

# Improvements in oral functions of elderly after simple oral exercise

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**Purpose:** Conventional oral exercises in previous studies are considered impractical for continuous use in the elderly because of the extended duration needed for effective outcomes. Therefore, in the present study, a simple oral exercise (SOE) was developed to reduce performance time, focusing on improvements in mastication, salivation, and swallowing functions. The aim of this study was to determine the short-term effects of the SOE with respect to improving mastication, salivation, and swallowing function in elderly subjects  $\geq 65$  years of age.

**Patients and methods:** The study included 84 subjects, all of whom performed the SOE 2 times per day for 1 week. Masticatory performance was assessed using the mixing ability index (MAI). Unstimulated saliva and the degree of moisture of the tongue/buccal mucosa were evaluated, and the repetitive saliva swallowing test was performed. On the basis of each of these four measurements, subjects were dichotomized into two groups with high (good) and low (poor) conditions. The same evaluations were conducted before and immediately after intervention, as well as after 1 week of intervention. A subjective evaluation with questionnaires was performed after 1 week of intervention. The changes were analyzed using repeated-measures ANOVA, Cochran's Q test, and McNemar's test.

**Results:** The mean MAI increased by 6% immediately after the intervention, and by 16% in the poor-chewing group. Similarly, the amount of unstimulated saliva increased by 0.1 ml/min immediately after the SOE, and by 29% in the poor-salivation group. The degree of tongue moisture increased by 3% and was maintained. In the poor-swallowing group, 25% and 40% of the subjects were upgraded to the good-swallowing group immediately after intervention, as well as after 1 week of intervention, respectively. The subjects experienced less discomfort as their oral function improved.

**Conclusion:** The SOE was effective in immediately improving oral functions, and improvement was maintained for 1 week.

**Keywords:** deglutition disorders, elderly, mastication, oral exercise, salivation, xerostomia

## Introduction

Oral health is closely related to systemic health, and poor oral health can lead to deterioration of systemic disease.<sup>1</sup> Impaired oral health affects dietary habits, nutrition, sleep, mental status, and social relationships.<sup>2</sup> It is important for elderly individuals to improve and/or maintain oral function because this population exhibits various risk factors that threaten oral function; moreover, such individuals are susceptible to various diseases based on aging-related changes in bodily functions.<sup>3</sup>

Among oral symptoms, decreased salivation in the elderly may cause various diseases, such as oral soft tissue disease, dental caries, periodontal disease, and oral candidiasis.<sup>4</sup> In addition, xerostomia—the subjective sensation of dry mouth—can

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cause speech and mastication problems, as well as dysphagia, thus reducing quality of life.<sup>5,6</sup> Therefore, measures to alleviate hyposalivation and xerostomia should be implemented to improve quality of life and overall health in old age. However, chemical agents used to relieve dry mouth may cause side effects and often require a prescription.<sup>7</sup>

Furthermore, masticatory and swallowing functions in the elderly are closely related to general nutritional status and quality of life. As the first step in the digestive process, mastication has been reported to affect both physical and mental health, and is a major factor in maintaining a healthy diet.<sup>8–10</sup> A decline in swallowing function may lead to severe pneumonia or respiratory disease.<sup>11</sup> However, masticatory and swallowing functions can be restored through muscle-strengthening activities and rehabilitation.<sup>11,12</sup> Several previous studies have reported that restoration of masticatory function can be achieved by improving muscular strength; notably, the effects of physical oral exercises (similar to those proposed by Hakuta et al<sup>13</sup>) have been described.<sup>13–16</sup>

Thus, oral exercise has been introduced to improve weakened oral function in the elderly. Oral exercise is part of a rehabilitation strategy initiated in Japan in 2002.<sup>17</sup> The program is easy to teach and follow, and includes oral stretching and exercise. The program was introduced in Korea by Cho et al<sup>17</sup> in 2012, with some modifications based on Korean situation; subsequently, it has been widely used to improve oral health in the elderly, both in public health and in dental clinics. Several previous studies have reported improvements in salivation, relief of oral dryness, swallowing function, subjective chewing ability, and oral health-related quality of life, on the basis of follow-up 3–6 months later.<sup>13,16–19</sup> Most studies have evaluated only the long-term effects of the program because they were performed in community-based programs at senior citizens' centers. However, individuals experiencing mouth discomfort may expect that their oral function will recover rapidly after any intervention. Therefore, continuous progress can be facilitated by short-term improvement of oral function through oral exercise, which then further motivates patients. Second, time can be an important factor in the maintenance of continuous engagement in oral exercises. Notably, the oral exercise programs that were used in previous studies involved only physical exercise, without oral health education, for  $\geq 20$  min.<sup>17</sup> Therefore, there may have been practical limitations that impacted the abilities of elderly individuals to continuously perform these exercises.

