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Original Research

Newly developed care food enhances grip strength in older adults with dysphagia: a preliminary study

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ABSTRACT

BACKGROUND/OBJECTIVES: Maintaining total muscle mass in the older adults with swallowing difficulty (dysphagia) is important for preserving swallowing function. Increasing protein intake can help sustain lean body mass in the older adults. The aim of this study was to evaluate the effect of various high-protein texture-modified foods (HPTMFs) on muscle mass and perform dietary assessment in ≥ 65-yrs-old patients with dysphagia.
SUBJECTS/METHODS: Participants (n = 10) received the newly developed HPTMFs (average 595.23 ± 66.75 kcal/day of energy, 54.22 ± 6.32 g/day of protein) for 10 days. Relative hand-grip strength (RHS), mid-upper arm circumference (MUAC), body composition, mini nutritional assessment (MNA), mini dietary assessment (MDA), and Euro Quality-of-Life questionnaire 5-dimensional classification (EQ-5D) were assessed.
RESULTS: After 10 days, an increase in MUAC (26.36 ± 2.35 cm to 28.50 ± 3.17 cm, $P = 0.013$) and RHS (0.38 ± 0.24 kg/kg body weight to 0.42 ± 0.22 kg/kg body weight, $P = 0.046$) was observed. Although MNA, MDA, EQ-5D, subjective health status, muscle mass, and calf circumference showed a tendency to increase after intervention, no significant differences were found.
CONCLUSIONS: These results suggest that the HPTMFs can be used for improving the nutritional and health status in patients with dysphagia.

Keywords: Deglutition disorders; aged; diet; high-protein diet; grip strength; nutritional status

INTRODUCTION

Dysphagia is a symptom that describes the difficulty in swallowing food or fluid caused by various reasons such as head and neck cancer, neurodegenerative diseases, stroke, and aging [1-3]. The exact prevalence of dysphagia is unclear, but a recent systemic review article indicated that the estimated overall prevalence of dysphagia in the older adults was 32.83% [4,5]. According to World Health Organization (WHO), the population aged ≥ 60 yrs will

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Conflict of Interest

The authors declare no potential conflicts of interests.

Author Contributions

Conceptualization: Kim Y, Cho M, Jung H, Park JY; Data curation: Park Y, Jeong Y; Formal analysis: Park Y; Funding acquisition: Cho MS, Park JY; Investigation: Kim Y; Methodology: Han H, Park Y, Kwon H, Jeong Y, Joo S; Project administration: Park JY, Kim Y; Resources: Jung H, Park JY; Software: Han H, Park Y, Jeong Y; Supervision: Kim Y; Validation: Park Y, Jeong Y, Kim Y; Visualization: Park Y; Writing - original draft: Han H, Park Y; Writing - review & editing: Kim Y, Jeong Y.

increase from 1 billion in 2020 to 1.4 billion in 2030 [6]. By 2050, the world's population of people ≥ 60 yrs will double (2.1 billion), which suggests that approximately 690 million older adults could be considered to be at risk for dysphagia by 2050.

Dysphagia makes it difficult to obtain sufficient nutrition through an oral diet alone, which increases the risk of malnutrition and dehydration [7]. Approximately 25–75% of older adults with dysphagia are at risk of malnutrition or dehydration [8]. Malnutrition is closely associated with increased morbidity, length of hospital stay, mortality, and depression [9,10]. In addition, patients with dysphagia are at high risk of aspiration pneumonia, as oropharyngeal or gastric contents cannot pass normally into the esophagus and enter the lungs through the bronchi [11,12]. The estimated mortality rate of aspiration pneumonia is about 20–62% and increases with age [13,14]. In addition, patients with dysphagia need longer meal times, which makes them anxious about eating together, leading to social isolation and further limiting food intake [15]. Therefore, nutritional support for older adults with dysphagia is critical in improving the physical and psychological health and quality of life of the older adults.

