Effectiveness of oral exercise on oral function among the elderly

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ABSTRACT

Purpose: To evaluate the effectiveness of oral exercise on oral function among the elderly at a selected old age home in Chennai. **Research Design:** The present study adopted a one-group pretest and posttest (preexperimental) design. **Methods:** Participants received intervention "oral exercise" which comprised of exercises for expression muscles (orbicularis oculi, buccinator and orbicularis oris), tongue, salivary glands, and swallowing. The pre- and posttests included assessment of oral function (dry mouth symptoms, amount of salivary pH, salivary secretion, size of mouth opening, halitosis, and oral motor function) using summated xerostomia inventory, spitting into a measuring container for 10 min, pH meter, Vernier caliper, organoleptic test, and Sunnybrook facial grading system, respectively. **Results:** Using nonprobability convenience sampling technique, a total of 48 older people living in an old age home who met the inclusion and dental screening criteria were recruited. There was a statistically considerable difference noted in the mean scores of the dry mouth symptoms ($t = 11.88$), amount of salivary secretions ($t = 17.05$), salivary pH ($t = 8.68$), size of mouth opening ($t = 14.76$), halitosis ($t = 13.13$), and oral motor function ($t = 11.52$) at $P < .001$ before and after oral exercise among the elderly. **Conclusion:** Oral exercise as a self-regulating intervention can efficiently promote oral health of older people.

Keyword: Elderly, oral exercise, oral function

Introduction

Poor oral health is one of the most important issues among the elderly.[1] The Centers for Disease Control and Prevention, Division of Oral Health, found that about 25% of adults over the age of 65 no longer have their natural teeth and they are at risk for altered oral health. The common oral health issues associated with older adults include dry mouth, gum disease and mouth cancer.[2]

Most elderly over the age of 65 years have tooth loss and the teeth present are often diseased or decayed. Muscles of mastication are weaker causing increased fatigue while eating. There is an age-associated functional decline of taste buds with reduced ability to discriminate flavors. Salivary secretions are reduced and more alkaline.[3] Failing of oral muscle that occurs with age causes difficulty in maintaining oral functions, such as opening the mouth and masticating food.[4]

A multitude of options exist for management of hyposalivation and xerostomia. They include topical preparations (toothpastes, mouthwashes, gums, or moisturizers), drug therapy (e.g. pilocarpine or cevimeline), acupuncture, electrostimulation, gene therapy, and stem cell transfer.[5] Behavioral management, such as increased consumption of water, avoiding mouth breathing, and avoiding caffeine or alcohol, may also be recommended. Drug therapies

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have been observed to be effective in relieving symptoms of xerostomia or hyposalivation. However, side effects (e.g. sweating, joint pain) and broad lists of contraindications are noted for these treatment options.[6]

Hence, simple and effective self-controlled interventions are needed to manage oral health issues and preserve oral health. Literature supports the role of oral exercises in promoting oral health of elderly people. The investigator could not retrieve any similar studies in India. Hence, the investigator has made an attempt to study the effectiveness of oral exercise on oral function in terms of oral dehydration, oral motor function, and size of mouth opening, saliva flow, halitosis, and salivary pH among older people living in old age home. This study was performed to assess the effectiveness of oral exercise on oral function among the elderly at a selected old age home, Chennai. We assessed oral function of the elderly before and after oral exercise and found an association of oral function with selected background variables of the elderly.

Methodology

Setting

This study was carried out at Little Drop (Home for destitute elders). Little drop, the old age home is located at Paraniputhur, Chennai, Tamil Nadu. Little drop is accredited by International Organization for Standardization. Little drop is a registered charitable organization devoted to neglected and destitute elders. A total of 272 elders (116 males and 156 females) live in this home.

Research approach

Quantitative research approach was used to assess the effectiveness of oral exercise on oral function among elderly at a selected old age home, Chennai. A preexperimental design (one-group pretest and posttest) was used for this study. Nonprobability convenience sampling technique was used to select the samples.

Variables

The independent variable in the study was oral exercise and the dependent variable was oral function (dry mouth symptoms, amount of salivary pH, salivary secretion, and size of mouth opening, halitosis, and oral motor function).

