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Original Article

Frequent Snacks Improved Energy Intake and Nutritional Status in Community-Dwelling Older Adults at Risk of Malnutrition, Chiang Mai, Thailand

Yupa Chanwikrai[1*], Jukkrit Wungrath[2], Sunard Taechangam[3], Chanida Pachotikarn[3], Shigeru Yamamoto[4]

[1]Graduate School of Human Life Sciences, Jumonji University, Saitama, Japan
[2]Faculty of Public Health, Chiang Mai University, Chiang Mai, Thailand
[3]Thai Dietetic Association, Bangkok, Thailand
[4]Asian Nutrition and Food Culture Research Center, Jumonji University, Saitama, Japan

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***Corresponding author:**
Yupa C., Address: Graduate School of Human Life Sciences, Jumonji University, Sugasawa 2-1-28, Niiza, Saitama, Japan, Postal code: 352-8510, Tel: +81 (48) 2607613, Fax: +81(48) 4789367, Email: chanwikrai.yupa@gmail.com

Abstract
Background: Inadequate dietary intake and malnutrition are commonly found in older adults. They tend to have early satiety that limits intake from main meals. Some reports indicated that small frequent meals may promote higher intake. From that point of view, snacks may be useful. Therefore, this study aimed to determine the effects of frequent snacks on energy intakes and nutritional status in older adults at risk of malnutrition.

Methods: A randomized controlled study was conducted among older adults at risk of malnutrition in a suburban community from November 2020 to March 2021 in Chiang Mai, Thailand. Two villages were randomly assigned to either a control group (n = 17) or an intervention group (n = 17), and they were matched pairs by age and gender. An intervention snack consisted of 2 desserts and a box of milk (total 548 kcal) was used. For the first 3 weeks, an intervention snack was provided every day although it was too heavy for some participants. Therefore, after that, the intervention snack was provided every other day for 4 weeks. A nutrition survey by the 24-hour recall method for 3 days, body weight, mid-arm circumference (MAC), triceps skinfold (TSF), and grip strength were assessed at weeks 3 and 7 as baseline.

Results: Thirty-one participants completed the study (91%). The average age was 71.8 ± 4.8 years, and body mass index (BMI) was 19.0 ± 2.1 kg/m^2. In the intervention snack group, there was an increased daily energy intake by 316 kcal and 214 kcal at weeks 3 and 7, respectively, ($P < 0.001$, effect size: 0.884), with a body weight of 0.8 kg ($P < 0.001$, effect size: 0.314), BMI of 2% ($P = 0.009$, effect size: 0.314), and MAC of 4% ($P < 0.001$, effect size: 0.265) compared with baseline, but such energy intake was not observed in the control group.

Conclusion: Providing frequent snacks was an effective way to improve energy intake and nutritional status in community-dwelling older adults at risk of malnutrition.

Keywords: Age, Nutritional intake, Energy intake, Snack food

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Introduction
The aging population is increasing rapidly worldwide. In Thailand, the number of older adults aged 60 years and older is expected to increase to 20% of the population by 2021 (1). Chiang Mai province is located in the northern part of Thailand in which there were more than 300 000 older adults (20%) in 2021, the third-highest population in the country. The increasing older adult population promotes a public health concern in society because a larger number of people require medical health care.

Malnutrition referred to as undernutrition is common among older adults over 60 years old. In 2015, the age-standardized global prevalence of malnutrition was estimated to be 8.8% in men and 9.7% in women as determined by body mass index (BMI) less than 18.5 kg/m^2 (2). The Thai National Health Examination Survey 2019-2020 reported that the prevalence of underweight was 8.1% in men and 4.8% in women aged 60-69 years, and this trend increased at older ages (3). Similar to some studies conducted in 2020 among suburban community, Chiang Mai estimated that 10.6% of older adults aged 60 or above were underweight, and 54.8% were at risk of malnutrition based on the Mini Nutritional Assessment Tool (4). According to the above information, it can be seen that malnutrition in older adults is an important problem both globally and nationally, accelerating the need to implement strategies to prevent and handle malnutrition.

