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Effects of Olfactory Stimulation on Swallowing Function in Taiwanese Older Adults

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Abstract

This pretest-posttest pilot study was to examine the effects of how olfactory stimulation (OS) influenced swallowing function in older adults. Forty-four community-dwelling older residents (24 OS & 20 control) from southern Taiwan were recruited. Participants in the intervention group administered pre-meal OS using odor and flavor inhalation. The study found that physiological responses for different food textures significantly differed between groups at post-test ($p \leq .02$). Within the experimental group, swallowing function, and individual satisfaction showed significant differences before and after the odor inhalation over time ($p < .01$, $\eta_p^2 = 0.16–0.33$). An individual's satisfaction to their own swallowing capacity was largely enhanced by the significant interaction between time and group ($F[1, 42] = 11.34$, $p = .002$, $\eta_p^2 = 0.21$), but not for physiological response to OS and swallowing function. The results suggest OS may be advantageous to improving physiological response to OS, swallowing function and satisfaction with swallowing capacity in older adults.

Keywords

swallowing function, olfactory stimulation, presbyphagia, aging, Taiwan

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Introduction

A decline in swallowing function is a relevant and critical facet of the natural cycle of aging. Swallowing difficulty and oropharyngeal dysphagia are increasingly frequent clinical symptoms in the geriatric population (Freitas et al., 2020; Takizawa et al., 2016; Wirth et al., 2016). The upward trend of the prevalence of oropharyngeal dysphagia is observed in 11% to 34% of community-based old and very old people (Holland et al., 2011; Wirth et al., 2016; Yang et al., 2013). Presbyphagia, difficulty in swallowing of older adults and frail aged people without a diagnosed disorder, is seen in as high as 63% to 72% (González-Fernández et al., 2014; LaGorio et al., 2017). Presbyphagia also impacts people with post-neurological disorders and injuries, such as cerebrovascular accident, traumatic brain injury, or degenerative diseases (e.g., dementia and Parkinson's diseases).

The common factors influencing geriatric swallowing ability include the weakened oropharyngeal muscles which decrease movement of the hyoid bone, and sensory dysfunction of the oral and pharyngeal cavities (Dejaeger et al., 2015; Lee et al., 2018; Wirth et al., 2016). Symptoms or complications due to changes of age-related anatomic and physical structures in swallowing are atypical and likely to be unrecognized in older adults (González-Fernández et al., 2014). If these physiological characteristics are ignored or undertreated, swallow dysfunction can result in complications such as dehydration, malnutrition, choking, aspiration pneumonia, poor quality of life, and even fatal outcomes (Ginocchio et al., 2009; Loret, 2015). Older adults are often unaware of their swallowing problems and when/whom to seek for help. This leads to the substantial issue

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of swallowing safety in the rapidly growing aging society. Therefore, it is crucial to increase providers' understanding of the mechanism of oropharynx physiology and oropharyngeal function in geriatric swallowing.

Prior studies (Loret, 2015; Steele & Miller, 2010; Wahab et al., 2010) have investigated how sensory stimulation improves swallowing performance leading to its favorable use in current swallowing treatment. Many techniques of sensory stimulation focus on the oral cavity, such as thermal stimulation (Alvarez-Berdugo et al., 2018; Magara et al., 2018), taste stimulations (Brady et al., 2016; Humbert & Joel, 2012), and combined sensory stimulations (Ortega et al., 2016; Wahab et al., 2011) with multiple levels of stimulation triggering cortical activations associated with swallowing. These sensation stimulations aim to activate and modulate receptors' sensitivities to facilitate the onset of the swallowing mechanism to achieve the most effective timing for passing the bolus. However, the use of olfactory stimulation (OS) is seldom seen clinically. Noticeably, olfaction is the only sensation routed directly to the cerebral cortex without bypassing the thalamus (Bear et al., 2016; Sharma & Matsunami, 2014). The olfactory sensory neurons project their axons to the primary olfactory cortex, which involves the olfactory nucleus, piriform cortex, lateral enterorhinal cortex, olfactory tubercle, and the amygdala. Such a long projection disperses throughout the brain (Sharma & Matsunami, 2014).