As a person ages, muscle mass and function decrease, which leads to a deterioration of various health outcomes [16]. Older adults are more vulnerable to muscle loss because both protein intake and physical activity are decreased [17,18]. Increasing protein intake in the older adults may help slow down the rate of decline of lean body mass [19]. Houston *et al.* [20] evaluated the effect of a high-protein diet on lean mass change in community-dwelling older adults. The older subjects in the highest quintile of dietary protein intake lost about forty percent less lean body mass than those in the lowest quintile [20]. Moreover, as swallowing is a complex process involving more than 30 muscles of the mouth, pharynx, and esophagus, maintaining total muscle mass in the older adults with dysphagia is important for the preservation of swallowing function [21,22].

It is essential to maintain appropriate physical properties and viscosity of food or liquid for safe swallowing in dysphagia patients [12]. In Japan, the Ministry of Agriculture, Forestry and Fisheries gathered to establish a new policy in 2006 for standardizing nursing care foods called "Smile Care Food." This includes texture-modified foods (TMFs), which are categorized by the degree of tenderness. Care food products such as stewed meat, porridge, pudding, and jellies are being developed, but it is still insufficient to provide to consumers with a variety of options [23].

Thickened liquid is commonly used for the nutritional management of patients with dysphagia in hospitals and long-term care facilities [24]. However, thickened liquid and TMFs do not preserve the original appearance of food and are, therefore less appealing to patients than original food [25]. In addition, TMFs tend to have lower nutrient content than a regular diet and, thus may not be able to provide the required nutrients to patients with dysphagia [26]. Therefore, the development of TMFs that preserve the original appearance of foods and increase nutrient density is an important task for the improvement of the nutritional and health status of older adults patients with dysphagia.

This study aims to evaluate the effects of newly developed high-protein texture-modified foods (HPTMFs) on the nutritional and health status in older adults with dysphagia. These HPTMFs were prepared using saturated vapor and blending techniques that can soften foods without changing the original appearance.

SUBJECTS AND METHODS

Subjects

From May 1, 2022, to July 27, 2022, 10 adults aged 65 yrs or older, who were diagnosed with laryngeal or esophageal dysphagia and who had visited the Department of Geriatrics at Asan Medical Center, enrolled in this study. Patients unable to consume food orally due to severe dysphagia with a score of less than 1 on the swallowing test and those who were taking other care foods were excluded. This study was conducted after receiving approval from the Clinical Research Ethics Review Committee of Asan Medical Center in Seoul (IRB No: 2022-0701).

Data and assessment tools

Patient information regarding age, history of drinking/smoking, drug use, physical disability, subjective health status (SHS), and medical history was collected. Anthropometric parameters, including height, weight, and body circumference (mid-upper arm and calf), were measured. Height and weight were measured using an auto weight- and height-measuring machine (GL-150C; G-Tech International Co. Ltd., Uijeongbu, Korea). Mid-upper arm circumference (MUAC) and calf circumference (CC) measurement were performed using a flexible plastic tape with the subject seated comfortably. The bioelectrical impedance analyzer (Inbody S10; InBody Co. Ltd., Seoul, Korea) was used for measuring body composition.

Mini nutritional assessment (MNA), mini dietary assessment (MDA), and Euro Quality-of-Life Questionnaire 5-Dimensional Classification (EQ-5D) were used in this study. The MNA is a worldwide nutritional evaluation tool for the older adults, consisting of 18 questions with a total score of 30 points. A score of less than 17 points is judged as 'malnutrition,' 17 to 23.5 points as 'risk of malnutrition,' and 24 to 30 points as 'well-nourished status' [27]. The MDA is a dietary habit evaluation tool for Koreans developed by Kim *et al.* [28] consisting of 10 questions to help evaluate dietary habit problems easily by identifying the score for each questionnaire item (frequency of intake of milk or dairy product/high-protein foods/vegetable/fruit/fried food/fatty meat/sodium/simple sugar snacks consumption, regular meals, and balanced diet). Eating habits were judged to be good if the total score for all responses was ≥ 30 points [28]. The EQ-5D is an assessment questionnaire developed by the EuroQoL Group (1990). It consists of 5 questions, including mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. The score ranges from −0.171 to 1 and scores closed to 1 indicates better health-related quality of life. SHS was asked using question for SHS in EQ-5D, which has a scale of 0 to 100 [29].

