

# POSITIVE EFFECTS OF “TEXTURED LUNCHES” GATHERINGS AND ORAL EXERCISES COMBINED WITH PHYSICAL EXERCISES ON ORAL AND PHYSICAL FUNCTION IN OLDER INDIVIDUALS: A CLUSTER RANDOMIZED CONTROLLED TRIAL

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**Abstract:** *Objectives:* Proper nutrition and physical exercises are essential to prevent frailty in older adults. Proper masticatory performance and oral function may influence on physical activities as well since the mouth is the entrance of nutrition and digestion. Thus, the present study aimed to test the combined program of specially devised lunch gatherings containing textured foods with oral and physical exercises on the improvement of oral and physical function in community-dwelling older adults. *Design:* A Cluster randomized controlled trial; *Setting and Participants:* Eighty-six community-dwelling older adults in Daito city, Japan, were randomly assigned into control (n = 43) or intervention (n = 43) groups. *Intervention:* The control group performed the physical exercise regimen only. The intervention group participated in a 12-week physical and oral exercise program and ate a so-called “munchy lunch” that introduced textured foods with proper nutrients together after performing the physical exercise twice a week following brief dietary instruction at the intervention onset. Physical training and lunch gatherings were held at local public centers. *Measurements:* The differences in measured variables for physical and oral function between baseline and 12 weeks of intervention were statistically tested. *Results:* Oral function as measured by tongue pressure increased significantly in the intervention group (p=0.031), but not in the control group. Physical properties and activities, including body fat percentage and results of the timed up and go test, decreased more significantly in the intervention group than in controls (p<0.05). *Conclusions:* Our findings suggest that a combined program of textured lunch gatherings with oral and physical exercises may improve physical and oral function as a preventative approach for frailty in community-dwelling older adults.

**Key words:** Oral health, textured lunch, comprehensive program, frailty, dietary instruction.

## Introduction

Oral health is one of important factors to maintain good general health. As the oral cavity is the entrance of food ingestion, poor oral conditions restrict proper feeding. In older adults, oral health and function are gradually deteriorated with falls in general health, leading to malnutrition. Associations between malnutrition and oral condition, such as the number of teeth, occlusal force, and tongue strength, have been broadly reported (1-5). Fewer teeth are significantly correlated with a lower intake of meat and vegetables and increased consumption of fat and carbohydrates, resulting in nutritional imbalances. (1) Such deviations eventually lower dietary protein amount to insufficient levels and cause malnutrition and frailty in older adults. Moreover, recent studies revealed that poor oral health, also called oral frailty or oral hypofunction, was a significant risk factor for poor prognosis in hospitals and the community. (2, 6) Therefore, oral exercises maintaining oral function are recommended to improve oral health and eating ability (7, 8).

Proper ingestion of meat and vegetables are important to maintain or improve oral and general health, but older adults tend to avoid foods with hard textures and opt for softer foods. Both maintaining healthy oral conditions to chew harder

foods and retaining these habits are important for sufficient nutrition. Fabricating new dentures could improve masticatory ability, but nutrition status did not change (9-11). However, dietary instruction or even simple dietary advice in addition to denture fabrication could increase awareness and intake of meat and vegetables (9, 10). Actively encouraging older adults to eat foods with more texture and hard particles with proper dietary instruction could raise their awareness of their chewing behaviors and texture of their usual diet. Thus, the present study aimed to test the integrated program combining specially devised lunch gatherings containing textured foods with oral and physical exercises on the improvement of oral and physical function in community-dwelling older adults.

## Methods

This study’s protocol was approved by the Institutional Review Board (Approval ID: HM17-182). The study was registered as a University Hospital Medical Information Network Clinical Trials Registry (UMIN-CTR) clinical trial (Unique trial ID: UMIN000030090).

A sample size of 40 participants in each group was calculated based on previous studies (12, 13) to provide an

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effect size of 0.25 between intervention and control groups for a two-tailed significance level, a type I error of 0.05, and a type II error of 0.20 (power = 0.80). Considering a drop-out rate of 25%, 120 participants (60 in each group) were targeted for enrollment.