Criteria for sample selection

Inclusion criteria

Elderly persons who spoke/understood Tamil and/or English aged over 60 years were included in the study. Other factors considered were agreed to cooperate with an oral function assessment, did not suffer oral health problems (dental caries, oral ulcers/patches/growth, gingival problem and temperomandibular disorder) as screened by a dentist, and willing to participate in the study.

Exclusion criteria

Elderly with/who had been diagnosed for dementia, head and neck trauma, treatment of radiation therapy, habit of mouth breathing, taking medicines, such as antipsychotics/sedatives and muscle relaxants/angiotensin-converting enzyme inhibitors/alpha and beta blockers/anticholinergics/antidepressants/antihistamine, hearing, vision, and speech problem and paralysis of upper extremities.

Research instruments

Description of instruments, scoring, and interpretation

The tool consisted of two sections: Section-A: Assessment of background variables and Section B: Assessment of oral function.

Section A: Assessment of background variables
Part-1: Demographic variables
It included age (years), sex, education, source of income, and dietary pattern.

Part-2: Clinical variables
This questionnaire had clinical characteristics of the elderly, such as smoking habit, comorbidity, alcoholism, dentures, experience bad breath, tooth brushing (times/day), medication, use of mouth rinse solution, and tongue cleaning.

Section B: Assessment of oral function
This section consists of six parts.

Part-1: Summated xerostomia inventory to assess dry mouth symptoms
The tool used was Summated Xerostomia Inventory (SXI) developed by Thomson.[7]

Part – 2: Measuring container to measure saliva
Based on previous studies, saliva was collected in a sterile measuring container for 10 min using the spitting method and it was gravimetrically measured.[8] The protocol for saliva collection is derived from "Salivary Proteome Handbook Procedures and Protocols" (National Consortium for the human saliva proteome, 2004).[9] The unit of measurement was ml/min.

Part- 3: pH meter to determine salivary pH
The salivary pH was measured using Digital LCD TDS3 pH meter (part No. CB18845). Saliva was collected in a sterile measuring container and the pH measured by using a pH meter twice. The salivary pH of each participant was determined by obtaining the average of two test values. The accuracy of pH meter was ensured after 24 tests using standard buffers. The normal salivary pH range was 6.7–7.3.[10]

Part- 4: Vernier calliper to measure the size of mouth opening
The size of the mouth opening was estimated by measuring the distance between the upper and lower incisors using a Vernier

caliper (Part No. pr17 is millimeter (mm). Three measurements were taken and the obtained results were averaged. The normal range was 40–77 mm for males and 32–75 mm for females in Indian population.[11]

Part-5: Organoleptic test for halitosis

Oral malodor was measured using organoleptic test developed by Murata *et al.* It is a widely used gold-standard scale for assessment of oral malodor. Participants were instructed to take deep breathe by inspiring the air by nostrils and holding a while, then to expire by mouth. The examiner sniffed the odor at a distance of 20 cm and scored the category of malodor in organoleptic scale of 0–5.[12]

Part-6: Sunnybrook facial grading system to assess oral motor function

Oral motor function was assessed using the Sunnybrook facial grading system developed by Ross *et al.*, (1996).[13] It included evaluation of three components: *a. Resting symmetry component; b. Symmetry of voluntary movement component; c. Synkinesis of involuntary muscle component.*

Validity and reliability

The research tools (background variables and SXI tool) used in the study were translated from English version to Tamil and back to English. The validity of the tool was obtained from nursing experts. The reliability of the SXI tool using test–retest method was $r = 0.79$. The reliability of measuring container, pH meter, and Vernier caliper was ensured by using the same equipment, and same person. The reliability of organoleptic test and Sunnybrook facial grading system was ensured by using interrater method and the reliability scores were 0.63 and 0.982, respectively.

The study was conducted in three phases
Phase I

A total of 48 participants were recruited using nonprobability convenience sampling technique. Considering the sampling criteria, pretest was carried out as follows: four participants per day (3.10.17–9.10.17) followed by three participants per day (10.10.17–16.10.17). Background data were obtained using the tool. Following this, the elderly were assessed by the investigator for oral functions which included, dry mouth symptoms, amount of salivary secretion, salivary pH, size of mouth opening, halitosis and oral motor function by using summated xerostomia inventory, spitted saliva in a container for 10 min, pH meter, Vernier calliper, organoleptic test score, and Sunnybrook facial grading system.

