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ORIGINAL REPORT

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

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Objective: **To compare the effects of game-based Chin Tuck against resistance exercise and head-lift exercise on swallowing function and compliance of patients with dysphagia after stroke.**

Patients and methods: **A total of 37 patients with stroke were randomly assigned to 2 groups. The experimental group performed game-based chin tuck against resistance exercise, whereas the control group performed traditional head-lift exercise. The videofluoroscopic dysphagia scale (VDS) and penetration-aspiration scale (PAS) were used to evaluate swallowing function. In addition, the functional oral intake scale (FOIS) was used for dietary assessment. Finally, the numerical rating self-report scale was used to assess compliance (motivation, interest/enjoyment, physical effort needed, muscle fatigue) with the 2 exercises.**

Results: **After intervention, there was no significant difference in VDS, PAS, and FOIS between the 2 groups. Comparing the compliance with the 2 exercises, the scores for motivation and interest/enjoyment items were significantly higher, and the scores for physical effort needed and muscle fatigue were significantly lower, in the experimental group than in the control group.**

Conclusion: **Game-based Chin Tuck against Resistance exercise not only has a similar effect to head-lift exercise on swallowing function of patients with dysphagia, but is also a less strict and more enjoyable and interesting method.**

Key words: stroke; dysphagia; videofluoroscopic swallowing study; head-lift exercise; Chin Tuck against resistance; game.

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LAY ABSTRACT

This study compared the effects of game-based Chin Tuck against resistance exercise and traditional head-lift exercise on swallowing function and compliance of patients with dysphagia after stroke. There was no significant difference between the 2 exercises in terms of videofluoroscopic dysphagia scale, penetration-aspiration scale and functional oral intake scale, suggesting that both therapeutic methods have similar effects in patients with dysphagia after stroke. However, on comparing the compliance of the 2 exercises, it was found that game-based Chin Tuck against resistance exercise is not only more interesting and exciting than head-lift exercise, but also less physically demanding. Therefore, these results suggest that game-based Chin Tuck against resistance exercise is less restrictive for patients with post-stroke dysphagia and is a therapeutic exercise that provides enjoyment and excitement.

The submental muscles are a group of muscles located between the hyoid bones just under the jaw, which include the geniohyoid, mylohyoid, and digastric muscles (1). During swallowing, contraction of these muscles pulls the hyoid and larynx upwards, resulting in normal swallowing (2). Training to strengthen the submental muscles is therefore important for safe swallowing in elderly individuals or patients with stroke who are susceptible to swallowing problems, such as airway aspiration (3).

Head-lift exercise (HLE), also called Shaker exercise, is a representative dysphagia treatment aimed at strengthening the submental muscles. While the patient is in the supine position they are asked to repeatedly lift their head and maintain a head-lift position for a specific time (4). Previous studies have shown that HLE is effective in activating the submental muscles, which reduces airway aspiration and helps open the upper oesophageal sphincter in patients with dysphagia after stroke (4–6). Thus, in clinical practice, HLE is used to improve swallowing function in patients with dysphagia.

Nonetheless, HLE is a very challenging exercise and is therefore difficult to perform. Given that HLE affects not only the submental muscles of the target muscle, but also the sternocleidomastoid muscle, it causes a high level of fatigue of the neck and results in discomfort, muscle aches, and temporary pain (7, 8). This, in turn, negatively affects performance compliance, and participants may fail to complete the exercise protocol, resulting in drop-out.

Several studies have reported on Chin Tuck against resistance exercise (CTAR) as an alternative to overcome the limitations of HLE (8–10). Unlike in HLE,

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in this exercise, the jaw is moved downwards against resistance using an elastic body (see Fig. 1), while sitting, in order to strengthen the same submental muscles as those targeted in the HLE; hence, the expected effect is similar to that of HLE. Sze et al. (11) demonstrated that CTAR exercise is more efficient than HLE because it the activates submental muscles similar to or higher than the HLE. As a result, patients were able to perform the exercise more easily than HLE, and the drop-out rate, which was moderate, also decreased. Park et al. (9) demonstrated that CTAR exercise is effective in decreasing aspiration, residue in valleculae, pyriform sinuses and increasing laryngeal elevation/epiglottic closure. However, previous studies on CTAR exercise have reported limitations of the exercise; for example, the intensity of resistance cannot be controlled using simple tools, such as elastic balls and elastic synthetic resins. In resistance training, applying an appropriate resistance intensity according to the patient's condition is very important. In addition, simple and repetitive training methods have low motivation for rehabilitation training because substantial physical effort is required for resistance training. Therefore, the resistance strength can be adjusted, and a supplement to provide motivation for resistance training is needed.