### **Participants**

Community-dwelling older adults were recruited in Daito city, Osaka, Japan, in February and March, 2018. Recruitment was administrated by the Coomin Corporation (Daito town development business center, an external organization of Daito City) as follows: distributing flyers to elderly community groups, visiting each community group individually, and giving public information sessions on the study concept at Daito Civic Hall from January to March, 2018. The inclusion criteria were individuals over 65 years of age who could participate in the trial for 12 weeks and undergo examinations beforehand and afterwards. The exclusion criteria were edentulous without using dentures, food allergies, severe kidney failure, and severe dysphagia. All participants gave written informed consent prior to enrollment in this study.

### **Randomization**

The allocation of the participants was managed by the Coomin Corporation. Participants were assigned randomly to the control or intervention groups as clusters of local community centers which were distributed in each area in the city. The size of clusters depended on the size of local community centers. The participants were not notified as to what was being conducted in the other group. The examiners who assessed physical and oral function at the baseline and final measurements were blinded to patient groupings. The main investigator, who did not attend the assessments, gave instructions on nutrition and oral exercise to the intervention group, and thus was not blinded to the intervention.

### **Intervention**

For the intervention group, the 12-week program was started in April, 2018. The intervention program included group physical exercises, home oral exercises, so-called “munchy textured lunch” gatherings, and basic dietary instruction. For the control participants, group physical exercise sessions at local community centers were conducted for twice a week for 12 weeks.

#### *Oral exercise*

Two simple home-based oral exercises were assigned to the intervention group. The exercises were instructed to perform at home by the principal investigator at the beginning as follows: (1) Tongue muscle strength training: A tongue strength training device (Peko-panda, JMS, Japan, Figure 1A) was used. The device head becomes collapsed by the tongue pushing against the palate and returns to its original shape when the tongue is backed. If pre-intervention tongue pressure was more than 30

kPa, the Hard-type device (30 kPa) was given, and the Medium-type device (20 kPa) was given to participants having a tongue pressure of below 30 kPa (2). Tongue rotation and swallowing exercise (Figure 1B): The participants were instructed to rotate their tongue as much as possible in the mouth, and then swallow saliva forcibly after the rotation.

The training regimen was set based on previous reports, as follows (14, 15): 3 sets of 5 cycles twice a day for 3 times a week. They were advised to increase the number of repetitions if they felt the training load was too low. Adherence to the program was self-recorded on a training record sheet.

#### *Physical exercise*

Daito city had already established a public group-style physical exercise program in each area as part of a long-term care prevention program,(16) which was applied to the current combined regimen. Each 20-minute exercise session contained the following 2 parts performed between periods of abdominal breathing: (1) Chair exercise: Stepping exercises, repeated toe and heel raises, repeated knee lifts and extensions, shoulder external rotations, and squats were done while seated on a chair for 10 minutes. (2) Standing exercise: While standing on 1 leg, multidirectional weight shifts and body and arm extensions were performed. The exercises were continued for 10 minutes.

Identical exercises were provided twice a week for 12 weeks for both intervention and control groups. Attendance was self-recorded in a training record log for both groups.