Phase II

Oral exercise intervention was given to 48 elders in little drop. They were provided a calm environment for oral exercise intervention. The samples were seated on a sheet spread over the living room for intervention. Investigator explained the purpose of the study and advantages of practicing oral exercises. The oral exercise intervention comprised of exercises for expression muscles, tongue, salivary glands, and swallowing.

Intervention: Oral exercise

The intervention was given in two phases: First was the learning phase in which the investigator taught oral exercises for an hour using lecture-cum-one-to-one demonstration method. The medium of instruction used was Tamil. Around three to four elders attended the demonstration per day. Each participant was asked to do a return demonstration and correction was given as needed. Pamphlets were distributed to the participants during this phase.

Phase I: Learning phase

It comprises of one-to-one demonstration of exercise[14] that involves expression muscles (orbicularis oculi, buccinators, and orbicularis oris), tongue, salivary glands, and swallowing, followed by return demonstration for one hour on the first day and distribution of pamphlets during the session.

Phase II: Performance phase

Following learning phase, the second phase (performance phase) was carried out. In this phase, participants were asked to perform oral exercise every day for about 30 min for 15 days under supervision of the investigator. The participants were divided into groups of five members each for performance of oral exercise in order to maintain one-to-one supervision. The intervention consisted of four exercises: 1. *Exercise for expression muscle, 2. Exercise for tongue, 3. Exercise for salivary gland, 4. Exercise for swallowing.* Each exercise was done ten times. After 16 days of oral exercises intervention, posttest was conducted on the seventeenth day which included assessment of oral function (dry mouth symptoms, amount of salivary secretion, salivary pH, size of mouth opening, halitosis, and oral motor function).

Phase III

Oral function was assessed (posttest) on the seventeenth day with the same tools.

Data analysis

The collected data were grouped and analyzed using Statistical Package for Social Science (SPSS) version 19.

Results

Distribution of the elderly according to the background variables

Majority of the elderly were in the age group of 60–69 years and 75% of them were females.

Among them, 72.9% had no formal education. The old age home had sponsored 83.4% of the elderly. The remaining were dependent on family members. Majority of them (87.5%) did not have the habit of smoking or alcohol consumption. With regard to comorbid illness, 39.6% had hypertension, 16.6% had both hypertension and diabetes mellitus, 6.2% had asthma; 16.6% of the elders did not have any comorbid illness. With regard to dentures, majority of the elders (97.9%) were not using dentures;

only 2.1% were using complete dentures. Of the elderly, 39.6% were taking antihypertensive drugs and 16.6% were taking antihypertensive along with oral hypoglycemic agent. None of them had the habit of using mouth rinse solution [Tables 1 and 2].

Assessment of dry mouth symptoms, amount of salivary secretion, salivary pH, size of mouth opening, halitosis, and oral motor function

After the posttest, there was significant improvement in dry mouth status of the elderly people and marked xerostomia (20.8%) was decreased to 2.12% of subjects. Normal salivary secretion was observed in 45% of elders which significantly increased after posttest. There were also significant differences observed in oral motor function and variables [Table 3].

Assessment of the oral function before and after oral exercise

Table 4 depicts that there was a statistically significant difference noted in the mean scores of dry mouth symptoms ($t = 11.88$), amount of salivary secretions ($t = 17.05$), salivary pH ($t = 8.68$), size of mouth opening ($t = 14.76$), halitosis ($t = 13.13$), and oral motor function ($t = 11.52$) at $P < 0.001$, before and after oral exercise [Figure 1].

Association between the oral function and the background variables among the elderly during pretest

There was a statistically significant association noted between dry mouth symptoms and age ($F = 3.566$, $P < 0.05$) and experience of bad breath ($t = 3.131$, $P < .01$) among the elders in the pretest; other findings included, salivary secretion and age ($F = 3.098$, $P < 0.05$), history of alcoholism ($F = 3.149$, $P < .05$), and experience of bad breath ($t = 2.368$, $P < .05$) and also between the salivary pH and history of alcoholism ($F = 8.021$, $P < .001$) [Supplementary file 1].