Accordingly, in the present study, a simple oral exercise (SOE) was developed to reduce oral exercise performance time to and be completed in approximately 2 min, focusing on improvement in mastication, salivation, and swallowing functions. We attempted to design the SOE intervention to produce immediate improvements in oral functions; this would enable it to be used as a preparatory exercise before meals, thereby providing elderly subjects with adequate nutrition by reducing their discomfort during eating. We also expect that the SOE might be useful as an early intervention to prevent aspiration pneumonia, which is the most common cause of death in the elderly population.<sup>19,20</sup> In the present study, oral functions related to nutrition intake in the elderly were classified into three factors: mastication, salivation, and swallowing; each was evaluated using objective measurements. In particular, we aimed to evaluate masticatory function more precisely and objectively using a wax cube, which aids in simulation of the actual masticatory process. The primary aim of this study was to evaluate the immediate effects of the SOE on mastication, salivation, and swallowing function in elderly individuals  $\geq 65$  years of age.

## Material and methods

### Participants

This was a short-term interventional study of elderly individuals  $\geq 65$  years of age who were recruited from a senior citizens' center located in a metropolitan area of Korea between April 2017 and June 2017. The number of subjects at baseline was 116, and denture wearers were included. Edentulous individuals who did not wear dentures and those who had been diagnosed with severe periodontal disease through oral examinations were excluded. Those who received dental treatment during the study period, or who had incomplete data collection, were also excluded from the analysis. A total of 84 subjects were included in the final analysis. The average number of present teeth in the subjects was  $18.1 \pm 8.4$  at baseline. No patients were treated for Sjögren's syndrome, had received therapeutic irradiation, or were on medications, such as antidepressants, psycholeptics, or those used to treat urinary incontinence; all of these factors have been related to suppression of salivation.<sup>21</sup>

All subjects received written and oral explanations describing the purpose and methods of the study, as well as confidentiality practices and their ability to withdraw from the study; they all then provided written informed consent. This study was conducted in compliance with the

Declaration of Helsinki and approved by the Institutional Review Board of Yonsei University (Seoul, Korea; No. 2–2016-0034).

## Simple oral exercise (SOE)

SOE training was provided by one trained dental hygienist. The SOE intervention was performed for approximately 2 min after simple oral health education. The SOE intervention included only exercises for mastication, salivation, and swallowing from among the exercises modified by Cho et al<sup>17</sup> which included lip stretching, tongue stretching, cheek stretching, masticatory muscle exercise, and swallowing movements. Subjects were instructed to perform the SOE intervention as preparation before meals at home each day. A leaflet illustrating the motion was distributed to all subjects, who performed the SOE intervention 2 times per day. The training was conducted in groups of five subjects.

## Study protocol

The study was performed at the Dental Hospital of Yonsei University of College of Dentistry. Evaluations of oral functions were conducted before the intervention. The same assessments of oral functions were performed immediately after the intervention, as well as after 1 week of intervention, to examine both temporary effect and short-term effects of the SOE intervention. After 1 week of home-care, subjective assessment was measured along with evaluation of oral functions.

## Subjective measurement

Sociodemographic characteristics were surveyed. In addition, modified questionnaires described by Torres et al<sup>22</sup> and Fox et al<sup>23</sup> were implemented using “yes” and “no” nominal scales, in order to assess discomfort in mastication, swallowing, and dry mouth. Two researchers reviewed the details of each questionnaire to ensure comprehension among subjects.

## Objective measurement

Subjects were divided into one of two groups—good and poor function—using appropriate criteria for each oral function (mastication, salivation, and swallowing function). Each oral function was evaluated according to the degree of change in each group.

## Evaluation of masticatory performance

The mixing ability index (MAI), which is an objective evaluation of masticatory function previously described by Sato

et al,<sup>24</sup> was calculated using a modified method described by Jeong et al<sup>25</sup> MAI was significantly correlated with the sieving method, which has been used as a “gold standard” assessment of masticatory performance.<sup>26</sup> Two-color wax cubes (12×12×12 mm<sup>3</sup> [made from red and green utility wax rods]) were used as artificial food. Each subject was provided with two wax cubes and required to chew one cube for 10 strokes in a habitual manner. The chewed wax samples were rinsed with water and dried at room temperature.