There has been some evidence supporting the relationship between olfactory sensation and swallowing in previous research. Viewed as a role of sensory-motor integration, one of the olfactory pathways connects directly to the insular cortex which is responsible for the production of voluntary swallowing (Ebihara et al., 2006). Steele and Miller (2010) reported that olfactory sensation increased saliva secretion to improve swallowing ability. Our preliminary data, testing a rat model in a fundamental *study*, revealed that the volatile molecules via olfaction might have activated the neuronal reactivities related to swallowing in the brainstem as well as enhance the associated muscular activities, such as increased c-fos immuno-expression in the nucleus tractus solitaries (NTS), changes on frequency, amplitude, and duration of the intramuscular contraction (Chen et al., 2017; Chen et al., 2019). Other effects also caused by specific odors were noted, including anti-inflammatory, anti-anxiety, anti-stress, antinociceptive, and anti-aging effects (Buckle, 2015). Studies examining the role of odor as a neurotransmitter have been supported in human cognition process (Ayaz et al., 2017; Wang & Heinbockel, 2018), but absent in aging swallowing. In addition to odor stimuli, the combined effects of olfactory, and gustatory stimulations were studied in relation to swallowing dysfunction (Wahab et al., 2010, 2011). Using combined sensory stimuli, such as lemon taste and odor through sensation stimulation, resulted in activating the neural activity of the submental muscles to influence swallowing in healthy adults. The odor plus flavor stimulation triggers a cluster of neural information carried directly to the cortex to process smell identification and discrimination collectively.

Taiwan has become one of the more aged countries in the world, indicating that old people are healthier and living longer (Tahara, 2016). The National Development Council (2018) has predicted that by 2026 the "super-aged" Taiwanese society, defined as adults over 65, will comprise 20.7% of the population versus 14.5% in 2018. The impact of geriatric functional impairment, such as swallowing difficulty or oropharyngeal dysphagia, has arisen as an urgent need in Taiwanese society. The World Health Organization (WHO, 2017) has recommended that the impact of declined intrinsic capacity (e.g., aged swallowing) will be improved with proactive interventions to maximize and maintain functional ability for old adults in the community. To date, there is relatively little research associated with OS, specifically the therapeutic effect of olfaction and the associated physiological influence on swallowing of older adults. Therefore, extending the preliminary results with rats (Chen et al., 2017; Chen et al., 2019), this study aimed to understand the effects of OS on the swallowing function of older community residents.

The following three research questions were examined in this study: (1) In comparison with older adults not receiving OS, were there differences in swallowing-associated physiological response to OS, swallowing function, and satisfaction with swallowing capacity?, (2) Were there differences between pretest and posttest of physiological response to OS, swallowing function, and satisfaction within each study group?, and (3) Was there a main effect of time and/or an interaction effect by time × group on the study variables?

Methods

A pretest-posttest comparative design was used to understand the relationship between smell stimulation and swallowing. The effect of smell stimulation with and without odor and flavor inhalation was investigated among the community-dwelling older adults. This study protocol was approved by the University of Taipei Institutional Review Board (UT-IRB Number: 2018-048).

Participants

Older adult residents from community centers in southern Taiwan were approached and the written consents were obtained from all participants prior to participation in the study. Each participant was assigned to either the intervention or control group using the covariate adaptive randomization procedure. This procedure was applied to reduce and minimize the covariate bias for group variations (Osman, 2016). Age and gender were balanced in both groups.

Table 1. Demographic Characteristics of the Study Participants.

Characteristic items	Total (N = 44)	Intervention group (N = 24)	Control group (N = 20)
Age in years (M ± SD)	74.0 ± 8.2	74.5 ± 8.3	73.3 ± 8.2
Range	(60.5–92.0)	(60.6–92.0)	(60.5–88.4)
Gender: Female (n; %)	29 (65.9)	16 (66.7)	13 (65.0)
Education (n; %)			
Non-literate	7 (15.9)	3 (12.5)	4 (20.0)
Elementary-middle school	15 (34.1)	10 (41.7)	5 (25.0)
High school	10 (22.7)	6 (25.0)	4 (20.0)
College and above	12 (27.3)	5 (20.9)	7 (35.0)
Residential location (n; %)			
City	19 (43.2)	13 (54.2)	7 (35.0)
Suburban	25 (56.8)	11 (45.8)	13 (65.0)

Note. M = mean; SD = standard deviation.