Studies using games software for rehabilitation have been reported (12–14). The game is intuitive and has the advantage of enhancing patient engagement because it can be enjoyable and interesting (13). In addition, it is possible to obtain immediate feedback, and adjust the force (control of resistance) alone, and the accuracy is improved by detecting performance error. These advantages of game-based exercises can be applied to the existing CTAR exercise. The aims of this study were therefore to investigate the effect of game-based CTAR (gbCTAR) exercise in patients with dysphagia after stroke, and to compare the results with those of HLE.

MATERIAL AND METHODS

Participants

Participants were recruited from the rehabilitation centre centre (InJe University Hospital, Busan) in South Korea. Forty-six stroke patients with dysphagia were eligible for the study, which was conducted from October 2018 to March 2019. Inclusion criteria were: diagnosed as having had a stroke within 6 months post-onset; pharyngeal dysphagia confirmed through a videofluoroscopic swallowing study (VFSS); ability to follow study instructions; ability to swallow voluntarily; only liquid aspiration or penetration observed on a VFSS; presence of a nasogastric tube; ability to use at least one arm; absence of any cognitive deficits (a score of >22 points in the Mini-Mental Status Examination; MMSE); and cortex damage only. Exclusion criteria were: secondary stroke; presence of other neurological diseases; pain in the disc and cervical spine; cervical spine orthosis; presence of a gastrostomy tube; and problems with the oesophageal phase of dysphagia (e.g. achalasia or upper oesophageal sphincter opening dysfunction), as confirmed by VFSS. The study protocol was approved by the Institutional Review Board of Seoul Medical Center in South Korea (SEOUL 2019-03-001), and all participants provided written informed consent for study participation. The patient's permissions to publish this study were obtained including picture.

Sample size estimation

To perform a sample size calculation, the G-Power 3.1 software (University of Dusseldorf, Dusseldorf, Germany) was used. The power and alpha levels were set at 0.80 and 0.05, respectively. In addition, the effect size was set at 0.85. According to a prior analysis, each group required at least 18 subjects. Therefore, this study assigned 23 participants to each group in preparation for drop-out.

Instrumentation

LES 100 (LES 100, Cybermedic Inc., Iksan in South Korea) consists of a tablet PC screen, a resilient resistance bar, and a Bluetooth connector, and implements a game-based exercise in which the chin is tucked down against a resilient resistance bar to strengthen the suprahyoid muscles. The subject sits 30 cm away from the 8-inch tablet PC on the table and tucks the chin downward against the resistance bar to reach the target (set resistance value) displayed on the screen. At this time, the external force applied to the resistance bar is displayed on the screen through the pressure system. The maximum force (1-RM) applied to the resistance bar when the chin tuck is performed using a resistance bar is measured to determine the resistance value of the motion before exercise; the resistance value starts at 70% of 1-RM.

Intervention

Eligible participants were allocated to the experimental or control group using blocked randomization after taking baseline measures (block size=4). Allocation was concealed using sealed opaque envelopes.

The experimental group performed the gbCTAR exercise using the LES 100 device. The participants in the experimental group were instructed to sit on a chair and place both arms on the desk. A 10-inch tablet PC was placed approximately 30 cm away from the desk. Before the gbCTAR exercise, 1-RM was measured to determine resistance training values. For the 1-RM measurement, the resistance bar was placed directly beneath the jaw, and the chin tuck was directed strongly against the resistance. The gbCTAR exercise was performed at a threshold value of 70% 1-RM. The exercise was divided into isometric and isotonic exercises in combination with the game, based on a previous study (8) (Fig. 1).

The control group performed HLE in the supine position, based on the previous study (4). Conventional HLE was divided into isometric and isotonic exercises (Fig. 2).

Table I shows the gbCTAR exercise and HLE protocol performed by the 2 groups. Both groups received the same type of exercise, and the time involved in the exercise was also the same. The intervention was conducted 5 times a week for 4 weeks by 3 experienced occupational therapists. In addition, both groups received traditional dysphagia treatment (TDT) from skilled occupational therapists (30 min a day). TDT included oral facial massage, thermal-tactile stimulation and various compensatory training (e.g. head tilting, rotation, chin tuck).

