Original Article

Efficacy of a Health Promotion Program with Facial Mimetic Muscle Training in Residents of a Medical Care Facility for the Elderly

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Abstract

Objective: We conducted an anti-aging medical checkup and health promotion program, including facial mimetic muscle training, in residents of a geriatric medical care facility. Here, we evaluate the physical and mental effects of these activities.

Methods: Three male and 16 female residents (83.7±6.8 years, BMI 22.2±3.0) underwent occupational therapy, with the addition of facial mimetic muscle training with a medical device, "M Patakara", for 3.0 – 4.5 minutes four times per day for 24 weeks. Efficacy was evaluated by anti-aging medical checkup before and after the study.

Results: The Anti-Aging QOL Common Questionnaire (AAQol) showed a significant improvement in the symptom scores of "anorexia", "early satiety", "epigastralgia", "constipation", "headache", "dizziness", and "arthralgia" ($p<0.05$). Laboratory results showed significant changes in LDL cholesterol (111.6±24.8 mg/dl → 120.2±27.5mg/dl, $p=0.022$) and IGF-I (123.2±50.9ng/ml → 109.6±55.5ng/ml, $p=0.005$) at 24 weeks. Serum cortisol (11.7±3.8μg/dl → 15.6±5.3μg/dl, $p=0.001$) significantly increased while DHEA-s/cortisol ratio did not change. The Wisconsin card sorting test showed a significant reduction in total errors (32.6±4.6 → 27.8 ±7.5, $p=0.022$) and unique errors (5.2±5.1 → 1.9 ±2.7, $p=0.026$). Body composition analysis (Physion MD) revealed a decrease in muscle mass in the upper arms (0.50±0.14kg → 0.45±0.12kg, $p=0.005$) and lower limbs (4.4±1.2kg → 4.1±1.0kg, $p=0.006$). There was no significant change in vascular age by fingertip acceleration plethysmogram (SDP-100) or in osteo-sono-assessment index of the calcaneus by ultrasonography (AOS-100NW). Saliva secretion increased significantly, from 8.0±5.0 mm/min to 12.6±2.3 mm/min ($p<0.001$) by the coffee filter method. Labial closure strength and electromyographic activity of the facial mimetic muscles increased significantly. No serious adverse event occurred during or after the study.

Conclusion: This health promotion program with facial mimetic muscle training improved saliva secretion and subjective symptoms, indicating that it improved QOL in these aged facility patients. On anti-aging medical checkup, however, it was ineffective in preventing sufficiently the muscle weakening.

KEY WORDS: saliva, facial mimetic muscle, anti-aging medical checkup, Wisconsin card sorting test, Patakara

Introduction

Senior residents in geriatric medical care facilities generally have lower activity of daily living (ADL) scores than independently living elderly. To prevent a deterioration in bodily function due to aging and to maintain quality of life (QOL) to the greatest extent possible, these facilities conduct various types of health promotion programs that combine occupational therapy, physiotherapy, oral health care, and rehabilitation. Although the coming advent of the super-aged society requires the development of effective and efficient programs able to operate in a restricted budgetary and human resources environment, the efficacy of programs developed to date has not been adequately verified. In particular, training of facial mimetic muscles has not been conducted.

The concept of anti-aging medicine recognizes the importance of maintaining body balance. For example, intraoral bacilli proliferate when oral health care is neglected, resulting in respiratory infection. Eating disorders result in serious nutritional insufficiency. Moreover, if the muscles of facial expression become weak, expression diminishes and mental function is adversely influenced.

Here, we conducted a health promotion program, which included facial mimetic muscle training using a medical device, "M Patakara" [1], with rehabilitation and occupational therapy in the elderly in an aged care facility. Efficacy of the program was evaluated using an anti-aging medical checkup [2,3].

Methods

Subjects

The subjects were 19 residents (3 males; mean age, 83.7±6.8 years; BMI: 22.2±3.0 kg/m²) of Long-Term Care Health Facility Yonan, located at Utsunomiya-city, Tochigi, Japan, who provided informed consent to join the program. Of 22 residents initially enrolled, 3 dropped out (ratio 9.5%), 2 due to moving out and 1 due to death from a cause unrelated with this program.

Health Promotion Program with Facial Muscle Training

The health promotion program, which was conducted on weekdays by physical therapists (PT) and occupational therapists (OT), was aimed at ensuring the maintenance of ADL and joint motion range. The physical program of about 40 minutes was composed of combination of (1) whole body exercise, (2) bed mobility training such as turning over in bed and getting up, (3) basic training for standing up, moving between the bed and wheelchairs and keeping the upright positioning, (4) muscle load training, (5) training for keeping joint motion range, and (6) walking exercise. Combination varied in ADL of each individual. Furthermore, occupational therapies such as handicrafts or calligraphy were conducted for about 40 minutes.

Facial mimetic muscle training was done four times a day on six days a week for 24 weeks under the observation of a PT, OT, or certified care worker, using the medical device "M Patakara" (Patakara, Musashino-city, Tokyo) for muscular power training around the lips (*Fig. 1*) [1]. One episode of treatment consisted of keeping the closed state of the lips for 3.0 – 4.5 minutes, as measured with a 90-second duration hourglass. The program was conducted to all the participants from July, 2009 to February, 2010. The following items were evaluated before the study at July 30, 2009 and after the program at February 4, 2010.

Fig. 1. A medical equipment used for the facial mimetic muscle training

Evalution methods

1. Levels of care needed, subjective symptoms and lifestyle-related behaviors

Subjective symptoms were categorized as physical or mental. Individual symptoms were rated as previously described using the Anti-Aging QOL Common Questionnaire (AAQol) according to a 5-point scale [3,4], consisting of: 1, not at all; 2, almost none; 3, a little; 4, moderate degree; and 5, high degree. With regard to lifestyle, subjects were questioned about dietary habits, fitness habits, sleep, smoking, alcohol drinking, and water consumption. The questionnaire was conducted before and after the program. Levels of care needed were assessed based on the standard criteria by the Ministry of Health, Labour and Welfare.

2. Anthropometry

The following anthropometric parameters were determined: height, body weight, blood pressure, pulse rate, and body composition which assessment was performed using a bioelectrical impedance analyzer, Physion MD (Physion, Shimogyo-ku, Kyoto) as reported previously [5].