Adults who met the following criteria were eligible: (1) aged greater than 60 years old, (2) living in communities or long-term care institutions, (3) cognitively intact and passed the test of lemon inhalation (a positive verification), (4) able to eat oral food, and (5) agreed to perform and cooperate with the study protocol (e.g., receiving the OS in the intervention group) during the study time period. Adults were excluded if they had (1) chronic health conditions, including diabetes mellitus, hypertension, and chronic nasal congestion, (2) history of any neurological damage or disease such as dementia, Parkinson's disease, stroke, traumatic brain injury, and/or (3) head and neck structural abnormality, for example, larynx, tongue cancer, oral cancer post-operation, post-concurrent chemoradiation therapy, or cleft palate/lip. Older adults regularly taking medications for chronic diseases were not eligible to participate due to the swallowing response caused by the side effects of the disease-associated medications.

Forty-four older adults (24 in intervention and 20 in control) were included. As shown in Table 1, participants were more likely to be suburban females with an average age of mid-70s (range: 60.5–92 years old) with at least an elementary level of education. The baseline demographics did not differ between groups ($p > .05$).

Intervention Protocol

The study intervention employed OS, via neutral nasal inhalation, to examine swallowing associated outcomes in older adults. The patented compound essential oil which consisted of four distinct types of oils was used to excite olfactory responses. This blended smell produced by a formulation of essential oils manifested in promoting geriatric swallowing (Chen et al., 2017; Chen et al., 2019). And, to preserve potency, a supplementary carrier oil or jojoba oil was used with the mixed essential oils to moderate and stabilize the nature of the 100% perfumed oil. The essential oil inhaler, similar to a lip balm in appearance, was a plastic tube measuring 6.5 cm × 1.5 cm × 1.5 cm. One piece of wick-like material was placed inside the plastic tube, fully soaked with the fragrant oils. The study package with the materials and operational directions was given to each participant prior to the start of the protocol.

Participants were asked to position the nasal oil inhaler approximately 1 to 2 cm from each nostril and smell the combined odor and flavor for 1 minute per nostril. Completing an inhalation of both nostrils was counted as a cycle. Taking short smell breaks (5 seconds each) was encouraged to prevent olfactory fatigue prior to repeating the next cycle. To reach the maximum stimulation intensity, participants conducted five cycles of the oil inhalation for a total of 10 to 12 minutes before each meal, three times per day. They were asked to record their responses post-olfactory stimulation in a diary.

Variables and Measurements

The study measures examined physiological response to OS, swallowing function, and satisfaction with swallowing capacity. Using three types of textures, two instruments were used to objectively assess muscle contraction during swallowing as physiological response to OS by surface electromyography (sEMG) and swallowing function by Bedside Evaluation of Dysphagia (BED) Screening. Satisfaction with swallowing capacity was evaluated by Simple Swallowing Self-evaluation Questionnaire (SSSEQ) which was developed for this study.

Surface electromyography (sEMG). The swallowing-associated muscle contraction is a parameter of physiological response to OS examined by sEMG in MicroVolt (μV). It is a technical program to record neural conduction of the submental muscles in response to electrical stimulation during water and solid swallowing. The

Guardian Aspire2 SwallowStim (Spectramed LLC, 2020) was used to record electrical activities of the submental muscles during swallowing. The Guardian Aspire2 biofeedback device captures the objective data (sEMG) by detecting the electrical signals in a small muscle during the dynamic process. Product training was conducted prior to using the device. This portable device was convenient and easily operated. Connected to the wireless iPad Pro, the electrical waves were recorded as an image for further analysis of the maximum amplitude of the muscular contraction.

Bedside evaluation of dysphagia (BED) screening. Swallowing function was examined using sub-items of the revised BED Screening (Hardy, 1995, 1999). The standardized BED estimates the potential risks of dysphagia and determines swallowing safety in adults. The screening sheet is scored by yes/no responses in identifying medical, behavioral, and oral-motor issues and observation of liquid/food swallows. When any "yes" response is detected, it indicates the potential presence of a swallowing problem. Clinicians then use the response results to determine whether more advanced assessment is recommended.