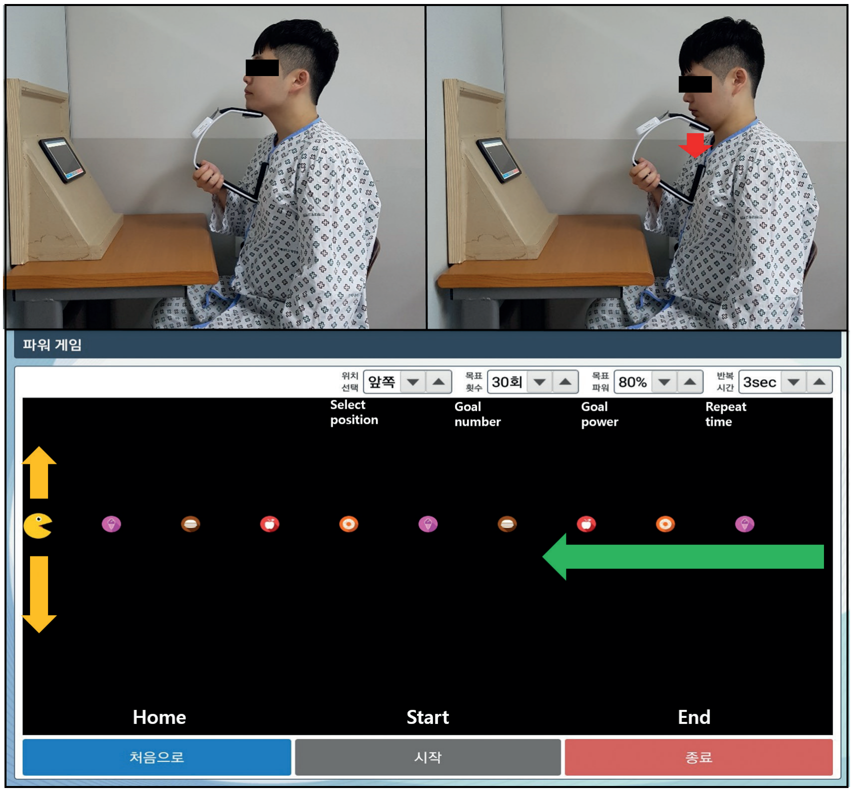

Fig. 1. Game-based Chin Tuck against Resistance exercise.

Outcome measures

This study used the videofluoroscopic dysphagia scale (VDS), penetration-aspiration scale (PAS) and functional oral intake scale (FOIS) based on VFSS to evaluate swallowing function and oral diet. Aspiration or penetration only in liquid type was evaluated in all study participants; thus, VFSS was evaluated only in the liquid type using milk. In addition, the effects of the 2 exercises were examined in terms of motivation, interest/enjoyment, physical effort needed, and muscle fatigue, using a 0-to-10 numerical rating self-report scale and drop-out ratio.

The VDS is a comprehensive swallowing assessment based on the VFSS findings. The VDS is divided into the oral phase (7 items: lip closure, bolus formation, tongue-to-palate contact, mastication, apraxia, premature bolus loss, and oral transit time) and the pharyngeal phase (7 items: pharyngeal triggering, vallecular residues, pyriform sinus residues, laryngeal elevation, pharyngeal wall coating, pharyngeal transit time, and aspiration) (15).

The PAS is an 8-point observational scale used to measure the severity of airway aspiration, with higher levels of airway aspiration indicating higher aspiration severity. Penetration is defined as the passage of material into the larynx, which does not pass below the vocal folds, whereas aspiration refers to the action of material penetrating into the larynx and entering into the airway below the true vocal folds (16).

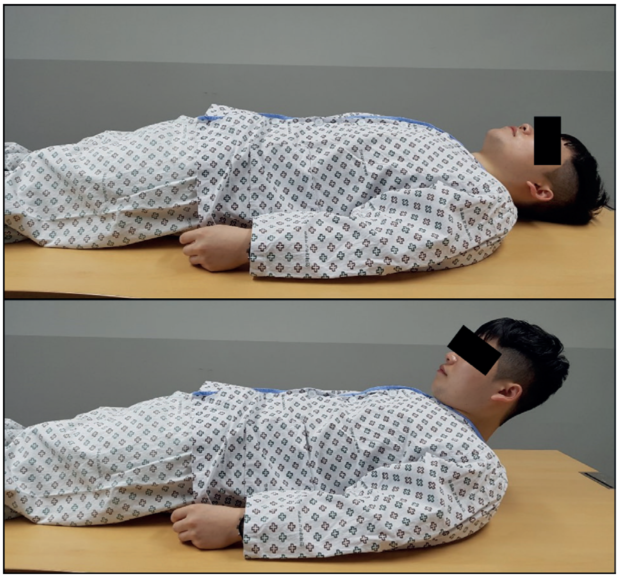

Fig. 2. Head-lift exercise.