Dried specimens were photographed on both sides using a digital single-lens reflex camera (D80, Nikon Co., Tokyo, Japan) under standardized conditions of distance and light. All images were saved as JPEG files and analyzed using an image analysis program (Image-Pro plus® version 6.0, Media Cybernetics Inc., Bethesda, MD, USA). In each image, the total area of the specimen, area with  $\leq 50$   $\mu$ m thickness, the maximum length and the maximum width, and area without color mixing were calculated. Using the above variables, the MAI was determined, in accordance with the method used in previous studies:<sup>25,27</sup> namely, MAI was analyzed for each specimen and calculated.<sup>27</sup> The average MAI of two specimens was then used as a representative value. The MAI score was calculated on a scale of 0–100 points. A higher score indicated better chewing performance. Specimens that were excessively crushed or torn were excluded from analysis. Only 73 of 84 subjects were evaluated. To compare relative masticatory performance among subjects, they were classified into good and poor chewing groups, based on median MAI.

## Evaluation of oral dryness

Moisture of the tongue and buccal mucosa was measured using an oral moisture-checking device (Moisture Checker Mucus®, Life Co, Ltd, Tokyo, Japan), which has good sensitivity and specificity.<sup>28</sup> A disposable polyethylene cover was applied to the sensor and replaced for each subject. For accurate measurement, one trained examiner manually applied the device to measurement sites at a pressure of approximately 200 g, in accordance with the manufacturer’s instructions. The measurement sites were the lingual mucosa, approximately 10 mm from the tip of the tongue, and the right buccal mucosa, approximately 10 mm from the mouth corner; these sites were described by Fukushima et al<sup>29</sup> To reduce error in measurement, the same areas were measured three times and the median value was used as the representative value.

According to a previous publication by the American Dental Association, the ideal method to diagnose

hyposalivation is measurement of salivary flow.<sup>30</sup> Unstimulated saliva was collected by spitting naturally collected saliva once per minute for 5 min into a test tube; during collection, subjects remained in a stable sitting position. Eating, drinking, and smoking were prohibited 1 h before unstimulated saliva collection. Evaluation after intervention was measured immediately after the SOE intervention. To compare the degree of change according to salivation status, a flow rate of  $\leq 0.2$  ml of unstimulated saliva per minute was defined as hyposalivation and used to distinguish between good and poor salivation groups.<sup>31</sup>

## Repetitive Saliva Swallowing Test (RSST)

RSST is a method to evaluate swallowing ability, which has demonstrated good accuracy.<sup>32</sup> Subjects were seated comfortably and asked to swallow their saliva continuously and as much as possible for 30 s. During this swallowing task, one trained dentist palpated the laryngeal prominence and elevations of the hyoid bone, and recorded the number of movements. In accordance with criteria reported in previous studies,<sup>11,16</sup>  $< 3$  times was defined as swallowing hypofunction and used to distinguish between good and poor swallowing groups.

## Statistical methods

Changes in oral function immediately after intervention, as well as after 1 week of intervention, were analyzed using one-way repeated measures ANOVA. The Bonferroni post hoc test was performed to determine differences among the time points. Cochran's Q test was used to compare changes in the proportions of good- and poor-swallowing subjects after interventions in the poor- and good-swallowing groups, respectively. Subjective changes after 1 week of intervention were analyzed using McNemar's test.

## Results

### Participant characteristics

The mean age of the subjects was 74.43 years (Table 1). The subjects were grouped on the basis of their use of removable partial dentures and complete dentures; notably, most (65.5%) of the subjects did not wear dentures. Based on the Asia-Pacific standard for body mass index (BMI),<sup>33</sup> most subjects were obese ( $\geq 25$  kg/m<sup>2</sup>); most non-obese subjects had a normal BMI ( $\leq 22.9$  kg/m<sup>2</sup>).