Supplementary file 2 depicts a statistically significant association between size of mouth opening and age ($F = 2.991$, $P < 0.05$),

gender ($t = 3.215$, $P < 0.01$), history of alcoholism ($F = 2.743$, $P < .05$) and experience of bad breath ($t = 2.734$, $P < .01$), age ($F = 3.358$, $P < .05$), experience of bad breath ($t = 5.554$, $P < .001$), and tongue cleaning during brushing ($t = 2.007$, $P = .05$). Also, there was a statistically significant association noted between oral motor function experience of bad breath ($t = 2.348$, $P < .05$).

Discussion

This study was undertaken to assess the effectiveness of oral exercises on oral functions, such as, dry mouth symptoms, amount of salivary secretion per minute, salivary pH, size of mouth opening, halitosis, and oral motor function among elders living in an old age home in Chennai. Study conducted by Cho

Table 1: Distribution of the elderly according to their background variables

Demographic variables	*n*	%
Age (in years)		
60-69	21	43.7
70-79	14	29.2
80-89	11	22.9
90-99	2	4.2
Gender		
Male	12	25
Female	36	75
Level of education		
No formal education	35	72.9
Primary	9	18.7
Higher secondary	3	6.3
Graduation	1	2.1
Postgraduation	0	0
Source of income		
Pensioner	4	8.3
Dependent (family)	4	8.3
Sponsor	40	83.4
Dietary pattern		
Vegetarian	9	18.7
Mixed vegetarian	39	81.3
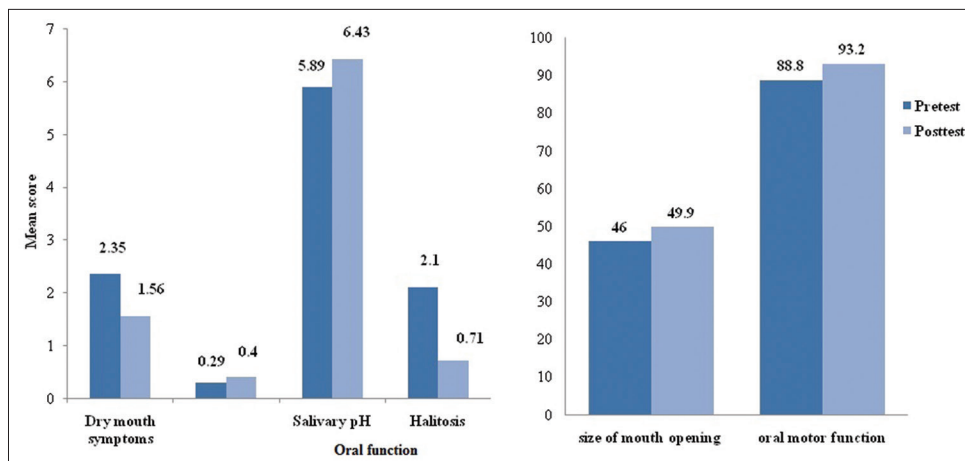
Figure 1: Comparison of mean score of oral function before and after oral exercise among elderly (*N* = 48)

Table 2: Distribution of the elderly according to their clinical variables

Clinical variables	n	%
History of smoking (No. of cigarettes/day)		
No	42	87.5
1-5	3	6.2
6-10	1	2.1
11-15	2	4.2
History of alcoholism (ml/day)		
No	42	87.5
≥250	1	2.1
251-500	2	4.2
501-750	3	6.2
Comorbidity		
No	8	16.6
Hypertension	19	39.6
Diabetes mellitus	2	4.2
Coronary artery disease	1	2.1
Asthma	3	6.2
Peptic ulcer	1	2.1
Hypertension + diabetes mellitus	8	16.6
Hypertension diabetes mellitus + coronary artery disease	1	2.1
Hypertension + coronary artery disease	1	2.1
Hypertension + asthma	2	4.2
Hypertension + diabetes mellitus + asthma	1	2.1
Hypertension + peptic ulcer	1	2.1
Dentures		
No	47	97.9
Partial	0	0
Experienced bad breath		
No	29	60.4
Yes	19	39.6
Tooth brushing (times/day)		
1 time	42	87.5
2 times	6	12.5
Current medication		
No	8	16.6
Antihypertensive	19	39.6
Oral hypoglycemic agent (OHGA)	2	4.2
Antiplatelets + antilipidemic	1	2.1
Antiasthmatic	3	6.2
Antiulcer	1	2.1
Antihypertensive + OHGA	8	16.6
Antihypertensive + antiplatelets + antilipidemic + OHGA	1	2.1
Antihypertensive + antiplatelets + antilipidemic	1	2.1
Antihypertensive + antiasthmatic	2	4.2
Antihypertensive + antiasthmatic + OHGA	1	2.1
Antihypertensive + antiulcer	1	2.1
Use of mouth rinse solution (No. of times/day)		
No	48	100
Yes	0	0
Tongue cleaning during brushing		
No	27	56.2
Yes	21	43.8