Table I. Protocol of 2 exercise programmes for dysphagia rehabilitation

Exercise type	Game-based Chin Tuck against Resistance exercise	Head-lift exercise
Isotonic	Patient performs 30 consecutive repetitions by strongly pressing against the resistance of the device and releasing it again	In the same supine position the patient performs 30 consecutive repetitions of head raising, without sustaining the lifted position.
Isometric	Patient performs chin tuck against device 3 times for 60 s with no repetition.	In the supine position the patient performs head raise up 3 times, and looks at their toes for 60 s without lifting their shoulder from the ground

FOIS consists of a 7-point scale, with level 1 indicating complete impairment of oral intake and level 7 implying complete oral intake regardless of food consistency or type This scale exhibits a reliability rating of Cronbach's $\alpha = 0.86–0.91$ (17). A 0-to-10 numerical rating self-report scale was used after every training session to assess motivation, enjoyment/interest, physical effort needed, and muscle fatigue of the exercise. On this scale, 0 indicated no motivation, not enjoyable, and pain/fatigue (13).

All assessments were completed before and after the intervention by an experienced occupational therapist who was blinded to the participants' group allocation. The assessments were performed immediately before the start of the intervention (pre-training) and after the 4-week treatment (post-training).

Statistical analysis

Statistical analyses were performed using SPSS version 15.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics are presented as means with standard deviations. The Shapiro–Wilk test was used to check the normality of the outcome variables. To evaluate the training effects, the paired *t*-test was used to compare measures before and after the intervention in each group. The independent *t*-test was used to compare post-intervention values and changes in outcome measures between the 2 groups. The significance level was set at $p<0.05$.

RESULTS

General characteristics of the subjects

A total of 46 subjects were enrolled in the study. Nine participants dropped out prior to the follow-up for the following reasons: discharge ($n=3$), hospital transfer ($n=2$), and neck pain, fatigue, and discomfort ($n=4$). Therefore, the data for the final 37 subjects were analysed. Fig. 3 shows the Consolidated Standards of Reporting Trials (CONSORT) diagram for participant recruitment. A summary of the clinical and demographic features of the subjects ($n=37$) is shown in Table II. The homogeneity test for each measurement item showed no significant differences in baseline characteristics between the groups ($p>0.05$).

Table II. Participants' characteristics

Characteristics	Experimental group	Control group
Age, year, mean (SD)	60.95 (11.19)	59.45 (9.34)
Sex, man/woman, *n*	13/7	10/10
Type of stroke, haemorrhage/infarction, *n*	12/8	14/6
Paretic side, right/left, *n*	11/9	13/7
Time since onset of stroke months, mean (SD)	3.60 (1.19)	3.85 (1.18)

SD: standard deviation.

Swallowing function

The experimental group showed statistically significant improvement in the oral and pharyngeal phases of VDS, PAS and FOIS ($p<0.05$, all). The control group also showed significant improvement in the oral and pharyngeal phases of VDS, PAS and FOIS ($p<0.05$, all). After the intervention, there was no significant difference in the oral and pharyngeal phases of VDS ($p=0.443$ and 0.335), PAS ($p=0.069$) and FOIS ($p=0.403$) between the 2 groups (Table III). A comparison of the amount of change in the groups showed no significant differences in the oral and pharyngeal phases of VDS ($p=0.624$ and 0.689), PAS ($p=0.403$) and FOIS ($p=0.191$) (Table IV).

Drop-out rate and side-effects

There was no drop-out in the experimental group, in terms of compliance with the gbCTAR exercise. In contrast, in the control group, 4 patients dropped out because of temporary pain, fatigue and discomfort in the neck. However, the discomfort as temporary, and no patient reported additional side-effects (Fig. 3).