Using the selected items from the screening sheet, our study examined the situational condition with liquid/food swallows. Three types of textures were evaluated by six condition items during the swallowing process, respectively. The six conditions were pocketing of material/residual in the oral cavity; multiple swallows per bolus; delay in triggering pharyngeal swallow; coughing or choking before, during, or after swallow; change in voice quality, and impaired laryngeal elevation. The numerical score points (0, 1) were denoted, and a total score was summed for each screening item. Specifically, while "yes" could be marked for any of the conditions, one point was given to indicate the swallowing problem existed; whereby a zero point was given for the "no" problem being observed. This screening section has the potential score range of 0 to 18 representing any objective dysfunction measured. Based on the rules of the BED Screening, "no ticks" are recommended for normal swallowing. Low scores suggest a better swallowing function in the study sample. By the BED Screening, it was not surprising that over 80% of the study sample were detected as suspected cases of geriatric dysphagia.

The Simple Swallowing Self-evaluation Questionnaire (SSSEQ). Self-rated satisfaction with swallowing capacity using the SSSEQ aims to reflect an individual's quality of life in association with the act of swallowing. Considering Taiwanese culture, the SSSEQ was developed due to lack of a valid swallowing survey in Mandarin and Taiwanese languages. Adopted from the widely used Eating Assessment Tool (EAT-10; Belafsky et al., 2008), the SSSEQ is composed of 10 questions to evaluate an individual's swallowing ability. It is a 5-point Likert scale with a total score of 40 points, rating from "0," no problem, to "4," a severe problem in swallowing. The lower the total score, the better the swallowing satisfaction. Prior to its use for this study, pilot testing was performed to evaluate the initial instrument psychometrics. The results validated the Mandarin/Taiwanese SSSEQ by good expert validity according to Bolarinwa (2015). The test-retest reliability using this study sample was also established ($r=0.81$, $p<.001$). The SSSEQ was considered as a reliable self-rating scale to evaluate swallowing difficulty for people speaking the traditional Mandarin Chinese. It was used in this study to measure one's satisfaction with their own swallowing capacity.

Data Collection Procedures

During the baseline interview, background information of the participants was obtained, including sex, age, education, residential location, and eating habits. Each participant was asked to complete three study assessments. Three types of textures, thin-liquid (water), semi-liquid (pudding-like jelly), and solid (a 4 × 4-cm soda cracker), were used to observe swallows by testing BED Screening and sEMG before and after the study intervention. The pre-test was conducted at study Day 1 during the baseline interview and the post-test was scheduled at Day 14 to end the study. When administering the BED Screening test, the sEMG device measured the muscular activities under the conditions of consuming the three textures. Electrodes were placed on the skin surface of the submental muscles and then connected to the sEMG device. The electrical dynamic waves were observed and recorded through an iPad. The study intervention using the odor and flavor stimulation lasted for 12 days (Day 2–13). The odor mixture was refilled in the inhaler every four days to keep the fragrance constant and fresh; the daily performance sheet was checked and monitored at the same time. This was also the time when participants were encouraged to ask questions related to the odor inhalation. It took 30 to 50 minutes to complete each interview and all required assessments. A daily phone follow-up was conducted to boost and maintain participants' adherence to the protocol. Two weeks after the initial interview, pre-test and post-test measures were administered and obtained from both groups. At least three visits to each participant's home were performed to complete data collection.

Statistical Analyses

Data were entered in Microsoft Excel and analyzed by Statistical Package for Social Science (IBM SPSS Statistics, Version 20). Individual baselines were summarized by descriptive analyses. Patterns of the changes on each study variable were observed over time and displayed by line graphs. Outliers of the study variables were identified and managed prior to conducting

Table 2. Comparisons of the Study Variables in Intervention and Control Groups.

Variable \ Time	Intervention group ($n=24$)				Control group ($n=20$)			
	Pretest	Posttest			Pretest	Posttest		
	Mean (SD)		*t*	*p*	*Mean (SD)*		*t*	*p*
sEMG(μV)								
Thin-liquid	376.99 (144.7)	↑397.00 (172.3)	–	NS	266.27 (112.7)	↑286.40 (119.6)	–	NS
Semi-liquid	405.65 (172.4)	↑438.56 (178.5)	–	NS	332.18 (124.9)	↓308.32 (95.4)	–	NS
Solid	521.62 (163.9)	↑551.67 (197.5)	–	NS	450.00 (177.5)	↓418.78 (159.4)	–	NS
BED Screening	4.71 (2.4)	↓3.75 (1.6)	2.10	.047	4.05 (1.4)	↓3.50 (1.4)	2.46	.024
SSSEQ	2.75 (2.6)	↓0.79 (1.2)	4.82	<.001	1.60 (1.5)	↓1.30 (1.2)	–	NS