#### *Munchy lunch gatherings*

##### Lunch box preparation

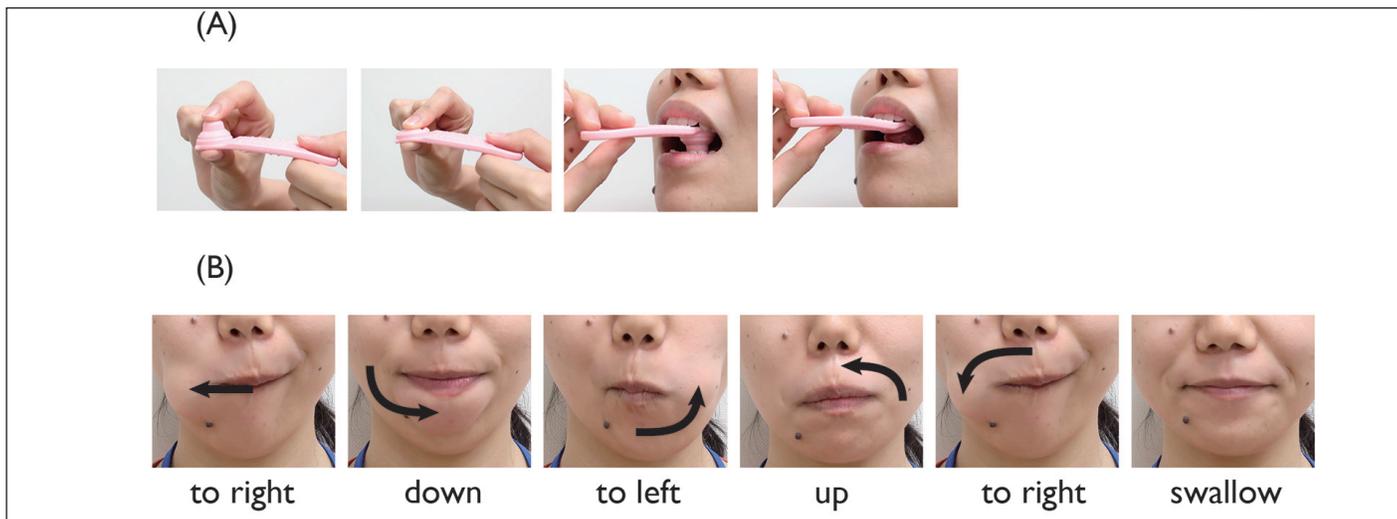
We introduced the concept of gathering to eat a munchy lunch in this comprehensive program to raise participant awareness of the composition and consistency of their diet. The munchy lunch is a packaged lunch box meal consisting of cooked rice, a main dish, and 2 side dishes designed to improve oral function with foods that require more chewing as well as nutritional status. The lunch boxes provided increased masticatory load by means of the following preparation principles (17): 1) Using hard or textured food ingredients, 2) Cutting ingredients into larger pieces, 3) Shortening cooking time for vegetables and root vegetables, and 4) Using less water. We also aimed that the lunches had specified amounts of calories (>600 kcal), protein (>25 g), vitamin D (>2.75 µg), and sodium (<2.5 g) based on the Dietary Reference Intakes for Japanese males over 70 years of age.(18) Twelve different types of lunch boxes were prepared and served twice each over 12 weeks (Figure 2).

##### Munchy lunch gatherings

Participants in the intervention group were instructed to have the munchy lunch together at Daito Civic Hall twice a week after their physical exercises. Attendance at the lunches and amount and type of leftovers in lunch boxes were recorded on eating record sheets.

**Figure 1**

(A) Tongue muscle strengthening training. A tongue strength training device (Peko-panda, JMS, Japan) made of silicone rubber has a convex-shaped head. The tongue is pushed against the hard palate in the oral cavity for training. The head is collapsed by the tongue pressure and returns to its original shape when the tongue pressure is released. (B) Tongue rotation and swallowing exercise. The participants were instructed to rotate their tongue as much as possible in the mouth, and then swallow saliva forcibly after the rotation



**Figure 2**

An example of munchy lunch boxes used in this trial. The foods in the lunch box were devised to contain harder food ingredients (sesame seeds, lotus root, carrots, burdock root, etc.) that were cut into larger pieces and had shortened cooking time. The lunch box contains 25.8 g of protein, 6.5  $\mu$ g of vitamin D, 2.3 g of sodium, and 659 kcal



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### *Brief dietary instruction*

Basic dietary advice was given at a lunch gathering by the principal investigator once at the early stage of intervention using a simple nutritional instruction guide (The Japanese Food Guide Spinning Top) published by the Japanese Ministry of Agriculture, Forestry, and Fisheries (19).