3. Blood biochemistry examination

Hematological parameters, including white blood cell (WBC) count, WBC fraction, red blood cell count, hemoglobin (Hb), hematocrit; biochemical parameters, including total bilirubin, aspartate aminotransferase (AST), alanine transaminase (ALT), lactate dehydrogenase (LDH), alkaline phosphatase (ALP), γ-glutamyl transpeptidase (γ-GTP), creatine phosphokinase (CPK), amylase, uric acid, blood urea nitrogen (BUN), creatinine, for lipid and sugar metabolism, total cholesterol (TC), low density lipoprotein-cholesterol (LDL-C), high density lipoprotein-cholesterol (HDL-C), triglyceride, fasting plasma glucose (FPG), HbA1c, immunoreactive insulin (IRI), for protein metabolism, total protein (TP), albumin, albumin / globulin (A/G) ratio, for electrolytes, sodium, potassium, chlorine, calcium, iron, and for hormones, cortisol, dehydroepiandrosterone-sulfate (DHEA-s), insulin-like growth factor-I (IGF-I), were determined. Biochemical examination was performed at the Mitsubishi Chemical Medience Corporation (Minato-ku, Tokyo). In addition, the atherogenic index (AI) and HOMA-R (homeostasis model assessment insulin resistance) were calculated according to the following formula, respectively:

AI = (TC − HDL-C) / HDL-C, and
HOMA-R = IRI × FPG / 405.

4. Anti-aging medical checkup

Physical function related to aging was evaluated by measurement of muscle mass and bone mineral density, hormonal tests, degree of atherosclerosis, and executive brain function tests, as follows.

Muscle age was evaluated by determining muscle mass with a bioelectrical impedance analyzer for muscle mass (Physion MD) [5]. We previously reported large-scale data regarding body composition and segmental muscle mass measurements with this analyzer in 10,335 healthy Japanese individuals [6]. Given the important role of muscles of the lower limb, particularly the quadriceps muscles, in loaded movements such as walking, stepping exercises, and standing up, the maintenance of quadriceps muscle strength is recommended for the maintenance of QOL in the elderly. To

assess ADL, the weight bearing index (WBI) [7,8] was calculated by measuring quadriceps muscle volume, and maximum strength was calculated from segmental muscle mass values and body balance (balance of right and left, upper and lower limbs, trunk and extremities). WBI was then calculated from the formula WBI = quadriceps muscle maximum strength / body weight.

Executive brain function was evaluated by the Wisconsin card sorting test (WCST) [3,9], with results expressed as categories achieved (CA), numbers of response cards used until the first category achieved (NUCA), total errors (TE), perseverative errors of Nelson (PEN), perseverative errors of Milner (PEM), unique errors (UE), bizarre response (BR), and reaction time. Atherosclerosis was evaluated by fingertip acceleration plethysmography (SDP-100, Fukuda Denshi, Bunkyo-ku, Tokyo), and the results were expressed as vascular age [3,10]. Bone age was evaluated from the value of bone mineral density of the calcaneus bone as determined by ultrasonography (AOS-100NW, Aloka, Mitaka, Tokyo) [3,11], and the results were expressed as the osteo-sono-assessment index (OSI) and % young adult mean (%YAM). Serum concentrations of dehydroepiandrosterone sulfate (DHEA-s), insulin-like growth factor-I (IGF-I) and cortisol were measured at Mitsubishi Chemical Medience (Minato-ku, Tokyo). For evaluation of hormonal age, measured values were referred to the reference data of Age Management Check (Gingakobo, Naka-ku, Nagoya), as previously reported [3].

5. Examination of saliva secretion, labial closure strength and facial mimetic muscle activity

The amount of non-stimulated saliva secretion was measured with simple-type saliva secretion measurement paper [12,13]. Briefly, rectangular coffee filter paper was cut to a 1cm width and 9cm length, then folded approximately in half (4cm and 5cm). The shorter part (4cm), on which the scale was printed, was left outside the mouth and the longer part (5cm) without the scale was put into the mouth. The tongue was retracted and the lips were lightly shut around the center of the tongue back. To absorb saliva in the mouth, the patient was instructed to maintain a vertical position with the face angled down. The external portion was detached within 60 seconds, and the length (mm) of the part wetted by saliva was measured. Coffee filter paper was found to be better than the other papers tested owing to its safety, excellent mouth feel, and high absorption. Measurement was performed repeatedly until Week 26.

Labial closure strength was measured a measurement apparatus (BHC-V01, Patakara, Musashino-city, Tokyo). The sensor was first covered with a vinyl cover or kitchen wrap, then the "RESET" button was pushed, resetting the device to its initial state. The sensor was then placed between the lips and gums with the subject sitting with the feet flat on the floor. Those using dentures were tested with the dentures in place. When the subject was ready, the "START" button was pushed, and the subject was asked to exert pressure for 12 seconds. The device measured the pressure for ten seconds, beginning 2 seconds after the button had been pushed. The maximum value obtained in the 10-second period was expressed. Measurement was repeated three times, and the mean values are shown.

Activity of the facial mimetic muscles was measured by electromyography (EMG Master, Mediarea Support Business Union, Kita-ku, Okayama). The electrode was set up at two independent points, the infraorbital foramen (on which a sphincter oculi is anatomically located) and the modiolus, under which the sphincter oculi is anatomically located. Between the two points are the levator labii superioris, musculus levator anguli oris, musculus buccinator, zygomaticus minor, and zygomaticus major muscles.

Electromyogram data were recorded for one minute, then the amount of muscle activity was evaluated by the area under the curve, which was integrated value of the wave.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki as annotated at the Tokyo General Meeting in 2004. The study was also in accordance with the "Ministerial ordinance (GCP) concerning the standard of the execution of the clinical trial of the medicine" (No.28 of the public welfare ministerial ordinance on March 27, 1997). A third-party Ethical Review Board in Mareesia Garden Clinic (Shinjuku-ku, Tokyo) approved the ethics and validity of the study. Subjects gave written informed consent of their own accord to participate in the study, and were informed that, after giving consent, they were allowed to withdraw consent for any reason without fear of being disadvantaged in any way.