Table 3: Assessment of dry mouth symptoms, amount of salivary secretion, salivary pH, size of mouth opening, halitosis, and oral motor function

Oral function variables	Pretest		Posttest	
	n	%	n	%
Dry mouth symptoms				
No xerostomia (1)	3	6.3	11	22.9
Mild xerostomia (1.1-3)	35	72.9	36	75
Marked xerostomia (3.1-5)	10	20.8	1	2.1
Salivary secretion (ml/min)				
Hypersalivation (>1.0)	0	0	0	0
Normal (0.41-1.0)	9	18.8	22	45.8
Reduced (0.21-0.40)	18	37.5	18	37.5
Hyposalivation (<0.20)	21	43.7	8	16.7
Salivary pH				
Acidic (<6.7)	42	87.5	31	64.6
Normal (6.7-7.3)	4	8.3	13	27.1
Alkaline (>7.3)	2	4.2	4	8.3
Size of mouth opening				
Normal male (40-74 mm)	12	100	12	100
Normal female (35-70 mm)	36	100	36	100
Restricted mouth opening (<35 mm)	-	-	-	-
Oral function variables				
Absence of odour (0)	4	8.3	25	52
Questionable odour (1)	13	27.1	15	31.3
Slight malodour (2)	12	25	6	12.5
Moderate malodour (3)	13	27.1	2	4.2
Strong malodour (4)	5	10.4	0	0
Severe malodour (5)	1	2.1	0	0
Oral motor function				
Normal (100)	1	2.1	5	10.4
Mild dysfunction (70-99)	46	95.8	43	89.6
Moderate dysfunction (43-69)	1	2.1	0	0
Moderate severe dysfunction (26-42)	0	0	0	0
Severe dysfunction (13-25)	0	0	0	0
Total palsy (0-12)	0	0	0	0

et al. (2011) found a significant difference in the pre- and the posttest subjective dry mouth symptoms ($P < 0.01$), which supports our study findings.[15] We expected a significant improvement in dry mouth symptoms after oral exercise and

we had study findings which indicated similar trends with a statistically significant difference in the mean scores of dry mouth symptoms before (2.35) and after (1.56) the intervention, with the mean difference of 0.79 at the level of $P < 0.001$. Hence, it becomes apparent that oral exercise helps the elderly in reducing dry mouth symptoms.

We also had the assumption that the amount of salivary secretion before and after oral exercise would vary among the elderly. The study findings reveal a significant improvement and 37.5% had reduced salivary secretion and 43.7% had hyposalivation. Our assumption was supported by the study findings that indicate a statistically significant difference in the mean scores of the amount of salivary secretion before (0.29) and after (0.40) the intervention. Thus, it becomes evident that oral exercise improves salivary secretion. Oral exercise that involves the movement of muscles, including the masticatory muscle, buccinators muscle, orbicularis oris muscle, and lingual roots, promotes salivary secretion.[8] According to Weerepong *et al.* (2005) salivary gland massage increases the blood flow and parasympathetic activity in

Oral function	Pretest		Posttest		Difference (post-pre)		Paired *t*	*P*
	M	SD	M	SD	M	SD		
Dry mouth symptoms	2.4	0.8	1.6	0.5	0.8	0.5	11.88***	0
Amount of salivary secretion	0.3	0.2	0.4	0.2	0.1	0.4	17.05***	0
Salivary pH	5.9	0.9	6.4	0.9	0.5	0.4	08.68***	0
Size of mouth opening	46	4.9	50	4.3	3.8	1.8	14.76***	0
Halitosis	2.1	1.2	0.7	0.9	1.4	0.7	13.13***	0
Oral motor function	89	6.8	93	5.3	4.4	2.6	11.52***	0