### **Measures**

#### *Oral function*

Four oral function parameters were measured based on a previous report (6) by trained dentists. Briefly, the procedures were as follows:

(1) Occlusal force: The occlusal force was measured by 3 seconds of clenching using pressure-indicating film (Dental prescale sheet, GC, Japan) (20). The area of changed color on the sheet by clenching was measured by analysis software and calculated as occlusal force. Calculated values were log transformed for analysis due to wide inter-subject variation.

(2) Tongue pressure: A tongue pressure sensor balloon probe connected to a digital tongue pressure meter (JMS, Hiroshima, Japan) was placed on the dorsal tongue surface. Participants were asked to press up against the probe with the tongue towards the hard palate at maximum strength for 3 seconds (21). After several practice movements, tongue pressure was assessed 3 times for calculation of mean values.

(3) Tongue-lip motor function: Participants were instructed to say the syllables /pa/, /ta/, or /ka/ as many times as possible for 5 seconds. The number of utterances was counted by a digital counter (Kenkokun Handy, Takei Scientific Instruments Co., Ltd, Japan) (22) and used for analysis.

(4) Masticatory function: Masticatory function was measured using a gummy jelly. Participants were instructed to chew 2 g of gummy jelly without swallowing the bolus or saliva for 20 seconds. They were then asked to hold 10 ml of distilled water in their mouth and spit out the jelly and water into a cup fitted with a funneled mesh. The amount of eluted glucose was measured with a masticatory ability testing system (Gluco Sensor GS-II, GC, Japan) (23).

#### *Physical properties and activities*

##### Body composition assessment

Body mass index (BMI) was calculated from height and weight and used for analysis. Body composition was measured by bioelectrical impedance analysis using an In Body 470 device (In Body Japan Inc., Tokyo, Japan). Participants stood on the apparatus during measurements. Appendicular muscle mass was divided by the square of the subject's height and used for calculation of skeletal muscle mass index (SMI). Body fat percentage was determined as well.

##### Physical activities

The following physical functions were measured based on previous reports (12, 24):

(1) Hand grip strength (HGS): Measurements were carried out in triplicate for each hand with a digital hand dynamometer (Grip-D, Takei Instruments, Niigata, Japan). The mean maximum grip strength for each hand was used for analysis.

(2) Normal walking speed: Participants were instructed to walk at normal speed for a distance of 5 meters. The time required to cover the middle 3 meters was recorded for calculations of walking speed.

(3) Time of timed up and go test (TUG): Participants were instructed to stand up from a chair, go around a pole 3 meters away, and sit back down on the chair. The time of the whole process was recorded for analysis.

#### **Data analysis**

The baseline demographics of the 2 groups were compared with the Student's t-test. The differences in measured variables for physical and oral function between baseline and 12 weeks of intervention were evaluated by the paired t-test. Between group comparison of outcome measures after 12 weeks was performed using analysis of covariance with adjustment by the baseline values. The critical value for rejecting the null hypothesis was  $P < 0.05$ . Statistical analyses were performed using SPSS version 24.0 software (SPSS Inc., Chicago, IL).

### **Results**

A total of 113 older adults were recruited for this study and allocated into the intervention or control groups randomly according to community group (Figure 3). Five subjects in the control group and 12 in the intervention group withdrew from the study due to lack of interest or hospitalization. Ultimately, each 43 subjects in the control and intervention groups completed the final physical and oral assessments.