Statistical Analysis

Measurements from week 0 and 24 were compared using the paired t-test, or the Wilcoxon signed rank test if the data did not have a normal distribution. Repetition decentralization analysis was also used to compare repeatedly measured values. Correlation analysis was performed by Spearman's method. All data are expressed as mean ± standard deviation (SD). Significance was set at $p<0.05$. SPSS for Windows Ver.15.0 (SPSS Japan, Shibuya-ku, Tokyo) was used for statistical analysis.

Results

1. Level of care needed, subjective symptoms, and lifestyle-related behaviors

The level of care needed is shown in *Fig. 2*. After having conducted the health promotion program for 24 weeks, the level of care needed improved by one stage in one subject from level V, in one subject from level IV, and in two subjects from level III.

Seven of the 32 physical symptoms were significantly improved, namely "anorexia" ($p=0.035$), "early satiety" ($p=0.021$), "epigastralgia" ($p=0.010$), "constipation" ($p=0.003$), "headache" ($p=0.030$), "dizz iness" ($p=0.049$), and "arthralgia" ($p=0.031$) (*Table 1*). No significant change was seen in any mental symptoms (*Table 2*), while with regard to lifestyle-related behavior, "Visual display terminal working hours" ($p=0.032$) was significantly changed.

2. Anthropometry

No significant change was seen in body weight or BMI (*Table 3*). In contrast, body composition data obtained by bioelectrical impedance analysis revealed a significant decrease in lean body mass (-3.1%, $p=0.028$) and water content (-3.1%, $p=0.026$) after 24 weeks.

3. Blood biochemistry

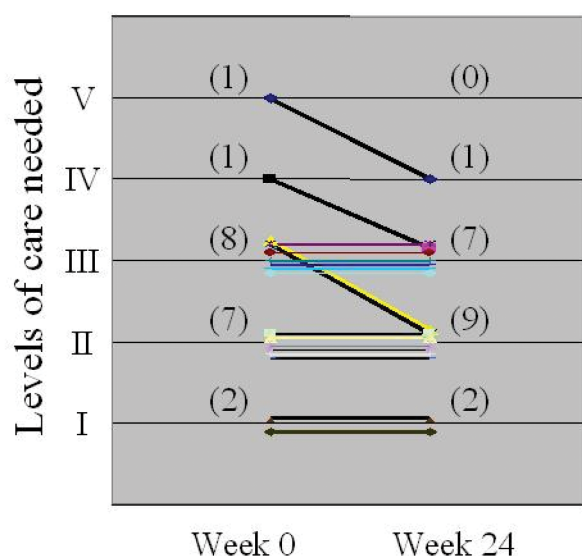With regard to lipid metabolism, no significant change was

Fig. 2. The composition of levels of care needed in the participants Parentheses present the number of cases at Week 0 or 24, respectively. n=19.

Table 1   Physical symptoms

	Week 0 mean SD	Weeks 24 mean SD	p-value (vs. week 0)
Tired eyes	1.9 ± 0.8	1.9 ± 1.0	1.000
Blurred vision	1.8 ± 1.1	1.8 ± 1.2	0.826
Painful eyes	1.5 ± 0.7	1.3 ± 0.6	0.056
Stiff shoulders	1.8 ± 0.9	1.9 ± 1.2	0.772
Muscular pain/stiffness	1.7 ± 0.7	1.7 ± 0.9	1.000
Palpitations	1.6 ± 0.8	1.4 ± 0.7	0.104
Shortness of breath	1.6 ± 0.8	1.4 ± 0.8	0.163
Tendency to gain weight	1.9 ± 0.7	1.9 ± 1.3	0.805
Weight loss/thin	1.8 ± 0.7	1.6 ± 0.9	0.818
Lethargy	1.9 ± 1.0	1.6 ± 0.9	0.233
No sense of wellness	1.9 ± 0.8	1.8 ± 1.0	0.863
Thirst	2.1 ± 0.9	1.9 ± 1.0	0.570
Skin problems	1.5 ± 0.8	1.2 ± 0.4	0.111
Anorexia	1.9 ± 0.9	1.4 ± 0.6	**0.035**
Early satiety	1.4 ± 0.6	1.2 ± 0.4	**0.021**
Epigastralgia	1.5 ± 1.0	1.2 ± 0.7	**0.010**
Liable to catch colds	1.7 ± 0.7	1.5 ± 0.6	0.259
Coughing and sputum	1.7 ± 0.8	1.4 ± 0.7	0.069
Diarrhea	1.4 ± 0.5	1.2 ± 0.4	0.104
Constipation	3.7 ± 1.1	3.0 ± 1.2	**0.003**
Hair loss	2.1 ± 0.6	2.2 ± 0.9	0.841
Gray hair	3.1 ± 0.9	2.9 ± 1.1	0.546
Headache	1.6 ± 0.7	1.3 ± 0.6	**0.030**
Dizziness	1.8 ± 0.9	1.4 ± 0.8	**0.049**
Tinnitus	1.6 ± 0.8	1.4 ± 0.8	0.104
Lumbago	2.2 ± 1.3	1.8 ± 1.1	0.134
Arthralgia	1.9 ± 1.0	1.5 ± 0.8	**0.031**
Edematous	2.3 ± 1.1	2.1 ± 1.3	0.350
Sweat easily	1.5 ± 0.6	1.6 ± 1.1	0.607
Frequent urination	2.1 ± 1.0	1.9 ± 1.2	0.409
Hot flashes	1.5 ± 0.5	1.2 ± 0.5	0.135
Cold skin	1.8 ± 1.0	1.6 ± 1.0	0.448

n = 19.