Table 4: Assessment of the oral function before and after oral exercise among elderly

the surrounding area of the salivary glands increase the amount of salivary secretion.[16]

Earlier researchers have examined the effects of an exercise programmer on oral function in healthy elderly people of Japan.[14] The findings depicted that exercise programmer on oral function facilitates a significant improvement in the mean scores of unstimulated salivary flow rate before (0.30) and after (0.43) the intervention at the level of *P* < 0.01, whereas no improvement was observed in the control group. We also saw improvement in salivary pH; after posttest, pH was decreased to acidic range. Hence, it becomes obvious that low saliva flow rate was associated with a more acidic salivary pH. Oral health worsens when the salivary pH is below 6.6.[17] Therefore, oral exercise helps in maintaining salivary pH. The above findings were supported by a study conducted by Nam and Uhm (2016).[18] The study investigated the effects of intra- and extracircumoral exercise on subjective and objective parameters of pre- and postoral health of older people living in nursing homes of South Korea. The results showed that there was a significant improvement in salivary pH (*P* < 0.001) after intra- and extracircumoral exercise. The mean score of salivary pH in pretest was 6.46 and in posttest it was 6.86 with the mean difference of 0.40.[18]

Other factors, such as size of mouth opening, halitosis factors, oral motor function, or dry mouth symptoms were found improved and oral exercise seems to have great impact on oral functions and environment.[19] A study of Kim and Park (2012) indicated that the experimental group had significantly better salivation (*t* = 3.40) and less xerostomia (*t* = 5. 17) and halitosis (*t* = 7.77) at *P* < 0.001 than the control group.[8] Similarly, Nam and Uhm (2016) findings depicted decreased dry mouth symptoms, improved oral motor function, increased salivary secretion and increased mouth opening size, improved salivary pH, and improved halitosis, more in the experimental group than in the control group.[18]

There was a statistically significant difference between mean dry mouth symptoms and age of the elderly. The study found that as age increased, the experience of dry mouth symptoms also increased. A high mean dry mouth symptom was noted among the elderly above 90 years of age. This might be due to age related

structural changes of glandular tissue that cause dryness in the mouth. There was a statistically significant difference between mean dry mouth symptoms and experience of bad breath. The mean score of dry mouth symptoms was high in those who experienced bad breath. These findings were similar to the results of the longitudinal study done by Locker (1995) which showed that xerostomia was a significant association with older subjects.[20,21]

The study participants expressed that they felt very much relaxed and relieved from dry mouth symptoms, oral malodor, and experienced ease in eating and mouth opening after performing oral exercise. The study showed that oral exercise is an effective method to enhance oral functions, such as decrease in experience of dry mouth symptoms, increase in amount of salivary secretion, normal salivary pH, normal size of mouth opening, absence of halitosis, and normal oral motor function. Oral function among elderly is influenced by some of the background variables (age, gender, history of alcoholism, experience of bad breath, and tongue cleaning during brushing).[11] The results of the present study showed that oral exercises, as an independent nursing intervention, can effectively promote oral health of older people. Also, oral exercise method improves oral function of older people living in nursing homes.

The limitation of study was that we adopted one-group pretest–posttest design and self-report method which might pose potential issues concerning accuracy of information but, the use of standardized tool may have minimized the issues. Also, the study results may not be generalized to the entire older population because data were collected from convenience samples of the older people living in one old age home as the study group without control group. The study has inequality in distribution of samples with respect to gender and this might have influenced the results because effect of gender on oral function has been noted in previous studies. Despite these limitations, the study showed promising results, such as a higher mean difference in the outcome variables between *before* and *after* oral exercise among the elderly, revealing the effectiveness of oral exercise.