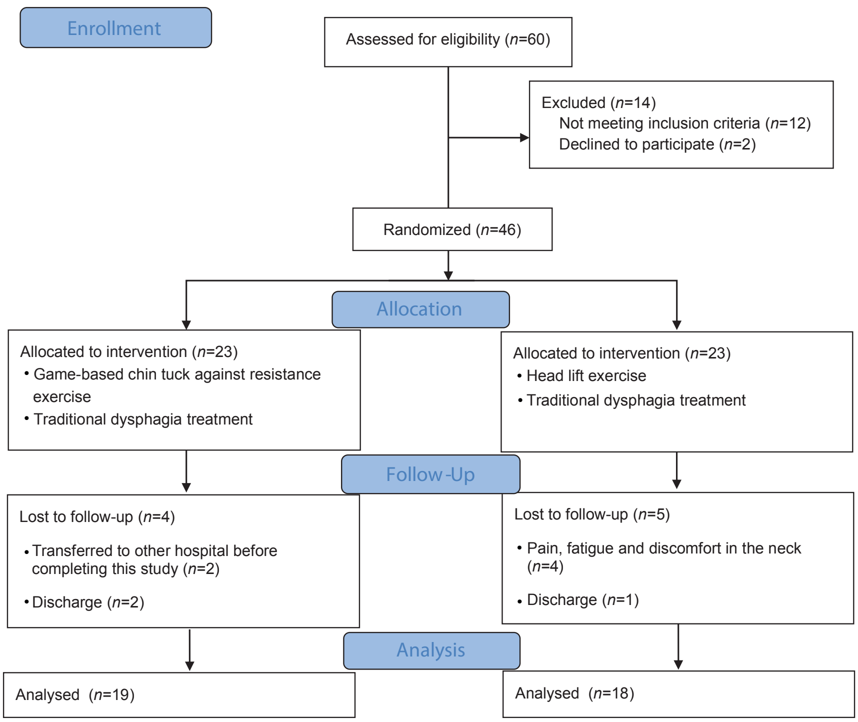

Fig. 3. Study flow diagram.

Table III. Changes in parameters before and after treatment

	Experimental group			Control group			
	Pre- Mean (SD)	Post- Mean (SD)	Within-group *p*-value	Pre- Mean (SD)	Post- Mean (SD)	Within-group *p*-value	Comparison between groups after intervention
Videofluoroscopic dysphagia scale							
Oral phase	11.35 (1.96)	9.52 (1.84)	< 0.001*	10.75 (1.89)	9.15 (1.12)	< 0.001*	0.443
Pharyngeal phase	40.45 (2.77)	32.22 (4.35)	< 0.001*	38.57 (3.41)	30.75 (5.15)	< 0.001*	0.335
Total score	51.80 (3.40)	41.75 (4.71)	< 0.001*	49.32 (4.10)	39.90 (5.44)	< 0.001*	0.258
Penetration-aspiration scale	4.60 (0.88)	3.30 (0.73)	< 0.001*	4.85 (0.93)	3.85 (1.08)	< 0.001*	0.069
Functional oral intake scale	3.45 (0.82)	4.70 (1.21)	< 0.001*	3.25 (0.78)	4.10 (1.33)	< 0.001*	0.403

*$p < 0.05$ by paired *t*-test.
SD: standard deviation.

Table IV Comparison of the differences after the 4-week treatment in the 2 groups

	Experimental group Mean (SD)	Control group Mean (SD)	*p*-value
Videofluoroscopic dysphagia scale			
Oral phase	−1.82 (1.35)	−1.60 (1.51)	0.624
Pharyngeal phase	−8.22 (2.90)	−7.82 (3.34)	0.689
Total score	−10.05 (2.76)	−9.42 (3.80)	0.556
Penetration-aspiration scale	−1.30 (0.73)	−1.05 (0.99)	0.403
Functional oral intake scale	1.25 (0.91)	0.85 (0.98)	0.191

SD: standard deviation.

Numerical rating self-report scale

The experimental group had higher scores in the motivation and interest/enjoyment items than the control group ($p < 0.001$), but the scores in the physical effort needed and muscle fatigue items were significantly lower ($p < 0.001$) (Fig. 4).

DISCUSSION

This study compared the effects of gbCTAR exercise and HLE on swallowing function and compliance in patients with dysphagia after stroke. Both methods resulted in significant improvement in swallowing function, but there was no significant difference between the 2 groups. This suggests that gbCTAR exercise and HLE have similar effects in patients with dysphagia.