Note. SD = standard deviation; sEMG = surface electromyography in μV (MicroVolt); BED Screening = revised version of Bedside Evaluation of Dysphagia Screening; SSSEQ = Simple Swallowing Self-Evaluation Questionnaire; NS = non-significant ($p > .05$).

inferential statistics. Two samples of student *t*-test and paired *t*-test were taken to compare between and within group differences. Further, a mixed-design, two-way repeated measures analysis of variance (RM-ANOVA) evaluated the combined effects to expand our understanding of the intervention for geriatric swallows. The procedures of two-way 2 × 2 RM-ANOVAs were conducted separately to identify the main effects by within-subjects factor of time (Day 1 and Day 14) and between-subjects factor of group (intervention vs. control), as well as the interaction effect of the combined time × group on each measure of the variables. Effect size to detect intervention difference was determined by partial eta squared (η_p^2) coefficient (Cohen,1988). Statistical significance was set at .05 or less.

Results

Intervention Effect of OS

Within-group difference. Among the intervention participants, significant differences were shown in swallowing function (BED Screening), and swallowing satisfaction (SSSEQ) after OS. In Table 2, as compared with pretest, the post-test scores of the BED Screening, and SSSEQ were lower, indicating better swallowing function and swallowing satisfaction ($M=4.71$ vs. 3.75, $t=2.10$, $p=.047$ & $M=2.75$ vs. 0.79, $t=4.82$, $p<.001$, respectively). For the control group, statistical difference was unexpectedly identified pre- and post-BED Screening ($M=4.05$ vs. 3.50, $t=2.46$, $p=.024$), but not in SSSEQ ($p>.05$). Of the BED Screening items assessed, the two most common swallowing symptoms reported were "multiple swallows," and "delay in triggering pharyngeal swallows." The sEMG results within each group had not shown differences during the intake of three textures. Even though not significant, an increased sEMG was consistently noted for the intervention group, but not the control (see Figure 1).

Between-group difference. The significant differences between groups mainly appeared at post-test sEMG for all three textures (thin-liquid: $t=2.50$, $p=.016$; semi-liquid: $t=3.08$, $p=.004$; solid: $t=2.42$, $p=.02$, respectively). There were no differences on BED Screening and SSSEQ in pretests and posttests ($p>.05$).

Time × Group Interaction Effect

In addition to the group main effect described previously, the results from repeated measures of ANOVA revealed that the significant interaction between time and group was effective on swallowing satisfaction ($F[1, 42]=11.34$, $p=.002$, $\eta_p^2=0.21$; Table 3). The largest intervention effect, as measured by the mean scores of SSSEQ, depended upon the timing of the assessments. Presenting the same pattern of the downward crossover slopes in both groups, the pre-SSSEQ score was higher than the post-score (intervention group: $M=$ pretest 2.75 vs. posttest 0.79; control group: $M=$ pretest 1.60 vs. posttest 1.30, respectively). The scores of the SSSEQ decreased by time; specifically, the intervention participants at post-test had the lower mean score, indicating a better satisfaction with swallowing capacity than the controls. In contrast to swallowing satisfaction, there was no interaction effect on swallowing function and maximum amplitude of sEMG for three textures ($p>.05$, see Table 3).

Discussion

This study aimed to examine the effects of OS on geriatric swallowing function. The findings substantiated the effects of OS on swallows of older adults. Physiological responses to OS (or muscle contractions) in post-sEMG differed significantly between groups. Of the group receiving OS, positive changes were observed in swallowing function and satisfaction over time.

The participants using the odor and flavor inhalation demonstrated the maximum amplitudes of muscle contractions across all testing textures of water, semi-liquid, and solid. Although evidence of this is lacking in the previous literature, similar swallowing patterns were revealed (Ko et al., 2021; Molfenter et al., 2019).