Table 2   Mental symptoms and lifestyle-related behaviors

		Week 0 mean SD	Weeks 24 mean SD	p-value (vs. week 0)
Mental symptoms				
Irritability		1.9 ± 0.7	1.9 ± 0.9	0.834
Easily angered		2.0 ± 0.7	2.0 ± 1.0	1.000
Loss of motivation		2.2 ± 1.0	1.8 ± 0.9	0.233
Unhappy		2.1 ± 0.8	1.8 ± 0.9	0.449
Nothing to look forward to in life		2.3 ± 0.9	2.5 ± 1.2	0.878
Daily life is not enjoyable		2.1 ± 0.8	2.3 ± 1.1	0.626
No confidence		2.1 ± 0.8	1.7 ± 1.0	0.187
Reluctance to talk with others		1.9 ± 0.8	2.1 ± 1.3	1.000
Depressed		1.8 ± 0.5	1.7 ± 0.9	0.507
Feeling useless		1.9 ± 0.6	2.0 ± 1.4	0.762
Shallow sleep		2.4 ± 0.7	2.2 ± 1.3	0.494
Difficulty falling asleep		2.3 ± 0.6	2.1 ± 1.3	0.384
Pessimism		2.3 ± 0.7	2.1 ± 1.2	0.466
Memory lapse		2.6 ± 0.9	3.1 ± 1.3	0.116
Inability to concentrate		2.1 ± 0.6	2.1 ± 1.0	0.633
Inability to solve problems		2.4 ± 1.0	2.5 ± 1.0	0.859
Inability to readily make judgments		2.3 ± 0.7	2.2 ± 1.1	0.564
Inability to sleep due to worries		1.9 ± 0.6	2.0 ± 1.1	0.631
Feeling tense		1.9 ± 0.6	2.0 ± 1.1	0.742
Feeling anxious for no particular reason		2.0 ± 0.7	1.6 ± 0.7	0.185
Vague feeling of fear		1.7 ± 0.5	1.5 ± 0.5	0.104
Lifestyle-related behaviors				
Smoking	Cigarettes/day	0.0 ± 0.0	0.0 ± 0.0	1.000
Alcohol consumption	mL/day	0.0 ± 0.0	0.0 ± 0.0	1.000
Frequency of alcohol drinking	times/week	0.0 ± 0.0	0.0 ± 0.0	1.000
Exercise	days/week	2.8 ± 1.7	2.6 ± 1.7	0.625
Sleeping hours	hours/day	7.2 ± 1.0	7.3 ± 1.3	1.000
Water consumption	L/day	1.5 ± 0.3	1.4 ± 0.2	0.907
VDT watching hours	hours/day	2.5 ± 1.7	1.6 ± 1.8	**0.032**

n = 19.

Table 3   Anthropometry

		Week 0 mean SD	Weeks 24 mean SD	p-value (vs. week 0)
Height	cm	149.4 ± 6.1		
Weight	kg	49.7 ± 8.7	49.1 ± 9.7	0.512
BMI	kg/m^2	22.2 ± 2.9	21.9 ± 3.4	0.483
Systolic blood pressure	mmHg	123.4 ± 10.7	124.6 ± 13.8	0.805
Diastolic blood pressure	mmHg	72.6 ± 6.1	75.4 ± 9.2	0.301
Heart Rate	bpm	86.1 ± 27.8	74.1 ± 9.3	0.078
Body composition testing				
Amount of fat	kg	13.1 ± 4.6	13.7 ± 5.1	0.348
Percentage body fat	%	26.1 ± 6.4	27.4 ± 6.8	0.159
Lean body mass	kg	36.5 ± 6.0	35.4± 6.5	**0.028**
Muscle mass	kg	17.8 ± 4.1	17.5 ± 4.4	0.401
Bone mass	kg	7.7 ± 1.9	7.7 ± 2.0	0.909
Water content	kg	26.7 ± 4.4	25.9 ± 4.7	**0.026**
Basal metabolic rate	kcal	1072.2 ± 153.2	1053.5 ± 163.9	0.189

n = 19.

seen in TC, HDL-C, or triglycerides, whereas significant increases were seen in LDL-C (7.7%, p=0.022), LDL-C / HDL-C ratio (15.9%, p=0.007) and AI (17.3%, p=0.004) (**Table 4**). No significant change was seen in blood sugar metabolism. In hormonal examination, no significant change was seen in DHEA-s, whereas a significant decrease was seen in IGF-I (-11.1%, 0.005). Concerning stress-related hormones, DHEA-s/cortisol ratio did not change significantly although cortisol significantly increased (32.9%, p=0.001).

The data for nutritional assessment are presented in **Table 5**. Of 7 cases with low TP (TP≤6.8g/dl), 5 cases improved in TP values at Week 24 and the rests remained the baseline value. Of 6 cases with low Alb (Alb≤3.6g/dl), 3 cases improved. Of 3 cases with low Hb (Hb≤10g/dl), 2 cases improved and the rest remained the baseline value.