The goal of submental muscle strengthening in patients with dysphagia is the same in both gbCTAR exercise and HLE, although they differ in terms of performance. These 2 exercise methods, through strengthening of the submental muscles, are known to induce physiological changes in the muscle, such as muscle thickness or strength. Physiological changes in the submental muscles through resistance exercise (e.g. CTAR or HLE) produce sufficient muscle contractility during swallowing, which directly contributes to kinematic effects, such as increased movement of the hyolaryngeal complex. This, in turn, affects airway protection through effective epiglottis tilting and swallowing function effects, such as increased opening of the upper esophageal sphincter. Previous studies have reported improvements in swallowing performance in the pharyngeal phase with decreasing aspiration in patients with dysphagia after stroke for both CTAR and HLE (4, 9, 10), which is consistent with the results of the current study. Both exercises are therapeutic methods for improving the swallowing function of patients with dysphagia, and their therapeutic effects are the same.

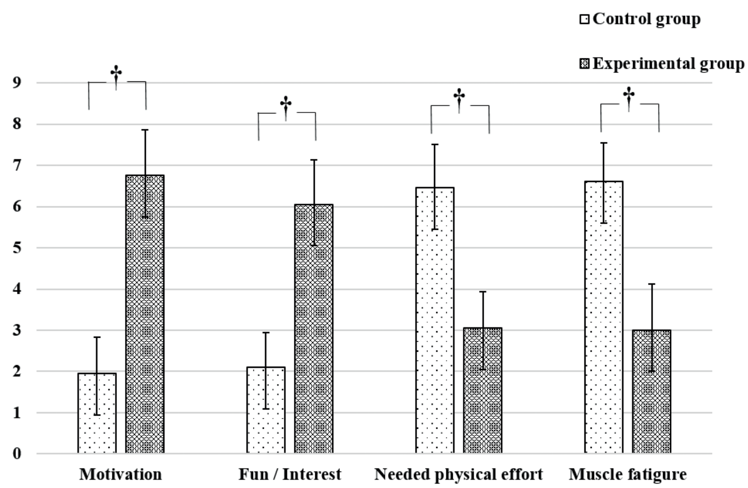

Fig. 4. Numerical rating self-report scale (motivation, enjoyment/interest, physical effort needed, and muscle fatigue).
†$p < 0.001$.

The greatest advantage of incorporating games into rehabilitation is to encourage participation by inducing enjoyment and excitement for patients (18). In particular, it is important to induce more active participation by motivating patients and piquing their interest in resistance training, which requires a lot of physical effort. Li et al. (12) reported that task-oriented repetition and patient motivation play an important role in stroke rehabilitation, and that interest, challenge, reward and competition, especially through games, can increase motivation to participate in rehabilitation. Therefore, this study assessed the effects of the 2 exercises in terms of motivation, enjoyment/interest, physical effort needed, and pain/fatigue during rehabilitation training using the 0–10 numerical rating self-report scale. The experimental group achieved significantly higher scores in the motivation and enjoyment/interest items than the control group. Conversely, the control group had significantly higher scores in the physical effort needed and pain/fatigue items than the control group, indicating that gbCTAR exercise is less physically rigorous than HLE. In fact, none of the patients in the experimental group in the current study dropped out because of physical difficulty. On the other hand, 4 patients in the control group dropped out due to temporary pain and discomfort in the neck.

Previous studies have also reported that HLE not only requires more effort from the neck muscles, but also induces sustained activation of the sternocleidomastoid muscle via surface electromyography, which is known to cause temporary pain or discomfort in the neck, thereby reducing compliance with exercise (7, 8). This finding is consistent with our results. In contrast, gbCTAR exercise can stimulate motivation, enjoyment, and interest from patients, thereby contributing to more active participation, which, in turn, increases patient compliance. The game programs induce enjoyment and interest in rehabilitation therapy, thereby acting positively to promote motor learning (19). The games also inspire, motivate, and trigger enjoyment and interest in rehabilitation by utilizing the player's intrinsic sense of competition and desire for interaction, thereby promoting learning movements (20). Therefore, the such games can contribute to successful rehabilitation as a positive factor for patients in rehabilitation.

Study limitations

The limitations of this study are as follows. First, the sample size was small, and therefore the findings are difficult to generalize. Secondly, the absence of follow-up after the intervention did not permit the determination of long-term effects. Thirdly, the findings do not reflect a pure effect of gbCTAR exercise because the exercise was prescribed together with conventional dysphagia therapy.

Conclusion

This study demonstrates that gbCTAR exercise is a therapeutic approach, which not only has a similar effect to HLE in patients with dysphagia, but is also less rigorous and more enjoyable and exciting for patients than HLE.

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The authors have no conflicts of interest to declare.

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