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Original Research

Swallowing Training Combined With Game-Based Biofeedback in Poststroke Dysphagia

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Abstract

Background: For patients with dysphagia due to stroke, in addition to compensatory strategies, exercises are used to help improve motor function. Biofeedback is used in neuromuscular training and is promising for swallowing training.
Objective: To evaluate the functional value of game-based biofeedback in swallowing therapy for patients with poststroke dysphagia.
Design: A case-control study.
Setting: Academic tertiary hospital.
Participants: Subjects with poststroke dysphagia (n = 20) were individually matched to 2 separate groups, a game-based biofeedback group (n = 10) or a control group (n = 10), for age, gender, duration of dysphagia, and dysphagia grades.
Interventions: Each participant underwent 1-hour sessions 3 times per week for a total of 16 treatment sessions. Each session included a 30-minute session of traditional swallow treatment and a 30-minute session of laryngeal elevation exercises. In the experimental group, laryngeal elevation exercises were combined with additional game-based biofeedback.
Main Outcome Measures: Outcomes assessed before and after interventions included hyoid bone displacement, Functional Oral Intake Scale (FOIS) scores, and nasogastric (NG) tube removal rate.
Results: Intergroup analyses showed larger differences in hyoid bone displacement and FOIS scores (before and after treatment) in the experimental group than in the control group, with statistical significance ($P = .007$ and $P = .014$, respectively). Intergroup analyses showed that the hyoid bone displacement change and FOIS scores before and after treatment exhibited statistically significant improvement only in the experimental group ($P = .002$ and $P = .004$, respectively). In all, 8 of 10 patients (80%) in the experimental group and 2 of 10 patients (20%) in the control group discontinued NG tube insertion after therapy. Participation in the experimental group was associated with an increased probability of tube removal (odds ratio = 6.00; 95% confidence interval = 1.08-33.27, $P = .009$).
Conclusions: Laryngeal elevation training combined with game-based biofeedback augments the change in hyoid bone displacement and FOIS scores, and increases the NG tube removal rate in patients with poststroke dysphagia.

Introduction

Dysphagia, which can result from a wide variety of disorders, is seen in 16%-64% of individuals who have sustained a stroke [1-4]. Exercise, in addition to compensatory strategies, can often improve motor function in patients who have acquired dysphagia following a stroke [5,6]. The effortful swallow and the Mendelsohn maneuver are 2 common compensatory strategies for oropharyngeal dysphagia. The effortful swallow increases the oropharyngeal swallow pressure and augments posterior motion of the tongue base [6]. The Mendelsohn maneuver prolongs and widens the cricopharyngeal opening by extending and sustaining laryngeal elevation during swallowing [6]. However, indiscernible motion or impaired sensation in the oropharynx often hinders patients' self-awareness during therapeutic procedures.

To help patients sense their deglutition, speech therapists have looked for easier methods of providing oral feedback or gestural cues [7,8]. Biofeedback uses specialized equipment to convert subconscious

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physiologic information into visual or auditory signals, helping patients to sense and manipulate physiological changes to improve their performance [9]. Although biofeedback is commonly used in neuromuscular training, it has not been widely applied to dysphagia treatment. Only a small number of investigations on biofeedback-assisted swallowing training have been conducted, with a focus mainly on laryngeal elevation by electromyography (EMG) or use of accelerometers [8,10-14]. In 1 such experiment, Crary applied biofeedback techniques on swallow training by surface EMG to 6 patients with dysphagia following brainstem strokes, resulting in 5 of the 6 patients regaining total deglutition function between 3 weeks and 7 months of therapy [12]. In another study, Huckabee and Cannito treated 10 patients through surface EMG and stethoscopes. Of the 10 patients, 8 were able to remove their nasogastric (NG) tube and regain deglutition function [8]. In previous studies, the lack of a control group, coupled with inconsistent independent variables such as frequency, intensity, and duration of treatment, affected the interpretation of the results.

Recently, the use of virtual reality or game-based biofeedback therapy has expanded to the treatment of motor disorders and other disorders in the cognitive and perceptual realms [15,16]. Virtual reality, when applied during stroke rehabilitation, allows the potential for patients to improve motor function and activities of daily living function [16,17]. Although there is promising evidence regarding the effectiveness of virtual reality biofeedback therapy, there have not been substantial applications of virtual reality or game-based biofeedback to the treatment of patients with dysphagia.

For the purpose of this study, biofeedback signals from laryngeal movement were detected by accelerometers and converted into an animation of a frog swallowing a mosquito. Repeated training with this "visualization" of the laryngeal movement may allow a greater possibility of improvement in deglutition functionality. The goal of this study was to determine the effect of incorporating game-based biofeedback into swallowing therapy on patients with poststroke dysphagia.

Methods

Subjects

We enrolled 20 patients in the study. Patients included had a history of hemorrhagic or ischemic stroke, were able to follow multiple-step orders, and had dysphagia classified as level 3 or lower on the Functional Oral Intake Scale (FOIS). Patients with nonstroke neurological disorders (eg, traumatic brain injury, brain tumor, neurodegenerative disorders, Parkinsonism), neck injuries, and surgery-induced dysphagia were excluded from the enrollment process. Informed consent was obtained from all participants, and the study protocol was approved by the institutional review board of a university teaching hospital.

The subjects had all had poststroke dysphagia for 2-72 months and had received traditional speech therapy (except laryngeal elevation exercise) for 1 month before this study. They were individually matched to either the experimental group (treated by traditional swallowing training and game-based biofeedback laryngeal elevation exercises) or to the control group (treated by traditional swallowing training and laryngeal elevation exercises). Four of 10 subjects had chronic dysphagia (>1 year poststroke) in both the experimental and control groups. Each participant underwent 1-hour sessions 3 times per week for a total of 16 treatment sessions. Each session included a 30-minute subsection of traditional swallow treatment and a 30-minute subsection of laryngeal elevation exercises with or without game-based biofeedback.

Submental ultrasonography was performed and FOIS scores were evaluated for each participant before and after the 16 treatment sessions to assess the swallowing function.

Effortful Swallow and Mendelsohn Maneuver

In this study, effortful swallowing combined with the Mendelsohn maneuver was used for laryngeal elevation exercises. For effortful swallow training, patients were asked to follow the instructions, "When you swallow, squeeze as hard as you can with all your throat muscles." Then patients were asked to continue following the next instructions for Mendelsohn maneuver: "Keep squeezing your throat muscles, and hold your larynx at the highest point. Don't let it drop, and hold it up for about 1 second" [6].

Submental Ultrasonography

Ultrasonography may provide a way to evaluate the effects of direct swallowing therapies. To measure the changes of hyoid bone displacement in dysphasic stroke patients, we implemented the method of submental ultrasonography as developed by Hsiao et al [18].

This study used an ultrasound machine with a curvilinear transducer (BS3C673 Convex Array, 3.5 MHz, BSUS20-32C; Broadsound Corporation, Hsinchu City, Taiwan, Republic of China). Images were recorded at a frequency of 22.5 frames per second. The subjects sat in an upright position with their head fixed and swallowed 3 mL of thickened water. The transducer was placed on the intersection of the midsagittal plane and the submental region to determine hyoid bone displacement (Figure 1a-c).