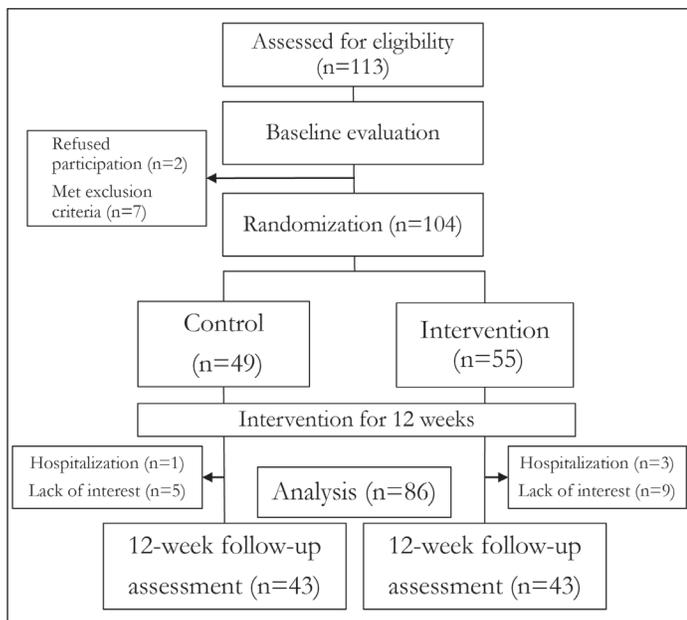
The baseline measurements of the cohort are summarized in Table 1. At the study onset, body fat percentage was significantly lower in the intervention group. No subject satisfied the criteria for sarcopenia (25). As the measure for oral function, the number of teeth, occlusal force, and masticatory function were significantly higher in the intervention group at baseline. The attendance rate for the munchy lunch gatherings in the intervention group was 95.2%. The percentage of leftover lunch was  $1.6 \pm 4.9\%$ .

#### **Oral function between subject effects**

For within-group difference, tongue pressure and lip-tongue motor functions (/ka/) became significantly increased in the intervention group ( $P = 0.004$  and  $0.004$ , respectively, Table 2). Masticatory function improved significantly in both groups, with a higher tendency in the intervention group ( $P = 0.001$  vs.  $P = 0.008$ ). For between group comparison, tongue pressure significantly increased in the intervention than in the control groups after 12 weeks intervention ( $35.5 \pm 7.4$  kPa for the intervention and  $32.3 \pm 7.8$  kPa for the control, respectively).

**Figure 3**

Schematic flow diagram of participants in this randomized control trial



**Physical properties and activities**

For within group comparison, body fat percentage and BMI decreased significantly in the intervention group ( $P < 0.001$ ) but not in the control group (Table 3). SMI was not significantly changed in either group. Normal walking speed increased significantly ( $P = 0.021$ ) and TUG time decreased significantly ( $P < 0.001$ ) only in the intervention group. For between group comparison, body fat percentage and TUG significantly decreased in the intervention than in the control groups after 12 weeks intervention ( $P = 0.014$  and  $0.006$ , respectively).

**Discussion**

The present study demonstrated that a combined program of munchy lunch gatherings with oral and physical exercises could improve oral and physical function in older adults. In addition to physical and oral exercises, a key concept of this study was gathering to eat a munchy lunch. Jelly- or drink-type supplementation is often used in nutrition trials (12, 24). They were not used in this study, which instead included natural foods that were rich in protein and vitamin D along with a more textured consistency. In line with its namesake, the consumption of textured foods containing hard particles

**Table 1**  
Baseline characteristics of participants

Characteristic	Overall (n=86)	Control (n=43)	Intervention (n=43)	P-value
	Mean SD	Mean SD	Mean SD	
Age (years)	75.6 (5.6)	76.7 (5.3)	74.4 (5.6)	0.06
Men : Women	6 : 80	2 : 41	4 : 39	
Oral functions				
Number of teeth	18.7 (9.4)	15.3 (10.3)	22.0 (7.1)	0.001
Occlusal force (log [N])	2.3 (0.4)	2.2 (0.4)	2.4 (0.4)	0.019
Tongue-lip motor function				
/pa/ (number/s)	6.1 (0.8)	6.1 (0.8)	6.2 (0.8)	0.89
/ta/ (number/s)	6.2 (0.7)	6.1 (0.7)	6.3 (0.7)	0.42
/ka/ (number/s)	5.8 (0.8)	5.7 (1.0)	5.8 (0.7)	0.69
Tongue pressure (kPa)	32.4 (8.0)	31.8 (8.6)	32.9 (7.4)	0.55
Masticatory function (mg/dL)	137.6 (48.7)	122.1 (50.6)	152.8 (42.0)	0.003
Physical properties and activities				
BMI (kg/m <sup>2</sup> )	23.7 (3.6)	24.3 (4.1)	23.1 (3.0)	0.13
Body fat percentage (%)	33.5 (6.7)	35.3 (5.8)	31.8 (7.0)	0.016
SMI (kg/m <sup>2</sup> )	8.2 (1.0)	8.1 (1.1)	8.2 (0.8)	0.38
HGS (kg)	21.6 (4.8)	20.9 (4.1)	22.4 (5.3)	0.14
Usual walking speed (m/s)	1.5 (0.3)	1.5 (0.3)	1.5 (0.3)	0.45
TUG (s)	7.0 (1.5)	7.0 (1.7)	7.0 (1.2)	0.92