Table 4 Blood biochemistry

		Week 0 mean SD	Weeks 24 mean SD	*p*-value (vs. week 0)
Leukocyte count	/μl	5116 ± 1716	5316 ± 1818	0.580
Erythrocyte count	×10⁴/μl	364 ± 99	390 ± 46	0.243
Hemoglobin	g/dl	12.0 ± 1.5	12.1 ± 1.3	0.135
Hematocrit	%	38.7 ± 4.5	38.7 ± 4.4	0.989
Platelet count	×10⁴/μl	20.6 ± 4.8	21.5 ± 5.7	0.221
Neutrophils	%	58.2 ± 8.6	58.6 ± 10.0	0.858
Lymphocytes	%	31.6 ± 7.6	31.8 ± 8.1	0.925
Monocytes	%	5.6 ± 1.4	6.3 ± 2.1	0.066
Eosinophils	%	2.6 ± 1.4	2.9 ± 1.8	0.375
Basophils	%	0.5 ± 0.3	0.5 ± 0.3	0.742
Total protein	g/dl	7.1 ± 0.4	7.2 ± 0.5	0.078
Albumin	g/dl	3.8 ± 0.3	3.8 ± 0.3	0.899
A/G ratio		1.2 ± 0.2	1.2 ± 0.2	0.205
AST	IU/l	19.5 ± 8.2	22.0 ± 9.5	0.097
ALT	IU/l	12.6 ± 6.9	15.4 ± 9.8	0.156
LDH	IU/l	179.5 ± 41.3	188.5 ± 47.8	0.232
Total bilirubin	mg/dl	0.7 ± 0.2	0.7 ± 0.2	0.480
ALP	IU/l	289.2 ± 126.3	315.8 ± 152.6	0.055
γ-GTP	IU/l	26.3 ± 24.6	30.6 ± 38.1	0.278
CPK	IU/l	60.5 ± 24.6	70.9 ± 39.7	0.264
Amylase	IU/l	83.4 ± 29.3	90.9 ± 33.7	0.139
Blood urea nitrogen	mg/dl	16.2 ± 10.5	16.8 ± 10.7	0.394
Creatinine	mg/dl	0.72 ± 0.25	0.71 ± 0.25	0.482
Uric acid	mg/dl	5.2 ± 2.0	5.2 ± 2.1	0.876
Sodium	mEq/l	140.9 ± 2.9	141.2 ± 2.4	0.573
Chlorine	mEq/l	4.3 ± 0.3	4.4 ± 0.4	0.351
Potassium	mEq/l	104.4 ± 3.1	103.8 ± 2.7	0.231
Calcium	mg/dl	9.5 ± 0.3	9.4 ± 0.4	0.271
Serum iron	μg/dl	74.4 ± 25.3	81.8 ± 20.2	0.055
Total cholesterol	mg/dl	190.4 ± 30.0	199.1 ± 32.2	0.051
LDL-C	mg/dl	111.6 ± 24.8	120.2 ± 27.5	**0.022**
HDL-C	mg/dl	52.5 ± 10.8	49.4 ± 10.9	0.087
L/H ratio		2.2 ± 0.7	2.6 ± 0.9	**0.007**
Triglyceride	mg/dl	103.2 ± 39.6	114.1 ± 49.3	0.154
Arterial sclerosis index (AI)		2.7 ± 0.8	3.2 ± 1.1	**0.004**
FPG	mg/dl	91.1 ± 9.0	86.1 ± 10.7	0.057
HbA1c	%	5.1 ± 0.3	5.0 ± 0.3	0.385
Insulin	μU/ml	6.1 ± 3.6	4.8 ± 3.2	0.212
HOMA-R		1.4 ± 1.0	1.0 ± 0.8	0.162
Cortisol	μg/dl	11.7 ± 3.8	15.6 ± 5.3	**0.001**
DHEA-s	μg/dl	79.2 ± 70.4	88.1 ± 76.1	0.183
DHEA-s/Cortisol ratio		7.2 ± 5.8	6.2 ± 5.3	0.108
IGF-I	ng/ml	123.2 ± 50.9	109.6 ± 55.5	**0.005**

n = 19.

A/G, albumin/globulin; AST, aspartate aminotransferase; ALT, alanine transaminase; LDH, lactate dehydrogenase; ALP, alkaline phosphatase; γ-GTP, γ-glutamyl transpeptidase; CPK, creatine phosphokinasel; LDL-C, low density lipoprotein-cholestrerol; HDL-C, high density lipoprotein-cholesterol; L/H, LDL-C/HDL-C; FPG, fasting plasma glucose; HOMA-R, homeostasis model assessment insulin resistance; DHEA-s, dehydroepiandrosterone sulfate; IGF-I, insulin-like growth factor-I.

Table 5 Nutritional assessment

ID	Age	Sex	TP (g/dl) week 0	TP (g/dl) week 24	Alb (g/dl) week 0	Alb (g/dl) week 24	Hb(g/dl) week 0	Hb(g/dl) week 24
1	83	F	7.8	7.9	4.1	4.1	12.9	13.0
2	92	F	7.5	7.9	3.4	3.5	10.2	10.4
3	93	F	7.0	7.3	3.2	3.4	10.2	10.6
4	77	F	6.6	7.0	3.8	3.8	12.4	13.6
5	91	F	6.8	7.1	3.6	3.7	9.0	10.0
6	81	F	6.3	6.3	3.6	3.5	13.1	13.4
7	78	F	6.5	6.6	3.9	3.9	11.8	11.8
8	88	F	7.1	7.5	3.9	4.1	11.3	11.9
9	86	F	6.7	7.7	3.7	4.0	10.0	10.5
10	89	F	6.9	6.6	3.6	3.4	9.9	9.9
11	88	F	7.0	7.2	3.9	3.9	12.6	13.0
12	84	M	7.5	7.6	4.1	4.1	13.5	13.6
13	65	F	7.7	7.0	4.0	3.6	13.1	12.3
15	84	F	6.7	6.7	3.7	3.9	13.1	12.2
17	79	F	7.2	7.0	4.3	4.2	12.1	12.4
18	84	F	7.8	7.9	4.1	4.1	13.3	13.0
19	85	M	7.0	7.1	3.3	3.1	13.3	13.1
20	75	M	7.5	7.5	4.3	4.1	13.9	14.3
21	89	F	6.8	7.4	4.1	4.3	11.4	11.6

TP, total protein; Alb, albumin; Hb, hemoglobin; F, female; M, male.
Shadows indicate the cases with poor nutritional assesment
(TP≦6.8, Alb≦3.6 or Hb≦10.0) at Week 0 and the cases with data improved at Week 24.

4. Anti-aging medical checkup

WCST showed no significant change in CA, NUCA, PEM, PE, or reaction time, while TE (p=0.022) and UE (p=0.026) significantly improved (**Table 6**). Muscle mass measured by the bio-electrical impedance method significantly decreased in the upper arms (both side: p=0.005), upper limb (left: p=0.017), legs (right: p=0.002, left: p=0.004), and lower limbs (right: p=0.006, left: p=0.025). WBI did not change significantly.

No significant change was seen in vascular age as measured by fingertip acceleration plethysmogram, or in osteo-sono-assessment index of the calcaneus bone by ultrasonography. No serious adverse event occurred during or after the study.

Results of functional age determined by the Age Management Check are shown in **Table 7**. Of the five categories of functional age, nervous age was highest in 84% (16 of 19) and vascular age was highest in 16% (3 of 19). No significant change was seen in respective functional age in the 24-week study period. Concerning risk factors for aging, mental and physical stress scores decreased significantly (p=0.002).

5. Examination of saliva secretion, labial closure strength, and facial mimetic muscle activity

Results for non-stimulated saliva secretion by the coffee filter method are shown in **Fig. 3**.

Saliva secretion increased gradually from 8.0±5.0 mm/min at baseline to 12.6±2.3 mm/min (p<0.001) at Week 26. Labial closure strength (**Fig. 4**) significantly increased from 2.6±1.7 N at Week 0 to 4.4±1.4 N at Week 24 (p=0.003).