**Table 1** Participant characteristics

Variable		n (%)
Age, years		
	65–69	18 (21.4)
	70–79	52 (61.9)
	$\geq 80$	14 (16.7)
Sex		
	Male	21 (25.0)
	Female	63 (75.0)
Education		
	Elementary school or less	38 (45.2)
	Middle school graduate	14 (16.7)
	High school graduate	20 (23.8)
	University or more	12 (14.3)
Smoking status		
	Current	4 (4.8)
	Ex-smoker	9 (10.7)
	Never	71 (84.5)
Number of medications		
	None	14 (16.7)
	1	34 (40.5)
	2	30 (35.7)
	$\geq 3$	6 (7.2)
Denture wear		
	No	55 (65.5)
	Removable partial denture	19 (22.6)
	Complete denture	10 (11.9)
Body mass index, kg/m <sup>2</sup>		
	$\leq 22.9$	29 (34.5)
	23–24.9	22 (26.2)
	$\geq 25$	33 (39.3)
Total		84 (100)

### Changes immediately after intervention and after 1 week of intervention in all subjects

In total, 45.2% or 16.7% of subjects completed the SOE intervention over 7 or 6 days, respectively. In addition, 4.8% of the subjects performed the SOE intervention for  $< 4$  days. The MAI increased by approximately 6%, immediately after the intervention (Table 2). Although there was no statistically significant increase in unstimulated saliva flow rate immediately after the SOE intervention, it increased by

**Table 2** Changes in oral functions across all subjects after simple oral exercise intervention

Variable	n	Baseline	Immediate	1 week	P-value
Masticatory performance	73	61.68±13.04 <sup>A</sup>	65.75±12.23 <sup>B</sup>	64.55±13.06 <sup>AB</sup>	0.008 <sup>a</sup>
Unstimulated saliva secretion	84	0.26±0.15 <sup>A</sup>	0.28±0.15 <sup>A</sup>	0.34±0.20 <sup>B</sup>	<0.0001 <sup>a</sup>
Oral moisture degree					
Tongue	84	27.27±3.00 <sup>A</sup>	28.15±1.90 <sup>B</sup>	28.03±1.90 <sup>B</sup>	0.005 <sup>a</sup>
Buccal mucosa	84	28.21±2.10 <sup>A</sup>	28.85±1.64 <sup>B</sup>	28.37±1.93 <sup>AB</sup>	0.023 <sup>a</sup>
Swallowing function	84				0.003 <sup>b</sup>
Poor		40 (47.6)	32 (38.1)	27 (32.1)	
Good		44 (52.4)	52 (61.9)	57 (67.9)	

**Notes:** <sup>a</sup>One-way repeated measures ANOVA, Mean ± S.D.; different upper case letters denote significant differences between groups by Bonferroni post hoc analyses.

<sup>b</sup>Cochran's Q test. n (%).

approximately 0.1 ml/min after 1 week of intervention. The degree of tongue moisture increased significantly (by approximately 3%), immediately after the intervention; this increase was maintained after 1 week of intervention ( $P=0.005$ ). The degree of buccal mucosa moisture also increased significantly, immediately after the SOE intervention ( $P=0.023$ ). The proportion of subjects that comprised the good-swallowing group significantly increased by approximately 9% and 15%, immediately after and after 1 week of SOE, respectively ( $P=0.003$ ).

### Changes immediately after and after 1 week of intervention in the good- and poor- groups

In a comparison between good- and poor- chewing groups, the average number of teeth at baseline significantly differed between the good-chewing group (21.5±6.9) and poor-chewing group (16.4±8.2). Masticatory performance did not change significantly after the intervention in the good-chewing group ( $n=36$ ), whereas it increased by 16% immediately after the intervention in the poor-chewing group ( $n=37$ ); this increase was maintained after 1 week of intervention ( $P<0.05$ ) (Table 3). The volume of unstimulated saliva was the same before and immediately after SOE in the good-salivation group ( $n=48$ ), whereas it increased by approximately 29% immediately after the intervention, and by 78% after 1 week of intervention in the poor-salivation group ( $n=36$ ). The intervention had no effect on the degree of tongue moisture in the good-salivation group; however, tongue moisture was significantly improved by approximately 5% immediately after SOE in the poor-salivation group. In total, 93.2% of subjects in the good-swallowing group retained their good-swallowing function after SOE

(Table 3). Additionally, 25% and 40% of those initially in the poor-swallowing group improved to the normal range immediately after, and after 1 week of SOE, respectively.

