subjects. Wilcoxon signed rank test was used to compare within the group. Mann-Whitney U test was used to compare the differences in MIPs, AMR, and SMR between groups. The statistical significance level was set to 0.05.

RESULTS

The general characteristics of the two groups showed no significant difference ($p>0.05$) (Table 1). There was no significant difference between the two groups before the intervention ($p>0.05$) (Table 1). After the intervention, the experimental group showed a significant improvement in MIPs, /tə/ of AMR and SMR ($p<0.05$) (Table 2). After the intervention, there was no significant difference in the control group ($p>0.05$) (Table 2). In a comparison between the two groups, the experimental

Table 1. General characteristics of two groups

	Experimental group (n=8)	Control group (n=8)
Gender (male/female)	5/3	6/2
Age (years)	64.7 ± 5.7	65.2 ± 5.9
Stroke type (ischemic/hemorrhagic)	5/3	6/2
Affected side (left/right)	3/5	4/4
Duration (month)	6.3 ± 2.6	6.2 ± 2.1
MMSE	26.5 ± 2.9	26.2 ± 2.4

Values are expressed as mean ± SD.

Table 2. Comparison of results within the group

	Experimental group (n=8)		Control group (n=8)	
	Before	After 4-week	Before	After 4-week
MIPs	21.7 ± 2.3	26.5 ± 2.7*	21.2 ± 4.4	21.8 ± 4.4
AMR (/pə/)	15.7 ± 2.2	16.1 ± 2.0	15.0 ± 1.7	15.2 ± 1.6
AMR (/tə/)	15.7 ± 2.3	16.4 ± 2.5*	15.0 ± 1.6	15.1 ± 1.6
AMR (/cə/)	12.6 ± 1.8	13.0 ± 1.8	12.4 ± 1.5	12.4 ± 1.6
SMR (/pə tə cə/)	6.2 ± 1.0	6.8 ± 1.0*	6.3 ± 0.8	6.5 ± 0.6

Values are expressed as mean ± SD. MIPs: maximum isometric tongue pressures; AMR: alternating motion rate; SMR: sequential motion rate
*p<0.05, significant difference within the group

Table 3. Comparison of results between two groups

	Experimental group (n=8)	Control group (n=8)
	Post-Pre	Post-Pre
MIPs	4.75 ± 1.49†	0.63 ± 0.92
AMR (/pə/)	0.34 ± 0.48	0.25 ± 0.53
AMR (/tə/)	0.70 ± 0.54*	0.12 ± 0.26
AMR (/cə/)	0.36 ± 0.57	0.01 ± 0.72
SMR (/pə tə cə/)	0.60 ± 0.52	0.17 ± 0.43

Values are expressed as mean ± SD. MIPs: maximum isometric tongue pressures; AMR: alternating motion rate; SMR: sequential motion rate
*p<0.05, †p<0.01, significant difference between groups

group showed a significant improvement in MIPs and /tə/ of AMR (p<0.05). There was no significant difference in the remaining items (p>0.05) (Table 3).

DISCUSSION

This study was performed to examine the effect of LST on lingual strength and articulator function in stroke patients with dysarthria. After the intervention, there was a significantly higher MIPs in the experimental group than in the control group. These results demonstrate that LST also improves the tongue strength in stroke patients with dysarthria, as well as swallowing patients[9)] and healthy elderly[14)]; it also has an effect on articulator function.

In SMR (/pə tə cə/) measuring the articulator function after the intervention, the experimental group showed a significant improvement before and after the intervention, but no significant change was observed in the control group. There was no significant difference betwe en the two groups in SMR (/pə tə cə/), but in AMR (/tə/), the experimental group showed a significantly larger improvement than the control group.

In this study, the reason that the experimental group showed a significant improvement in /tə/ than the control group is that /tə/ requires more tongue control than /pə/ and /cə/. In other words, /tə/—as compared with /pə/ and /cə/—is an alveolar fricative sound, requiring greater strength and coordination of the anterior portion of the tongue[15)]. Therefore, it is suggested that the training effect of LST performed in the experimental group is larger than that of /pə/ and /cə/.

Palmer and Enderb reported that strengthening related to the speech mechanism was effective for the articulation function[5)], and Mchenry et al. suggested that the articulator should be promoted first to improve the speech function in stroke patients[16)]. This study has demonstrated that LST, an additional non-speech oromotor exercise, can lead to a particular improvement in /tə/.

LST is a treatment method that trains its own tongue strength through monitoring of IOPI. In this case, the effect of biofeedback seems to be more effective than conventional exercise. Feedback is an important part of the learning process because it provides information about the differences between the goal and the progress, promoting a more active attitude toward learning[17]. Therefore, LST performed in this study will be clinically relevant as a remedial approach to strengthen muscles associated with articulation of stroke patients with dysarthria.

There are a few limitations to consider. First, sample size was small. Second, the evaluation used in this study was done only with clinical tools. Finally, we did not measure the long-term effects after training.

In conclusion, this study aimed to investigate the effect of LST on tongue strength and articulator function of stroke patients with dysarthria. The present study suggests that LST using IOPI can be used as effective intervention methods for tongue strength and articulation ability of stroke patients with dysarthria.

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