Nutritional intervention

HPTMFs were developed by Hyundai Green Food Inc. with Asan Medical Center. These products were designed in the form of instant food that can be consumed immediately after heating. The saturated vapor used to prepare HPTMFs can soften foods without damaging their appearance as the saturated vapor state without water evaporation can conserve moisture in food. Foods can be heated uniformly with high-temperature and high-pressure steam by using a saturated steam cooker. HPTMFs were enriched with an isolated soy protein, whey protein isolate, and/or L-leucine powder. The physical properties of the product were evaluated using an X-ray TV system (Sonialvision G4; Shimadzu Co., Kyoto, Japan).

Over a period of 10 days, the subjects were provided with two frozen HPTMFs per day, with non-overlapping main ingredients. These HPTMFs supplied an average of 595.23 ± 66.75 kcal/day of energy and 54.22 ± 6.32 g/day of protein per day (**Supplementary Table 1**). They

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consisted of a main dish and a snack or two main dishes. Braised beef short ribs and braised chicken with garlic were delivered on the first day. This was followed by ginseng and chicken porridge and hamburger steak on the second day, and dried pollack porridge and soy sauce braised beef on the third day. Braised beef short ribs and braised mackerel were delivered on the fourth day, and ginseng and chicken porridge and soy sauce braised pork on the fifth day. Dried pollack porridge and braised chicken with garlic were delivered on the sixth day, and soy sauce braised beef and soybean paste sauce for rice meal on the seventh day. Soy sauce braised pork and braised beef short ribs were delivered on the eighth day, followed by hamburger steak and Chinese meat sauce for rice meal on the ninth day. Lastly, soy sauce braised beef and braised chicken with garlic were delivered on the tenth day.

All subjects (or their caregivers in case of the subjects' inability) were given a dietary record book and instructions before starting the intervention. The subjects or their caregivers then maintained a dietary record during the intervention to evaluate the subjects' adherence to the provided HPTMFs. Nutrient analysis was performed using the Can-pro 5.0 software (The Korean Nutrition Society, Seoul, Korea). The food composition database of the Korean Ministry of Food and Drug Safety was used when there was no nutrient database for the specific food item in the Can-pro 5.0 software.

Muscle strength

Hand-grip strength was measured using a handgrip dynamometer (AP5154; Saehan, Goyang, Korea). The participants applied maximum strength with their dominant hand, while being seated in a comfortable sitting position. The measurement was repeated two times with a 1 min break. Relative hand-grip strength (RHS) was calculated by dividing hand-grip strength by body weight.

Statistical analysis

The data are presented as mean and standard deviation or frequency and percentage. Differences between the sexes were evaluated by an independent samples *t*-test for continuous variables and Fisher's exact test for categorical variables. Paired *t*-test or Wilcoxon signed rank test was used for evaluating the effect of the nutritional intervention depending on the data distribution. SPSS 26.0 (IBM SPSS Statistics for Window 26.0; IBM Corp., Armonk, NY, USA) was used for all statistical analyses. A P-value < 0.05 was considered statistically significant.

RESULTS

Subjects' characteristics

The general characteristics of the subjects are presented in **Table 1**; there were 6 women (60%) and 4 men (40%) of mean age 80.50 ± 6.85 yrs. At baseline, 60% (n = 6) of the patients had normal BMI, 30% (n = 3) were overweight, and 10% (n = 1) were obese according to the Asia-Pacific classification. Never-smokers comprised 60% (n = 6) and former smokers 40% (n = 4). None of the patients were current smokers or consumed alcohol. The majority (80%, n = 8) of the patients took more than three kinds of drugs, and 50% (n = 5) of the patients were not able to go out of their homes.