SD, Standard deviation; BMI, Body mass index; SMI, Skeletal muscle mass index; HGS, Hand grip strength; TUG, Time of timed up and go test

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**Table 2**  
 Oral functions at baseline and after 12 weeks for the control and intervention groups

Variable	Control			Intervention			Between-Group Differences	
	Baseline	12 weeks	P-value	Baseline	12 weeks	P-value	P-value	
	Mean SD	Mean SD		Mean SD	Mean SD			
Occlusal force (log [N])	2.2 (0.4)	2.3 (0.5)	0.266	2.4 (0.4)	2.5 (0.2)	0.309	0.36	
Tongue-lip motor function								
/pa/ (number/s)	6.1 (0.8)	6.3 (0.7)	0.121	6.2 (0.8)	6.4 (0.7)	0.074	0.482	
/ta/ (number/s)	6.1 (0.7)	6.2 (0.6)	0.323	6.3 (0.7)	6.3 (0.8)	0.472	0.855	
/ka/ (number/s)	5.7 (1.0)	5.9 (0.8)	0.237	5.8 (0.7)	6.1 (0.7)	0.004	0.107	
Tongue pressure (kPa)	31.8 (8.6)	32.3 (7.8)	0.420	32.9 (7.4)	35.5 (7.4)	0.004	0.031	
Masticatory function (mg/dL)	122.1 (50.6)	141.8 (62.5)	0.008	152.8 (42.0)	177.8 (49.0)	0.001	0.196	

SD, Standard deviation

**Table 3**  
 Physical properties and activities at baseline and after 12 weeks for the control and intervention groups

Variable	Control			Intervention			Between-Group Differences	
	Baseline	12 weeks	P-value	Baseline	12 weeks	P-value	P-value	
	Mean SD	Mean SD		Mean SD	Mean SD			
BMI (kg/m <sup>2</sup> )	24.3 (4.1)	24.0 (3.9)	0.181	23.1 (3.0)	22.8 (2.9)	<0.001	0.639	
Body fat (%)	35.3 (5.8)	34.8 (6.0)	0.060	31.8 (7.0)	30.7 (6.4)	<0.001	0.014	
SMI (kg/m <sup>2</sup> )	8.1 (1.1)	8.2 (0.9)	0.209	8.2 (0.8)	8.3 (0.8)	0.102	0.783	
HGS (kg)	20.9 (4.1)	20.8 (4.0)	0.547	22.4 (5.3)	21.7 (4.8)	0.026	0.425	
Walking speed (m/s)	1.5 (0.3)	1.5 (0.3)	0.103	1.5 (0.3)	1.6 (0.2)	0.021	0.289	
TUG (s)	7.0 (1.7)	6.9 (1.7)	0.201	7.0 (1.2)	6.5 (1.0)	<0.001	0.006	

SD, Standard deviation; BMI, Body mass index; SMI, Skeletal muscle mass index; HGS, Hand grip strength; TUG, Time of timed up and go test

with proper dietary instruction was intended to raise the awareness of the participants on their masticatory behavior and texture of their usual diet, presumably motivating them to eat a healthy, harder diet more regularly. Older individuals with decreased natural dentition tended to lack meat, fish, and vegetable intake (1, 26). In older adults, oral function declined gradually with falls in general function and was associated with systemic sarcopenia or frailty (2, 3). Thus, the results in this study indicate that a combined approach to oral health, eating behavior and general health may be important to maintain oral and general health.