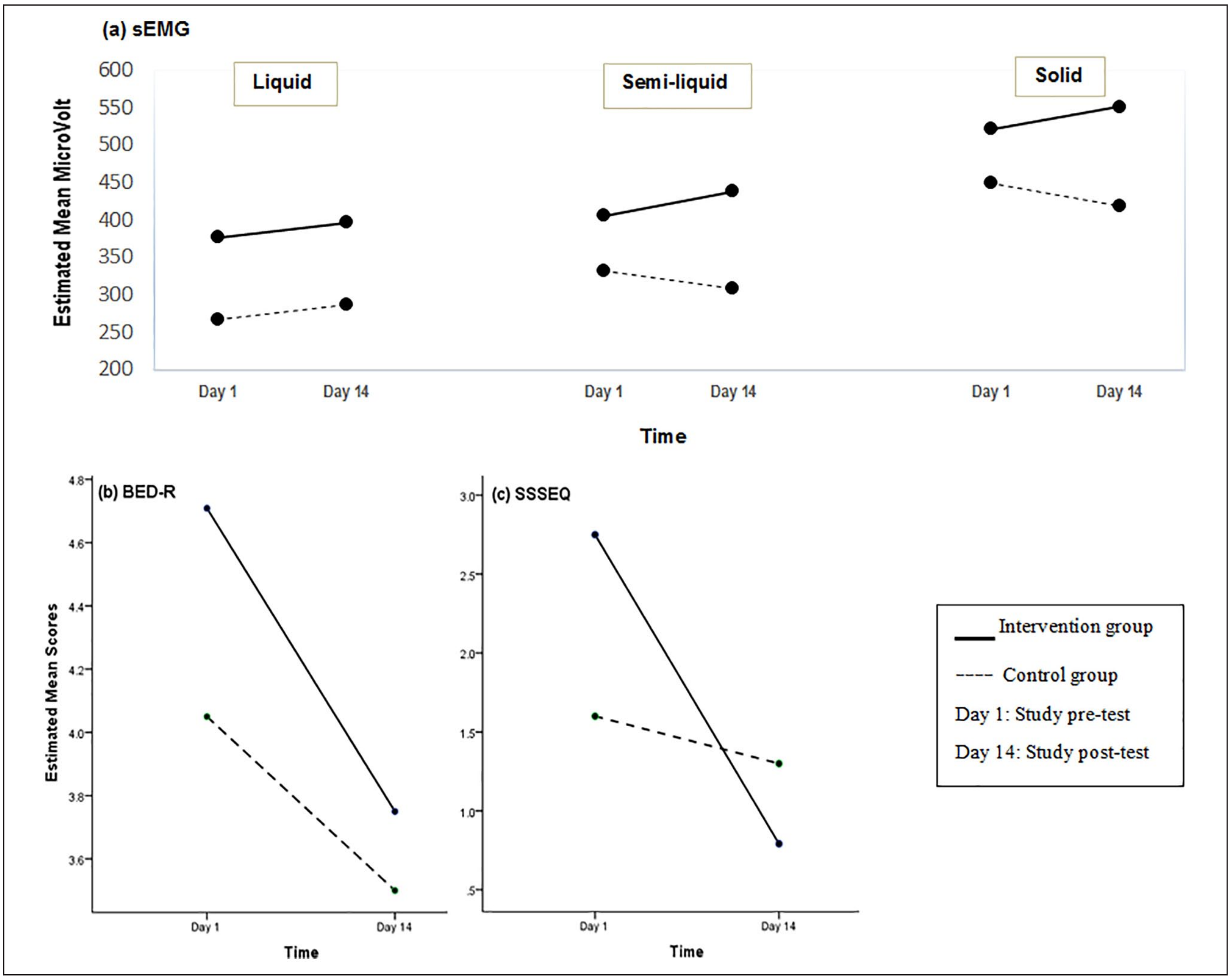

Figure 1. Pattern changes in swallowing variables before and after the study: (a) a consistent, positive pattern of surface electromyography (sEMG; μV) in three textures was observed at two time-points in the intervention group. In the control, the sEMG was decreased at post-test for semi-liquid and solid, (b) the parallel lines were shown on the improved swallowing at post-test for both groups, and (c) satisfaction with swallowing capacity had a similar direction from pre-test to post-test on both groups, whereas the interaction effect of OS (yes/no) and time (day 1 vs. day14) was significant on changes in swallowing satisfaction.