Facial mimetic muscle activity also significantly increased bilaterally, from 46.7±26.1 unit at baseline to 94.8±30.0 unit at Week 24 (p<0.001) in the right, and from 37.9±11.5 unit at baseline to 94.1±29.0 unit at Week 24 (p<0.001) in the left (**Fig. 5**). Correlation analysis revealed no significant correlation between labial closure strength and the facial mimetic muscle activity (r＝0.33, p=0.072).

Table 6   Anti-aging medical checkup

		Week 0 mean ± SD	Weeks 24 mean ± SD	*p*-value (vs. week 0)
Muscle mass				
(Right side)				
Upper arm	kg	0.50 ± 0.14	0.45 ± 0.12	**0.005**
Forearm	kg	0.45 ± 0.13	0.45 ± 0.16	0.856
Upper limb	kg	0.95 ± 0.26	0.90 ± 0.27	0.062
Thigh	kg	2.68 ± 0.61	2.68 ± 0.73	0.963
Leg	kg	1.74 ± 0.66	1.37 ± 0.37	**0.002**
Lower limb	kg	4.42 ± 1.17	4.05 ± 0.96	**0.006**
Trunk	kg	3.67 ± 1.20	3.91 ± 1.28	0.101
(Left side)				
Upper arm	kg	0.47 ± 0.12	0.43 ± 0.12	**0.005**
Forearm	kg	0.42 ± 0.09	0.42 ± 0.09	0.705
Upper limb	kg	0.88 ± 0.20	0.84 ± 0.20	**0.017**
Thigh	kg	2.70 ± 0.64	2.72 ± 0.76	0.779
Leg	kg	1.75 ± 0.56	1.44 ± 0.43	**0.004**
Lower limb	kg	4.45 ± 1.10	4.16 ± 1.07	**0.025**
Trunk	kg	3.45 ± 1.05	3.68 ± 1.27	0.086
(Right-left balance)				
Upper arm	%	94.8 ± 14.4	95.5 ± 15.7	0.836
Forearm	%	95.0 ± 12.7	95.8 ± 18.5	0.800
Upper limb	%	94.6 ± 11.8	95.0 ± 14.4	0.862
Thigh	%	101.0 ± 11.0	101.7 ± 9.3	0.737
Leg	%	104.4 ± 21.1	105.6 ± 13.7	0.753
Lower limb	%	101.7 ± 11.9	105.2 ± 14.7	0.358
Trunk	%	95.4 ± 14.8	94.3 ± 14.9	0.722
(WBI)				
Right		0.78 ± 0.13	0.78 ± 0.15	0.830
Left		0.79 ± 0.16	0.80 ± 0.17	0.698
Acceleration plethysmography				
Vascular age #	years	65.1 ± 13.8	68.3 ± 10.2	0.308
SDPTGAI	-	0.09 ± 0.35	0.14 ± 0.24	0.299
b/a	-	−0.41 ± 0.15	−0.47 ± 0.21	0.077
c/a	-	−0.16 ± 0.15	−0.23 ± 0.13	0.124
d/a	-	−0.44 ± 0.16	−0.50 ± 0.14	0.142
e/a	-	0.09 ± 0.06	0.09 ± 0.09	0.548
b-a	ms	86.0 ± 15.3	93.5 ± 22.3	0.107
c-a	ms	146.5 ± 22.3	140.7 ± 17.7	0.462
d-a	ms	205.8 ± 32.9	192.4 ± 27.3	0.188
e-a	ms	304.6 ± 30.7	287.8 ± 22.8	0.128
a-a	ms	885.4 ± 96.6	834.0 ± 112.4	0.407
PTGAI	ms	1.30 ± 0.21	1.24 ± 0.21	0.506
Bone mineral density tests				
Stiffness value		2.1 ± 0.3	2.1 ± 0.3	0.623
Comparison with the younger age group	%	76.7 ± 8.4	76.1 ± 10.1	0.574
Brain executive function test: WCST				
CA		0.9 ± 0.8	1.6 ± 1.4	0.081
NUCA		29.9 ± 17.4	15.8 ± 22.3	0.161
TE		32.5 ± 4.6	27.8 ± 7.5	0.022
PEN		9.1 ± 5.7	4.3 ± 6.3	0.057
PEM		12.7 ± 5.5	9.0 ± 3.8	0.072
UE		5.2 ± 5.1	1.9 ± 2.7	0.026
BR		0.0 ± 0.0	0.0 ± 0.0	1.000
Response time	second	379.2 ± 148.3	385.7 ± 192.3	0.849

n = 19.

#Vascular age: if the obtained value is "more than 80 years", it was considered "80 years" and calculated.
CA：categories achieved.
NUCA：numbers of response cards used until the first category achieved.
TE：total errors.
PEM：perseverative errors of Milner.
PEN：perseverative errors of Nelson.
UE：unique errors
BR：bizarre response.

Table 7   Various functional ages and risk factor score using the Age Management Check system

Degree of aging		Week 0 mean ± SD	Weeks 24 mean ± SD	*p*-value (vs. week 0)
Muscle age	years	61.9 ± 4.0	62.5 ± 4.0	0.066
Vascular age	years	71.8 ± 11.1	69.9 ± 6.2	0.421
Nervous age	years	88.5 ± 5.8	87.6 ± 5.0	0.507
Hormonal age	years	71.1 ± 11.0	71.8 ± 11.4	0.640
Bone age	years	75.7 ± 12.3	77.4 ± 11.9	0.389
Scores of risk factors for aging				
Immunological function	points	72.3 ± 17.1	75.3 ± 18.3	0.293
Antioxidant capacity	points	81.3 ± 4.4	81.1 ± 4.9	0.835
Mental and physical stress	points	64.6 ± 14.3	60.5 ± 13.7	**0.002**
Lifestyle-related habits	points	86.8 ± 3.2	86.9 ± 3.6	0.862
Metabolic function	points	91.3 ± 10.7	90.4 ± 10.9	0.597