Nutritional status, dietary habits, and quality of life at baseline

At baseline, 70% of the subjects were at risk of malnutrition, 20% were malnourished, and 10% were classified as well-nourished status according to the MNA. 90% of the subjects

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Table 1. General characteristics of subjects

Characteristics	Total (n = 10)	Men (n = 4)	Women (n = 6)
Age groups (yrs)			
70–74	3 (30)	2 (50)	1 (16.7)
75–79	1 (10)	0 (0)	1 (16.7)
80–84	2 (20)	1 (25)	1 (16.7)
≥ 85	4 (40)	1 (25)	3 (50.0)
Body mass index			
< 18.5	0 (0)	0 (0)	0 (0)
18.5–22.9	6 (60)	3 (75)	3 (50.0)
23–24.9	3 (30)	1 (25)	2 (33.3)
≥ 25	1 (10)	0 (0)	1 (16.7)
Alcohol			
Never	10 (100)	4 (100)	6 (100)
daily	0 (0)	0 (0)	0 (0)
Smoking			
Never smoked	6 (60)	0 (0)	6 (100)
Current smoker	0 (0)	0 (0)	0 (0)
Former smoker	4 (40)	4 (100)	0 (0)
Number of drugs			
≥ 3	8 (80)	3 (75)	5 (83.3)
< 3	2 (20)	1 (25)	1 (16.7)
Physical disability			
Yes	5 (50)	1 (25)	4 (66.7)
No	5 (50)	3 (75)	2 (33.3)

Values are expressed as number (%).

had good dietary habits according to the MDA. There was no significant difference in the nutritional status or dietary habits according to sex (data not shown). However, the EQ-5D was significantly higher for men than for women ($P = 0.039$) (**Table 2**). This difference was consistent with the difference reported by a previous study in which male EQ-5D was higher than female EQ-5D in the general population [30]. There was no significant difference in SHS according to sex ($P = 0.273$) (data not shown).

Changes in nutrition and health status before and after 10 days of the program

RHS and MUAC were increased significantly after the intervention program (**Table 3**). The average RHS was increased by ~0.04 kg/kg body weight from 0.38 kg/kg body weight to 0.42 kg/kg body weight ($P = 0.046$), while MUAC increased by ~2.14 cm from 26.36 cm to 28.50 cm ($P = 0.013$). Although MNA, MDA, EQ-5D, SHS, muscle mass, and CC showed a tendency to increase after the intervention, there were no significant differences.

Overall mean compliance monitored by self-recorded dietary records with HPTMFs was 69.50 ± 27.49%. Men consumed 92.17 ± 5.38%, while women consumed 54.58 ± 26.64% of the provided HPTMFs. The results of analyzing the differences in nutrition and health status according to sex before and after the intervention program are shown in **Table 4**. The SHS in men significantly increased from 46.25 points to 65 points ($P = 0.001$), while the MDA score

Table 2. EQ-5D score between sex in older adults with swallowing difficulty at baseline

Variables	EQ-5D	*t* (*P*-value)[1)]
Sex		2.463 (0.039)*
Men (n = 4)	0.886 ± 0.1	
Women (n = 6)	0.667 ± 0.1	

EQ-5D, Euro Quality-of-Life questionnaire 5-dimensional classification.
[1)]*t*-score and *P*-value from independent *t*-test.
*$P < 0.05$.

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Table 3. Changes in nutritional and health status in older adults with swallowing difficulty before and after the 10 days of high-protein texture-modified foods intervention

Variables	Before intervention	After intervention	*z* or *t* (*P*-value)
MNA score	19.15 ± 3.33	20.45 ± 3.95	−1.23 (0.22)[1]
MDA score	34.60 ± 3.44	37.30 ± 6.25	−1.50 (0.18)[2]
EQ-5D	0.76 ± 0.17	0.77 ± 0.20	−0.43 (0.68)[2]
SHS	53.80 ± 16.90	63.00 ± 17.67	−1.96 (0.08)[2]
RHS (kg/kg Bw)	0.38 ± 0.24	0.42 ± 0.22	−2.32 (0.05)[2]*
BW (kg)	56.35 ± 8.90	56.20 ± 8.63	0.23 (0.83)[2]
BMI	22.62 ± 3.40	22.70 ± 3.92	−0.21 (0.83)[1]
Muscle (kg)	21.60 ± 4.54	22.18 ± 4.80	−1.83 (0.10)[2]
Fat (kg)	15.99 ± 6.74	14.97 ± 7.87	1.07 (0.31)[2]
CC (cm)	32.00 ± 2.99	32.75 ± 1.99	−1.51 (0.17)[2]
MUAC (cm)	26.36 ± 2.35	28.50 ± 3.17	−2.49 (0.01)[1]*

MNA, mini nutritional assessment; MDA, mini dietary assessment; EQ-5D, Euro quality of life questionnaire 5-dimensional classification; SHS, subjective health status; RHS, relative hand-grip strength; BW, body weight; BMI, body mass index; CC, calf circumference; MUAC, mid-upper arm circumference.
[1]*z*-score and *P*-value from Wilcoxon signed rank test; [2]*t*-score and *P*-value from paired *t*-test.
*$P < 0.05$.