### Changes in subjective discomfort

Before SOE intervention, 46.4% of subjects answered “yes” to subjective difficulties in chewing hard food (Table 4). After 1 week, however, only 22.6% of the subjects answered “Yes” to this question; this difference was statistically significant ( $P<0.0001$ ). The number of the subjects who answered “yes” to “Aspiration when drinking liquid” decreased by approximately 20% ( $P=0.002$ ). With respect to oral dryness, subjects who experienced difficulties with swallowing food due to oral dryness and those who needed liquids to swallow dry foods were reduced by approximately 4% and 10%, respectively; however, these differences were not statistically significant. In contrast, there was a statistically significant decrease in the feeling of mouth dryness when eating a meal ( $P=0.049$ ).

### Discussion

In this study, the SOE intervention focused on enhancing mastication, salivation, and swallowing function; notably, the intervention was immediately effective in improving oral function. We confirmed that improved oral functions were maintained over the short study period of 1 week. In general, it is not recommended to provide a large amount of information to elderly individuals in a single session because this population often requires additional time to comprehend instructions and recall information, due to aging.<sup>34</sup> Therefore, an SOE intervention with several key motions is preferred over a conventional, complex oral

**Table 3** Changes in oral functions after performing simple oral exercise intervention, according to oral functional abilities

Variable	Poor			Good		
	Baseline	Immediate	1 week	Baseline	Immediate	1 week
Masticatory performance <sup>a</sup>						
	51.21±9.79 <sup>A</sup>	59.76±12.50 <sup>B</sup>	59.92±14.05 <sup>B</sup>	72.44±4.03	71.92±8.07	69.30±10.10
P-value <sup>d</sup>	<0.0001			0.084		
Unstimulated saliva secretion <sup>b</sup>						
	0.14±0.04 <sup>A</sup>	0.18±0.1 <sup>B</sup>	0.25±0.16 <sup>B</sup>	0.35±0.14 <sup>A</sup>	0.35±0.14 <sup>AB</sup>	0.41±0.20 <sup>B</sup>
P-value <sup>d</sup>	0.001			0.012		
Oral moisture						
Tongue	26.98±3.42 <sup>A</sup>	28.50±1.95 <sup>B</sup>	28.42±1.60 <sup>B</sup>	27.48±2.67	27.89±1.84	27.74±2.07
P-value <sup>d</sup>	0.002			0.511		
Buccal mucosa	28.01±2.25	28.72±2.08	28.74±1.42	28.36±1.98 <sup>A</sup>	28.94±1.22 <sup>AB</sup>	28.10±2.21 <sup>B</sup>
P-value <sup>d</sup>	0.063			0.034		
Swallowing function <sup>c</sup>						
Poor	40 (100.0)	30 (75.0)	24 (60.0)	0 (0.0)	2 (4.5)	3 (6.8)
Good	0 (0.0)	10 (25.0)	16 (40.0)	44 (100.0)	42 (95.5)	41 (93.2)
P-value <sup>e</sup>	<0.0001			0.247		

**Notes:** <sup>a</sup>Subjects were dichotomized into good- and poor-chewing groups based on the median mixing ability index (65.38); <sup>b</sup>Subjects were dichotomized into good- and poor-salivation groups based on 0.20 ml/min; <sup>c</sup>Subjects were dichotomized into good- and poor-swallowing groups based on the repetitive saliva swallowing test; <sup>d</sup>One-way repeated measures ANOVA, Mean ± S.D.; different upper case letters denote significant differences between groups by Bonferroni post hoc analyses.

**Table 4** Changes in the numbers of subjects who experienced discomfort after performing simple oral exercise intervention

Questions	Baseline	1 week	P-value
Mastication			
Difficulties in chewing hard food	39 (46.4)	19 (22.6)	<0.0001
Swallowing			
Aspiration when drinking liquid	29 (34.5)	12 (14.3)	0.002
Oral dryness			
Difficulties in swallowing food due to oral dryness	11 (13.1)	8 (9.5)	0.549
Feeling dry when eating a meal	23 (27.4)	12 (14.3)	0.049
Needing liquids in swallowing dry foods	33 (39.3)	25 (29.8)	0.248

**Notes:** Data presented as n (%) unless otherwise indicated. P-value calculated based on McNemar's test.

exercise method; moreover, the new method can be performed continuously because it is easier for elderly individuals to remember, and appears to be highly utilized.