Ethical statement

Permission was obtained from the Chairman, IEC, and SRMC and RI (DU). The study was conducted after the approval from the Principal (23/06/2017), Faculty of Nursing and the Administrator, Little Drop old age home. Participants were explained clearly about the study purpose and a written informed consent was obtained from all the participants before conducting the study. Assurance was given to all the study participants that confidentiality would be maintained throughout the study. Necessary permission was obtained from the author (Thomson, 2011) to use the tool in the present study.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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Supplementary file 1: Association between oral function and the background variables among the elderly during pretest

Background variables	Dry mouth symptoms					Salivary secretion					Salivary pH				
	n	M	S.D.	*F*-or *t*	*P*	*n*	M	S.D.	*F*-or *t*	*P*	*n*	M	S.D.	*F*-or *t*	*P*
Age (in years)															
60-69	21	10	3.8			21	0.3	0.1			21	6.1	0.7		
70-79	14	13	4.5	3.565*	0.022	14	0.3	0.2	3.098*	0.036	14	5.7	0.8	1.916	0.141
80-89	11	12	2.9			11	0.3	0.1			11	6	1.2		
90-99	2	18	1.4			2	0.1	0			2	4.8	0.3		
Gender															
Male	12	10	4.6	1.698	0.096	12	0.4	0.2	1.784	0.081	12	6.1	1.3	1.068	0.291
Female	36	12	3.8			36	0.3	0.1			36	5.8	0.7		
History of alcoholism															
No	42	12	3.9			42	0.3	0.1			42	5.9	0.7		
≥250	1	5	-			1	0.6	-			1	6.3	-		
251-500	2	9	5.7	2.106	0.113	2	0.4	0.1	3.149*	0.034	2	7.9	1.7	8.021***	0
501-750	3	15	0.2			3	0.1	0.1			3	4.7	0.2		
Experienced bad breath															
No	29	10	4	3.131**	0.003	29	0.3	0.2	2.368*	0.022	29	6.1	0.9	1.747	0.087
Yes	19	14	3.4			19	0.2	0.1			19	5.6	0.8		
Tooth brushing															
1 time	42	12	4.1	1.708	0.094	42	0.3	0.1	1.67	0.101	42	5.9	0.8	0.957	0.343
2 times	6	9.1	2.9			6	0.4	0.2			6	6.2	1		
Tongue cleaning															
No	27	13	4.4	1.708	0.094	27	0.3	0.1	0.73	0.467	27	5.9	1	0.326	0.746
Yes	21	11	3.5			21	0.3	0.2			21	5.9	0.7		

Supplementary file 2: Association between size of mouth opening, halitosis, oral motor function, and the background variables among the elderly

Background variables	Size of mouth opening					Halitosis					Oral motor function				
	n	M	S.D.	*F*-or *t*	*P*	*n*	M	S.D.	*F*-or *t*	*P*	*n*	M	S.D.	*F*-or *t*	*P*
Age (in years)															
60-69	21	47	4.4			21	1.8	1			21	91	7.7		
70-79	14	45	4.9	2.991*	0.041	14	2.7	1.5	3.358*	0.027	14	88	5.7	1.319	0.28
80-89	11	46	4			11	1.7	0.9			11	87	6.2		
90-99	2	38	1.9			2	3.5	0.7			2	83	0		
Gender															
Male	12	50	4	3.215**	0.002	12	1.8	1.4	1.161	0.252	12	87	8.7	0.927	0.359
Female	36	45	4.4			36	2.2	1.2			36	89	6.1		
History of alcoholism															
No	42	45	4.6			42	2.1	1.2			42	89	6.7		
≥250	1	49	-	2.743*	0.054	1	1	-	0.967	0.417	1	96	-	0.636	0.596
251-500	2	52	0.5			2	1.5	0.7			2	90	14		
501-750	3	50	2.2			3	3	1.7			3	85	5		
Experienced bad breath															
No	29	45	4.1	2.734**	0.009	29	1.5	1	5.554***	0	29	91	6	2.348*	0.023
Yes	19	48	4.9			19	3.1	0.8			19	86	7.3		
Tooth brushing															
1 time	42	46	4.6	1.008	0.319	42	2.2	1.2	1.68	0.1	42	89	7.1	0.061	0.952
2 times	6	48	5			6	1.3	1			6	90	4.8		
Tongue cleaning															
No	27	46	4.3	0.232	0.817	27	2.4	1.3	2.007*	0.051	27	89	6.3	0.232	0.817
Yes	21	47	5.2			21	1.7	1			21	89	7.6		

**P<0.01 and *P<0.05