Muscular amplitudes were consistently increased in aged people while changing food/liquid viscosity or volume in swallowing. Ko et al. (2021) found that greater viscosity of bolus consistency resulted in a higher amplitude, in particular the maximum amplitude seen prior to the "main-onset" motion in a geriatric swallow. Such adaptation during the swallowing process was observable in those with presbyphagia, as well. To promote a safe swallow, the consistencies of liquids (soft), and foods (hard) vary to generate different muscular amplitudes. A similar pattern was observed in the intervention group of this study although not statistically significant. This apparently supports a pivotal role of the submental muscles in pharyngeal swallows, including carrying sensory information, connecting to the protective reflexes (e.g., swallowing reflex, cough reflex), and projecting to the brainstem (Gallas et al., 2010; Kiyohara et al., 2012; Seikel et al., 2015).

The activation of submental muscles is increased in line with neural changes and effects (Gallas et al., 2010; Wheeler et al., 2007). Wheeler et al. (2007) found that activating the submental muscles in the dry-swallow (a harder viscosity) versus water-swallowing (a soft viscosity) training showed higher peak and greater amplitudes on average in EMG activity. In our study, the participants receiving the odor and flavor inhalation were able to expend greater muscular efforts to swallow semi-liquid and solid foods, indicating strengthened submental muscle force after OS. Such increased muscular efforts may be a result of the biomechanical changes being elicited by mixed or multiple types of odor inputs via olfaction. Consequently, the sensory-motor network occurring in the NTS and the nucleus ambiguus of the brainstem are triggered by facilitating swallow post food bolus propulsion, as well as activating muscle contractions (Steel & Miller, 2010; Wahab

Table 3. Main and Interaction Effects of Physiological Response to Olfactory Stimulation, Swallowing Function, and Satisfaction with Swallowing Capacity in Older Adults.

Variable	Main effect: group	Main effect: time	Interaction effect: group × time
	^{a}F (η_p^2)	^{a}F (η_p^2)	^{a}F (η_p^2)
Physiological response to olfactory stimulation			
Thin-liquid	F (1, 42) = 7.56 (0.15)**	NS	NS
Semi-liquid	F (1, 42) = 5.79 (0.12)*	NS	NS
Solid	F (1, 42) = 4.48 (0.10)*	NS	NS
Swallowing function	NS	*F* (1,42) = 7.78 (0.16)**	NS
Satisfaction with swallowing capacity	NS	*F* (1,42) = 21.02 (0.33)****	*F* (1,42) = 11.34 (0.21)***

Note. η_p^2 = partial Eta squared; NS = non-significant ($p > .05$).
[a]This was the results of two-way repeated measures analysis of variance (ANOVA).
*$p < .05$. **$p < .01$. ***$p < .005$. ****$p < .001$.

et al., 2011). In addition, the substantial change made by submental muscles must reach a cellular level known as neural plasticity to achieve a long-term effect on the cortical alternations (Papathanasiou et al., 2017). Likewise, Wahab et al. (2011) reported that flavor successfully increased amplitude and duration of submental muscle contraction post-stimulation in both measures of the EMG and motor-evoked potentials. Their study demonstrated that the biomechanical changes represented cortical plasticity. A recent study (Cheng et al., 2020) illuminated further that when the pharyngeal motor cortex was activated, metaplasticity (or a higher order plasticity) as well as alternation of swallowing behaviors were generated, such as enabling compensatory mechanism during a swallow. Overall, from previous research, the swallowing associated assessments and interventions were focused and administered mainly with volitional swallowing. For instance, participants would swallow when given an instruction. Our OS was reflexive and voluntary, oriented by inhaling odors prior to each meal, through activation of olfactory cortical processing areas (volitional priming) and fragments to stimulate odor receptors in the nose and oral cavity. That might be the best reason for better performance by our intervention participants. Salient over-time effects existed in the present study using odor and flavor inhalation which might facilitate motoneuron recruitments in the cortex and its pathways to enhance geriatric swallowing. The findings thus supported the study hypothesis that OS might have the potential to improve geriatric swallowing function and further demonstrate the previous literature.