Most previous studies have been limited to evaluation of changes in subjective masticatory ability after oral exercise. However, the evaluation of subjective chewing abilities is affected by other factors, such as adaptational

and psychological factors; thus, subjective evaluations are generally optimistic.<sup>35</sup> In the present study, we evaluated changes in objective masticatory performance by using the MAI, as well as by simultaneous assessment of subjective masticatory ability. The MAI reflected changes in masticatory performance with high sensitivity, similar to several previous studies that successfully evaluated masticatory

function in patients with temporomandibular disorder, botulinum toxin injection, orthodontic patients, and those receiving implants.<sup>27,36–38</sup> In the present study, the mean MAI of all subjects was 61.68, which was similar to the MAI in the 20–30-year-old age group in a previous study.<sup>25</sup> However, the prior study may have included only healthy individuals who could travel to the hospital alone, because it was conducted at a dental hospital. In addition, the poor-chewing group, which was classified as below the median in this study, was also in the relatively poor group, such that the baseline mean MAI was similar to that of subjects who were  $\geq 60$  years of age or those who had 1–2 lost teeth in a previous study.<sup>25</sup>

The present study demonstrated that masticatory performance in the poor-chewing group immediately improved by approximately 16% after SOE intervention. Approximately 64–69 MAI was the normal range of masticatory performance through the occlusion of all molars, based on previous studies using the MAI. The subjects with increased masticatory performance after the intervention did not reach the normal range. However, the increased values were higher than those in subjects without 1–2 molars; this change may be sufficient for robust oral intake. There was also a nine-point difference in MAI between healthy subjects and those without 1–2 molars, which was similar to the increase in MAI after the SOE intervention.<sup>25</sup> The number of teeth plays a major role in the masticatory system and is known to be closely related to chewing ability.<sup>35</sup> Although there was no increase in the number of functional teeth during the intervention period, the SOE intervention yielded a similar improvement in function in the short-term, compared with the group with all posterior teeth.<sup>25</sup>

In contrast, there was little change after SOE in the good-chewing group. Painter et al<sup>39</sup> reported that the effect of the exercise might be particularly noticeable in low functioning subjects because the intervention was designed to address physical functioning. Some previous studies reported that exercise was ineffective or less effective in normal subjects than in the low functioning subjects.<sup>40,41</sup> Similarly, in the present study, the good-chewing group, which exhibited the reference score of the general population (64–69) showed only a slight increase or decrease. However, we could not determine whether an effect occurred because we did not include a control group in the present study. Thus, our results should be interpreted carefully because the observed effects could be caused by statistical errors (eg, regression to the mean effect).

Previous studies have reported that repeated tooth-clenching tasks or short-term oral sensorimotor tasks can cause neuroplastic changes in corticomotor control of the masseter muscles over a short period of time, resulting in increased precision of task performance.<sup>42,43</sup> These results suggest that SOE may induce neuroplastic changes and improve masticatory performance by improvement of dexterity. Furthermore, Simona et al<sup>15</sup> observed an increase in masseter muscle activity enhanced by physical exercise over a 6-month period. In addition, maximum mouth-opening distance and bite force were increased after oral exercise at 3 months and 6 months, respectively.<sup>17,29</sup> These results suggest that the SOE intervention can improve masticatory function through enhancement of masticatory muscle activity over a longer period of time.

In the present study, we observed a significant increase in the unstimulated saliva flow rate after the SOE intervention. The rate of unstimulated saliva production in all subjects increased to 0.26 ml/min immediately after the intervention and to 0.34 ml/min at 1 week after the intervention. These results are very similar to those reported in a previous study by Sugiyama et al,<sup>11</sup> in which the rate of unstimulated saliva increased from 0.25 ml/min to 0.37 ml/min after a 3-month period of oral exercise. The present study was the first to reveal the unique phenomenon that salivation could be improved to a level similar to long-term performance of approximately 3 months, even during a short-term period of 1 week when the SOE intervention was performed every day. The motions for salivation in the SOE intervention included stretching the tongue up and down, as well as right and left, along with stimulation of the buccal mucosa and oral vestibule. The sublingual ducts and parotid papilla were stimulated by performing these motions; thus, saliva secretion was immediately increased. The interesting result observed in this study was that the amount of unstimulated saliva did not increase immediately after the SOE intervention in the good-salivation group, whereas it increased by approximately 29% in the poor-salivation group. In addition, the amount of unstimulated saliva increased by approximately 39% upon re-evaluation after 1 week of intervention, which was consistent with the increase in the 3-month oral exercise described by Ohara et al.<sup>19</sup> Moreover, the increase after 1 week of the SOE intervention was in the normal range of the rate of unstimulated saliva production (0.2–0.5 ml/min).<sup>44</sup> In addition, the number of subjects who experienced discomfort with oral dryness during food intake was markedly decreased in the subjective symptom survey, suggesting that the SOE

intervention proposed in the present study was effective in improving salivation in elderly individuals with decreased salivation. Therefore, the amount of saliva can be temporarily increased by the SOE intervention as a preparatory exercise immediately before food intake, which may help to relieve masticatory and swallowing discomfort.