n = 19
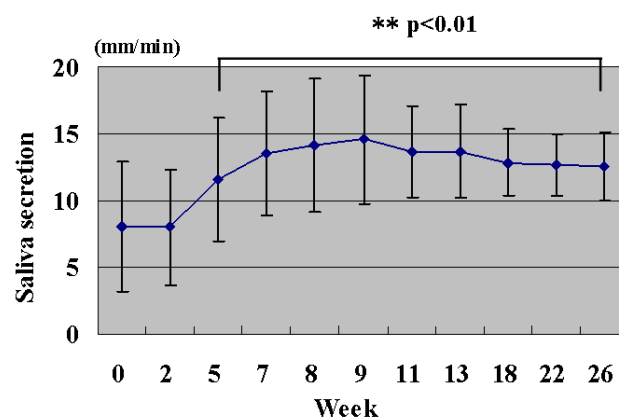
Fig. 3. Time course of non-stimulated saliva secretion
Mean ± SD. n=19.
**p<0.01, the values from Week 5 to Week 26 are significantly higher than the base line (from Week 0 to Week 2).
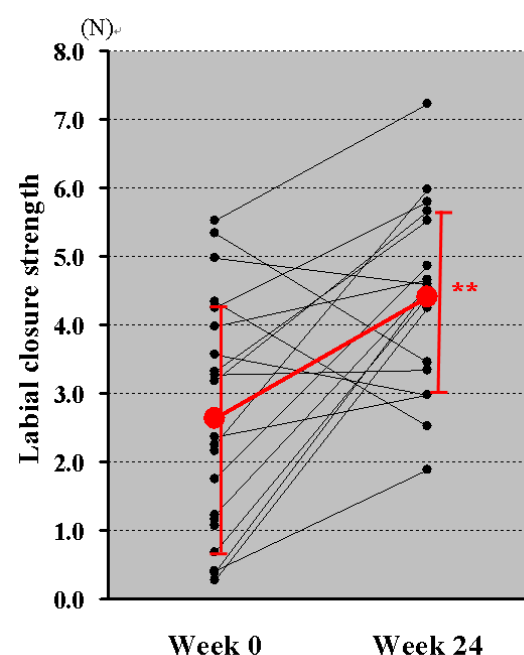
Fig. 4. Labial closure strength
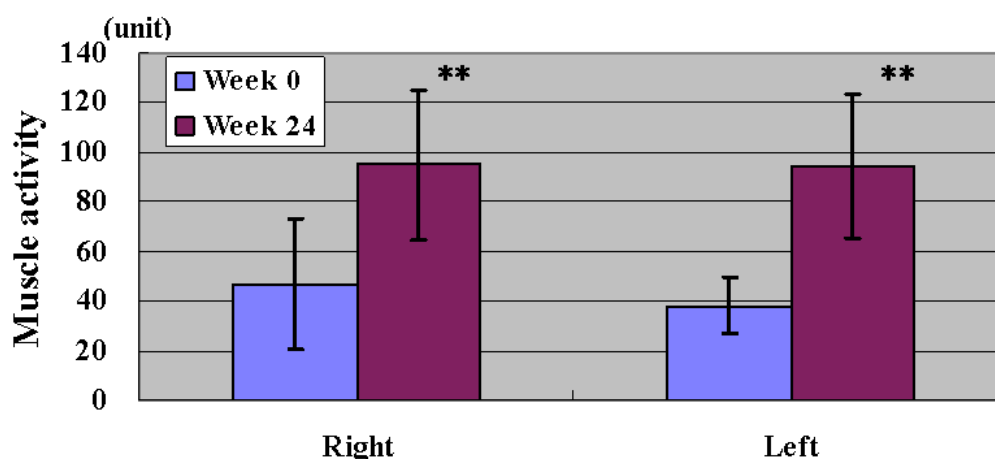Red line: mean ± SD. n=19, **p<0.01, paired t test.

Fig. 5. Facial mimetic muscle activity
n=19. **$p<0.001$, paired t test.

Discussion

Data Estimation

Body weight and the amount of body fat generally decreases with aging in aged care facility residents aged around 80 years [6], and nutrient state often deteriorates. Nevertheless, participants in the present study showed no significant changes in body weight or BMI over the six months of the study. Regarding to nutritional assessment, some of 19 participants were poor nutrition state including 7 cases with low TP values, 6 cases with low Alb values and 3 cases with low Hb values. In this study, average values of TP, Alb or Hb did not significantly change; however, these values were improved in more than half of individuals assessed as poor nutrition state. Considering the background in our facility that approximately 50% of inhabitants gradually lose their body weight annually, this ability to maintain weight over this period is meaningful. Results of AAQol showed a decrease in score for "anorexia", "early satiety", "epigastralgia", and "constipation", and in particular, an improvement in dietary intake. These findings suggest that the desire to eat may have been strengthened in these subjects.

Further, lipid profile, LDL-C and L/H ratio increased significantly. This finding should be considered with regard to the relatively poor nutritional state of the subjects at the start of the study, to the fact that that the increase in LDL-C was within the normal physiological range, and to the report that increases in total mortality rate, the incidence of cancer and cerebral hemorrhage was found in the elderly with hypocholesterolemia [15]. These changes are therefore thought to be favorable rather than adverse effects. A common problem for senior citizens housed in nursing homes is that dietary intake is low, indicating the need to improve nutritional status. One report noted that a decrease in adipose (fat tissue) function in highly aged citizens (>100 years old) manifests as a decrease in body fat mass, and that this influences the mortality rate [16]. A long-term view of this problem is required.

Mental and Physical Stress

In the present study, several significant changes were seen in stress markers. Generally, cortisol increases with stress load, while the DHEA-s/cortisol ratio decreases [17]. Here, however, we found no significant change in DHEA-s/cortisol ratio despite an increase cortisol, showing that stress load was not as great as the disturbance in stress balance. One study reported the possibility of sleeping well following facial mimetic muscle training using this device [18]. Good quality sleep helps recovery from damage due to stress [19], and might thus contribute to reducing the imbalance of stress-related hormones, DHEA-s and cortisol.

This health promotion program did not appear to be a source of stress for the subjects, but may have produced another stress, namely the encountering of new experiences with an enlarged area of activity due to the improved ADL. Among lifestyle-related behaviors, monitored TV viewing time decreased, due to a decrease in the time spent watching television as a result of the promotion of personal communication among subjects within the facility. A common problem with elderly residents of aged care facilities is their development of a sense of indifference to events within the facility and a general absence of stimulation. These changes are therefore considered favorable effects which will likely lead to an improvement in QOL.