Table 4. Comparison of changes in nutritional and health status according to sex in older adults with swallowing difficulty before and after the 10 days of high-protein texture-modified foods intervention

Variables	Men (n = 4)			Women (n = 6)		
	Before intervention	After intervention	*z* or *t* (*P*-value)	Before intervention	After intervention	*z* or *t* (*P*-value)
MNA score	20.13 ± 3.42	20.38 ± 4.48	−0.37 (0.71)[1]	18.50 ± 3.42	20.50 ± 4.00	−1.17 (0.24)[1]
MDA score	37.00 ± 3.56	37.00 ± 7.78	0.00 (1.00)[2]	33.00 ± 2.45	37.50 ± 5.82	−3.05 (0.03)[2]*
EQ-5D	0.89 ± 0.12	0.89 ± 0.14	0.01 (1.00)[2]	0.67 ± 0.15	0.69 ± 0.21	−0.45 (0.67)[2]*
SHS	46.25 ± 21.36	65.00 ± 19.15	−15.00 (0.001)[2]**	58.83 ± 12.81	61.67 ± 18.35	−0.42 (0.69)[2]
RHS (kg/kg BWw)	0.58 ± 0.17	0.62 ± 0.12	−1.29 (0.29)[2]	0.25 ± 0.18	0.29 ± 0.16	−1.84 (0.12)[2]
BW (kg)	59.93 ± 6.26	58.93 ± 5.07	0.69 (0.54)[2]	53.97 ± 10.10	54.38 ± 10.44	−0.72 (0.50)[2]
BMI	20.95 ± 1.94	20.60 ± 1.69	−0.37 (0.13)[1]	23.73 ± 3.85	24.10 ± 4.48	−0.73 (0.47)[1]
Muscle (kg)	25.93 ± 0.54	26.70 ± 0.44	−2.79 (0.07)[2]	18.72 ± 3.45	19.17 ± 3.76	−0.88 (0.42)[2]
Fat (kg)	12.65 ± 6.59	10.28 ± 4.57	1.45 (0.24)[2]	18.22 ± 6.27	18.10 ± 8.33	0.10 (0.92)[2]
CC (cm)	33.25 ± 1.50	33.63 ± 1.11	−0.68 (0.55)[2]	31.17 ± 3.56	32.17 ± 2.32	−1.31 (0.25)[2]
MUAC (cm)	26.03 ± 1.63	27.80 ± 1.76	−1.83 (0.07)[1]	26.58 ± 2.87	28.97 ± 3.96	−1.75 (0.08)[1]

MNA, mini nutritional assessment; MDA, mini dietary assessment; EQ-5D, Euro quality of life questionnaire 5-dimensional classification; SHS, subjective health status; RHS, relative hand-grip strength; BW, body weight; BMI, body mass index; CC, calf circumference; MUAC, mid-upper arm circumference.
[1]*z*-score and *P*-value from Wilcoxon signed rank test; [2]*t*-score and *P*-value from paired *t*-test.
*$P < 0.05$, **$P < 0.01$.

of women significantly increased from 33.0 points to 37.5 points ($P = 0.029$). RHS, muscle mass, and MUAC in men tended to increase, as did the MNA score, EQ-5D, SHS, RHS, and MUAC in women, but without statistical significance.

DISCUSSION

This study aimed to evaluate the effects of newly developed high-protein care foods in older adults (aged ≥ 65 yrs) with dysphagia. The present study demonstrated that HPTMFs, which preserved the original appearance of food using a saturated steam and blending technique, show increased MUCA and RHS in patients with dysphagia.