The degree of moisture in both the tongue and buccal mucosa also exhibited a statistically significant increase immediately after the intervention, with a greater effect on the tongue mucosa. This is consistent with the findings of a previous study by Hakuta et al,<sup>13</sup> in which tongue dryness was relieved by oral exercise over a 3-month period. In the present study, the degree of tongue moisture in the poor-salivation group was increased immediately after intervention, while there was no significant change in the good-salivation group. This tendency was consistent with improvement in other oral functions, as mentioned above. Conversely, the degree of moisture in the buccal mucosa was not affected in the poor-salivation group. This may be because the measurement site of the buccal mucosa was located near the parotid papilla, and recorded values may vary depending on the measurement site. According to a previous study, the tongue mucosa is more suitable for measurement using an oral moisture-checking device than the buccal mucosa;<sup>29</sup> therefore, results addressing the degree of moisture in the tongue mucosa in the present study may be more reliable than those collected in the buccal mucosa. After 1 week of intervention, many subjects reported that their mouth (ie, oral mucosa) had become soft. The results of the subjective evaluation suggest that moisture in the oral mucosa increased slightly with an increase in unstimulated saliva after the SOE intervention.

RSST assessment indicated that 25% and 40% of the subjects in the poor-swallowing group experienced improvements in swallowing function to within the normal range (RSST >3) immediately after, and after 1 week of intervention, respectively. The present study found that swallowing function in elderly individuals with poor swallowing ability could improve to within the normal range after a short period of time, both immediately after and after 1 week of intervention. Ibayashi et al<sup>18</sup> reported that the baseline RSST score in subjects with good-swallowing ability was 4 points, and that this increased to 5 points by the end of a 6-month intervention. In the present study, swallowing function did not improve after 1 week in the good-swallowing group. Nevertheless, if the SOE intervention is performed for an extended period, improvements in swallowing ability may also occur in elderly individuals with

good swallowing function. There was a statistically significant reduction in subjective discomfort during eating, with respect to mastication, salivation, and swallowing function, in responses to most interview questions. There was a possibility that false positives were recorded because the same questionnaire was administered after a short interval of 1 week. Nevertheless, objective numerical changes were observed according to test results of oral function; therefore, an actual relaxation in oral function may have occurred. In addition, approximately 70% of subjects were asked about their feelings regarding the SOE intervention with an open question. Most subjects responded positively, and most responses were “the motion was not difficult,” followed by “the mouth was softened and the saliva is well secreted.” Therefore, many subjects appeared to have experienced a salivation effect after performing the SOE intervention. It is expected that the SOE intervention will be performed continuously in the future because it was regarded as highly favorable.

The SOE intervention instruction in this study had the advantage of not being affected by multiple educators; therefore, educator differences were minimized, if not eliminated. The purpose of this study was to investigate the feasibility of using the SOE intervention as a pre-meal exercise; we acknowledge that the 1-week follow-up period was relatively short, compared with other studies involving periods of at least 3–6 months of intervention. Nevertheless, our results were clinically meaningful. In addition, there was no control group because all oral functions were evaluated immediately after the intervention. Therefore, it was not possible to directly compare the oral function of subjects who performed the SOE intervention and those who did not perform any intervention. In the future, a study is needed to overcome those limitations.

All oral functions involving mastication, salivation, and swallowing were particularly more effective in the relatively poor groups than in the relatively good groups. Therefore, it will be necessary to evaluate the effect of the SOE intervention in a target group with weak oral function in the future.

## Conclusion

In conclusion, the SOE intervention was immediately effective in improving oral functions, and the increased functions were maintained after 1 week of intervention. It is recommended that elderly people with poor oral functions perform the SOE intervention before each meal.

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## Disclosure

The authors report no conflicts of interest in this work.

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