In this study, tongue pressure were improved by the intervention program that contained 2 simple at-home oral exercises: tongue muscle training and tongue motor training. This trial employed a simple device, and participants could vary load by the number and frequency of training, which resulted in a significant increase in tongue pressure. The tongue has an important role in mastication and swallowing. Since the organ consists of muscle, decreased tongue pressure is observed in patients with dysphagia (3), sarcopenia (3, 27), neuromuscular disease (28), or cerebrovascular disorders (29), and is thus

related to diet type in those patients. Keeping an adequate functional reserve is essential to prevent the need for prolonged medical care. Therefore, tongue muscle strengthening exercises would be a key exercise to maintain oral health and proper diet.

We adopted a simple tongue motor exercise in addition to the strengthening exercise. Oral exercise regimens are often included in comprehensive long-term health programs (8, 30), with remarkable gains seen for lip-tongue motor function (8). Consistently with previous reports, the numbers of /ka/ utterances were significantly increased in the intervention group, although the between group difference showed no significant difference. These findings indicated that simple tongue motor exercises in addition to tongue strengthening exercise could improve lip-tongue motor function.

Masticatory performance increased significantly in the intervention group by within group comparison although specific exercises for masticatory performance were not planned in this study. Masticatory activities increase when chewing hard foods (31). Nakagawa et al. reported that 2 weeks of gum chewing exercise significantly increased occlusal force (32). Taken together, along with 12 weeks of

other interventions, eating a munchy lunch and brief dietary instruction may alter their eating habits to increase hard food intake and improve masticatory performance.

Unexpectedly, both body fat percentage decreased significantly by the intervention. Brief dietary advice was initially given to the participants using a simple instruction guide. Nutritional education can improve physical function and diet in community-dwelling people (33). Provided textured lunch contained proper protein and vitamins from vegetables. The dietary information in this study was basic, but our results indicated that the diet instruction and eating custom of provided healthy lunch could change their eating behavior and reduce body fat significantly. Although we did not conduct a detailed nutrition assessment in this study, eating a munchy lunch with the others might have increased participant interest in the ingredients of their meals. Foods with larger pieces and harder textures than in normal diets were incorporated into the munchy lunch, but leftovers were rarely observed, suggesting good compatibility of the munchy lunch with subject tastes for our cohort's demographic profile.

Previous studies reported that combined resistance training and nutrient supplementation for 12 weeks significantly increased walking speed and skeletal muscle mass (12, 24). The present investigation also showed improvements in TUG time to confirm that exercise intervention improved physical performance. Skeletal muscle mass did not increase significantly in this study. The participants were relatively healthy and none had sarcopenia, which may have been a reason for no remarkable gains.

### Limitations

This study had several limitations. Although physical and oral function were improved in the intervention group, we could not determine which program component was most efficient for each functional improvement because of the comprehensive nature of the physical and oral exercise, lunch, and diet instruction in this study. We suspect that each program had effects on both general and oral function because exercise and nutrition are jointly essential for functional improvement. They also enjoyed the exercises with the other participants and increased social connections each other, likely resulting in high adherence rates to exercise sessions. Such gathering and social interactions were also thought to influence the results of the study, which might prevent social frailty as well.

### Conclusions and Implications

The present study demonstrated that a combined program of munchy lunch gathering with oral and physical exercises could increase oral and physical function during 12 weeks. Such an integrated program may be of particular benefit to community-dwelling older individuals as preventive approach to frailty or dependency.

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*Conflict of Interest:* The authors have no financial or other kinds of personal conflicts with this work.

*Ethical standards:* This study protocol was approved by the Institutional Review Board of Fujita Health University (Approval ID: HM17-182).

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