Commercially available products designed to increase protein intake include protein powder, ready-to-drink beverages, and protein-fortified foods [31,32]. Protein powder is often favored due to its cost-efficiency and ease of use [33,34]. Beverages may be more suitable for increasing energy and nutrient intake in older adults as they result in less satiety than solid foods [35]. However, fortification using familiar foods could result in higher compliance

than using supplements [32]. Replacing regular food with nutrient-fortified food can provide a convenient way to increase nutrient intake without additional beverages or supplements. Familiarity positively influences food acceptance [36]. Additionally, protein-fortified food in the normal diet can help increase protein and energy intake with minimal supplement use, which may reduce the risk of side effects [37].

The strength of this study is that several HPTMF products were provided to the subjects, which preserved the original appearance of food. This enabled the alteration of the menus provided to the subjects during the 10-day intervention period. Offering a diverse range of menu options can also help encourage nutrient consumption among older adults [38]. Most food intervention studies have provided limited types of supplementary food and/or drink such as pureed meal, nectar, pudding, or oral nutritional supplementation (ONS) [39-41]. In previous nutritional intervention studies, pureed food was the most often used as TMF for the older adults patients with dysphagia [26]. Although some studies have evaluated the effects of protein-fortified foods on protein intake in adults [42,43], few have been conducted to verify the effectiveness of ready-to-heat TMFs that preserved the original food appearance [26]. Other studies focused on evaluating the physical or the sensory properties of TMF [44-46]. Another intervention study that provided TMF in the original food form had preserved the appearance by applying enzyme and only evaluated nutrition intake and satisfaction [25].

In a nutritional intervention study that provided a modified-consistency diet for 12 wk to ≥ 65-yrs-old patients with dysphagia, total calorie and protein intake, body weight, and grip strength were increased significantly [40]. Another intervention study provided pureed and reshaped texture-modified diet to patients with dysphagia and reported an increase in energy, protein intake, and body weight [47]. Other nutritional intervention studies in older adults also showed increased energy intake [48,49] and body weight [48,50]. The present study did not reveal any significant change in body weight; however, an improvement in RHS and MUAC were observed after providing HPTMFs for only 10 days. Increase in hand-grip strength has been reported by previous studies in which TMF and thickened drinks or ONS were provided for more than 12 wk to older adults aged 65 and over [40,51]. However, other intervention studies showed no increase in hand-grip strength [41,43]. This conflicting result may be explained by differences in the degree of physical activity and the severity of sarcopenia. The majority of subjects in the latter studies had hip fracture or chronic obstructive pulmonary disease, which can cause lower physical activity compared to the former study subjects. Hand-grip strength and MUAC are useful indicators for predicting the nutritional health status and mortality [52-54]. A low MUAC is associated with decreased swallowing function [55]. Therefore, it can be inferred that the newly developed high-protein care food could have a positive effect on the swallowing function and health outcome of older adult patients with dysphagia.

When analyzing the intervention effect by sex, a significant increase was observed in SHS among men, but not women. Although there was no significant difference in nutrient intake per 1,000 kcal between the sexes (data not shown), this increase in SHS could be because men consumed more of the care food than women. A study showed that the intake of functional foods was positively correlated with SHS [56]. Only women's MDA scores increased significantly even though the intake of the provided care food in women was lower than in men. The questionnaire items that indicated a significant impact on women's MDA score were 'regular meals,' 'frequency of vegetable consumption,' and 'frequency of fruit consumption.' This implies that women's dietary habits improved as a result of overall

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improvement in eating habits by participating in the intervention study rather than a direct correlation of HPTMFs provided.

This study has several limitations. First, the small sample size and short duration of the program make it difficult to extend these results to other patient' populations. Second, there could be a bias since information on food intake was collected via self-reported dietary records, which can lead to an underestimation of the actual food intake [57]. Third, the subject's baseline nutrient intake and level of physical activity were not considered in this study. Therefore, further studies with a large sample size and long-term intervention are needed to generalize these results. Further, more care foods must be developed and investigated in long-term studies with controlled physical activity and usual nutrient intake.

SUPPLEMENTARY MATERIAL

Supplementary Table 1

Total nutrients composition of high-protein texture-modified foods during a 10-day intervention period

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