Saliva

Saliva contains various constituents and demonstrates various kinds of effects [20,21]: amylase is an enzyme that helps carbohydrate digestion; secretory IgA plays a role in humoral immune function; lactoperoxidase demonstrates an anti-oxidative potential that removes free radicals; epidermal growth factor (EGF) takes part in restoration of the oral and gastrointestinal mucosa; IGF-I, a second messenger hormone of growth hormone, acts like insulin; and nerve growth factor (NGF) acts to enhance the restoration of neuronal cells and to maintain brain function against aging. Interestingly, the secretion of NGF increases when a person falls in romantic love [22]. These positive effects of saliva on health are considered indispensable to life, and a decrease in secretion causes various disturbances in the body, such as an increase in the incidence of periodontitis and carious teeth. Moreover, a decrease also causes respiratory infectious diseases, upper gastrointestinal diseases, dysphagia, and eating disorders, and thereby a decrease in QOL.

Here, we measured non-stimulated saliva secretion using a simple-type saliva secretion measurement paper. This convenient method uses coffee filter paper, a familiar material, and the subjects

are able to confirm the amount of saliva themselves. A significant correlation with values measured using a salivary wetness checker has been confirmed (KS-3, The Lion Foundation for Dental Health, Sumida-ku, Tokyo). Mean value in one group of senior citizens (mean age 77 years old, n=18) was 10.1±5.6 mm/min [13]. In the present study, values improved from a baseline of 8.0±5.0 mm/min to a post-study value of 12.6±2.3mm/min (mean age 83 years old, n=21), which was greater than that of the 77-year-old group above.

Saliva secretion is under the dominant control of parasympathetic innervation. Given that decreases in subjective symptom score were also seen for "anorexia", "early satiety", and "constipation", these findings indicate an improvement in gastrointestinal function which is also associated with parasympathetic innervation. The possible relationship between this training program and the parasympathetic nervous system awaits further study.

In a previous study [18], training of the facial mimetic muscles with the Patakara device improved nasal breathing function, with better collaboration among the nasal cavity, tongue position, larynx and the airway. Further, increased blood flow in the right frontal lobe was noted immediately after the start of training, as evaluated by optical topography [23], a method which noninvasively measures topographic images of human brain activity from the scalp using near-infrared light, which detects concentration changes in oxy- and deoxy-hemoglobin caused by brain activity. This training may have caused stimulation of the central nervous system. The cause of these reactions and the possibility that muscle training with this device influences autonomic nervous system activity awaits future study.

Facial Mimetic Muscle Training

Relatively few data are available concerning the anatomical structure or function of the facial mimetic muscles. Among this muscle group, the orbicularis oris muscle is involved in labial closure strength. In one study, this strength gradually increased from infancy to reach an adult level at age 30 – 40 years (males, 15-16N; females, 12-14N), then started to decline from the middle of the 50s to reach a minimum at over 80 years (6-7N) [24]. In one study, mean value at age 80-84 years was 7.1 N in males (n=9) and 5.8 N in females (n=7) [24]. In contrast, values in the present study were considerably lower (2.6±1.7N at baseline). The prevalence of oral disease, naso-pharyngeal disease and allergic disease was reportedly high in a group whose values were lower than the reference value (males, 14N; female, 12N) [25]. The maintenance of labial closure strength in the elderly is thus meaningful.

In the present study, facial muscle training consisted of training of the lips and surrounding muscle group for labial closure strength using an oral rehabilitation appliance. Facial muscle training with this device was found to improve stertor in post-surgical training in patients with oral cancer, cerebral infarction, cerebral hemorrhage, and Bell's palsy [26]. The following mechanisms are assumed to play a role in this effect. First, the movement of muscle groups innervated by the facial nerve is made smoother because of stretching of the muscles of the cheeks and lips, and the hyoid becomes fixed. Second, the dysphagia state arising due to cerebrovascular disorders is improved by the recovery of deglutition, in which innervation by the facial nerve is dominant. Third, stretching of the facial muscles by chewing acts to rehabilitate the articulation and deglutition organ.

Anti-Aging Medical Checkup

The anti-aging medical checkup revealed that CA of WCST was relatively low, at 0.9 ±0.8, compared with 5.4±0.8 in a previous study in middle-aged men (54.4±7.4 years old) [3]. This is likely due to differences between these institutionalized elderly and those who live independently, and shows a marked deterioration in nervous system function over three decades.

TE and UE of WCST were significantly improved by this program. The possibility of a favorable effect in the brain derives from the fact that the promotion of saliva secretion leads to an increase in NGF and IGF-I. Because nervous function will steadily weaken over six months without training, prevention of even a small decrease is meaningful. No significant difference was seen in vascular, hormonal, or bone age, suggesting that it is possible to maintain physical function. With regard to muscle age, however, a decrease in a part of the muscle mass was identified, suggesting that the health promotion program used may benefit from an increase in muscular load training.

One limitation of the present study warrants mention. Since the study involved training of facial mimetic muscles, in addition to usual occupational therapy, we did not observe the effect of facial mimetic muscle training alone. Because of the rapid weakening in physical function of the elderly and deterioration in QOL in the absence of occupational therapy using the whole body, establishing a group which receives facial mimetic muscle training without occupational therapy is ethically difficult. The additive effect of facial mimetic muscle training will be verified more clearly by setting a comparable group in which the physical and occupationalprogram was conducted without using Patakara in the next study.

Conclusion

We conducted a health promotion program, which included facial muscle training with an oral rehabilitation device, in 19 aged residents (average age 83.7±6.8 years old) of a geriatric health care facility for the elderly for 24 weeks, and estimated its efficacy by an anti-aging medical checkup. Results showed that this program was effective in improving QOL, including a decrease in gastrointestinal symptoms, stimulation of the secretion of saliva, improvements in executive brain function and nutritional status especially in cases with poor nutritional state. On the other hand, a trend of muscular aging was also identified, indicating the need to strengthen the preventive program of muscular aging.

Acknowledgements

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