Similar patterns of swallowing changes with varied food consistencies appeared in both groups. Particularly, two symptoms seen in the BED Screening differed before and after the study: multiple swallows in one texture and trigger delay in pharyngeal swallow. We found that most of the participants experienced the suspected swallow dysfunction as a delay in triggering pharyngeal swallow. They seem to have adopted compensatory strategies to produce a safe swallow, such as pocketing material/residual in the oral cavity, coughing or choking before, during or after swallow which was congruent with the previous literature (Aslam & Vaezi, 2013; Ebihara et al., 2006). According to Aslam and Vaezi (2013), degrees of oral temporal and pressure changes in geriatric swallows were caused by age-associated cerebral anatomical and nervous deteriorations, producing decreased peripheral muscle mass. Ebihara et al. (2006) suggested that improving sensory and reflexive swallow movements would contribute to shortening reflex latency and reduce bolus residuals around the piriform recesses. A potential explanation for the change in post-study swallow function in the control group could be otherwise related to older people's intention to adjust or modify their swallowing performance, and thus improving self-perception. As many of them perceived no problems in swallowing or eating difficulty, such purposive adjustment of swallow behavior may have been affected by their experiences in the pre-test, and/or being kind to help investigators via data collection.

This was the first study to substantiate the effect of OS in enhanced swallowing function and satisfaction among community-dwelling older adults in Taiwan. In regard to self-rated satisfaction to safe swallowing capacity, the most common problem being encountered was "choking and coughing when swallowing." Choking happened during swallowing when many of them tended to eat a meal with a mixed consistency (the solid and liquid), when eat quickly, or while talking and eating. Unlike in younger people, aged vocal folds adjust less easily to coordinate with the muscles for speech, swallowing, and inhaling; thus, easily cause choking. These statements were compatible with previous reports (Cichero, 2018; di Pede et al., 2016; Ozaki et al., 2010). Older adults were more likely to take a mixture food as the consequence of their dry mouth as an effect of normal aging. Other personal factors, such as tooth loss, poor dental status, eating behavior, or habit, could also contribute to the risk of choking (Cichero, 2018; di Pede et al., 2016). These physical changes restrict adequate use of the submental, lingual, and oro-facial muscles, evoking the occurrence of choking. On the other hand, in a videofluorographic swallowing study with multi-food textures, Ozaki et al. (2010) found that the pudding-thick texture was least likely to induce aspiration; the risk of aspiration was highest with the intake of a two-phase mixture of food (e.g., corned beef hash and thin liquid). In contrast, honey-thick liquids were found to be easier to swallow than any other viscosity (Butler et al., 2009). In our study, the intervention participants tended to be those who were highly motivated to adhere to the study protocol. Their satisfaction was recognized with positive changes in swallowing, but not so for the control group.

Limitations and Future Research Implications

This study was conducted in community-dwelling aged Taiwanese adults without major swallowing problems or health conditions. Thus, the results may not apply for adults undergoing severe dysphagia, neurological injury/disorder, or residing in other countries and cultures. To be culturally sensitive, the Mandarin and Taiwanese versions of the SSSEQ were developed and initially tested the psychometrics using this sample. Further assessments are needed in validating the measurement with other Chinese-speaking populations. When conducting a baseline measure, the difference of muscle contraction was observed while drinking water bolus. Muscle contractions in drinking water vary largely among older adults (Butler et al., 2009; Ko et al., 2021). The small sample size may impact the sEMG results as well as other group comparisons.

Geriatric swallowing performance in current study was measured by the submental muscular amplitudes, swallow screening, and satisfaction. Comprehensive evaluations combined with cognitive and other objective physiological examinations are recommended to fully determine levels of swallowing difficulty. Furthermore, even though a homogeneous sample was employed, individual variations (e.g., personal eating habit and experience) were noted during the study process which could distort the results and should be further considered. As our study participants self-enrolled to either study group based on the individual's preference, it might have contributed to potential selection bias. Future research applying random assignment with a larger sample will help minimize the study bias and validate the true intervention effects.

Conclusion

The study results indicate that OS may positively impact geriatric swallowing function. Olfactory stimulation using odor and flavor inhalation had a moderate-to-large effect on the improvement of aged swallowing function and satisfaction. These results illustrate that a positive relationship between OS and swallowing function may exist in presbyphagia. Given that this was a pilot study, the promising effects of OS need to be further strengthened and validated. The clinical implications would benefit by conducting a randomized trial with a large, representative sample of healthy versus neurologically impaired older adults which would warrant in detecting the intervention effects.

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Ethical Approval

The study protocol, including all procedures and materials, was approved by the University of Taipei Institutional Review Board (UT-IRB Number: 2018-048, Principal Investigator: Y. T. Chen) prior to beginning the study.

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