Malnutrition is associated with frailty, sarcopenia, decreased immunocompetence, physical performance, and life quality, leading to increased healthcare costs, hospital admissions, and mortality (5,6). Causes of malnutrition in older adults are attributed to several factors, including inadequate intake resulting from deterioration of senses of smell and taste and decline in gastric emptying associated with satiation (5). A study was conducted in Phayao, northern of Thailand, to investigate the dietary intake among community-dwelling older adults using 24-hour dietary recall method for 3 days. It was found that they had inadequate energy intake and low lipid intake (13%-16%) of energy distribution (7).

The effective strategies to promote adequate intake in malnourished community-dwelling older adults were still limited, while it is recognized and treated in hospitals. We did not know whether they could ingest higher lipids than they usually consumed. Oral nutrition supplement is a simple strategy used to improve intake in adults; however, some studies reported low compliance and satisfaction with oral nutrition supplement that may be related to unfamiliarity with and a lack of variety of foods (8). Some systematic reviews reported that food fortification by basic cooking ingredients such as oil, mayonnaise, honey, egg, and powdered milk may improve energy and protein intake in older adults. However, it is doubtful whether the use of fortified foods results in improved clinical outcomes such as weight, BMI, and muscle mass (9).-

Prior to the current study, a preliminary study was conducted in older adults at risk of malnutrition to investigate the acceptability of fortified lunch with oils and snacks with slightly higher energy on energy intakes. It was found that enhancing energy via lunch was not successful but it was successful via snacks with slightly higher energy (10). This may indicate that the participants could not consume large portions of high-energy meals, especially lipids, suggesting that the digestion of lipids is not smooth, but if the meal was composed of small portions as a snack, they could eat the whole amount. In addition, older adults tended to have early satiety that may limit intake from their main meals. Therefore, snacks are more acceptable than large meals. Following up the preliminary study, the present study was conducted. This study aimed to determine the effects of frequent snacks on energy intakes and nutritional status in older adults at risk of malnutrition in a suburban community in Chiang Mai, Thailand, where the prevalence of underweight was about 16.6% or 1.5 times of the previous report (4). Such information could help health care professionals to plan appropriate nutritional recommendations and interventions.

Materials and Methods

A randomized controlled study was conducted on older adults at risk of malnutrition recruited from a suburban community in Chiang Mai, Thailand, from November 2020 to March 2021. The participants from two villages were randomly assigned to either a control group or an intervention group, and they were matched-pair by age and gender.

This study was designed to detect a statistically significant ($P < 0.05$) effect of serving frequent snacks versus the control without frequent snacks on energy intake with a power of 80% if the effect exceeded 200 kcal. The expected difference of 200 kcal was based on our previous study (13) in older adults at risk of malnutrition who were provided energy-rich snacks resulting in an increased daily intake of 200 kcal/day. The standard deviation (SD) of energy intake among an intervention group was used to calculate sample size based on Sakpal's study (11). The number of participants was at least 15 per group, and the sample size required 17 per considering a drop-out of 20%.

The inclusion criteria included people aged 65 to 79 years, at risk of malnutrition that was classified by BMI less than or equal to 20 kg/m^2 and/or unintentional weight loss of 5 to 10% within the past 6 months, capable of eating by mouth, not having any illness that may affect taste or appetite (e.g., cancer and chronic kidney disease), having no dementia or depression recorded in the medical history, capable of communicating in Thai, and capable of taking part in activities for 7 weeks.

An intervention snack consisted of 2 desserts and a box of milk (total 548 kcal) was used. For the first 3 weeks, an intervention snack was provided every day, but it was too heavy for some participants. Therefore, after that, the intervention snack was provided every other day for 4 weeks. They were recommended to consume snacks between meals. The control group did not receive an intervention snack, but they were supplied with equivalent desserts and drinks and provided with recipes and cooking class at the end of the study. All participants were encouraged to keep their usual diet and physical activity unchanged during the study.

For the intervention, 34 kinds of desserts were prepared according to participants' opinions on their favorite snacks. The ingredients were locally available, and older adults' favourite seasonal ingredients were also provided such as banana, taro, purple sweet potato, pumpkin and perilla seeds, flour, sugar, and coconut milk along with a good source of energy. However, coconut milk is rich in saturated fatty acid (17%), and excessive consumption of dietary saturated fats may increase the risk of coronary heart disease (12). Therefore, we reduced the amount of coconut milk (approximately 50%) and substituted soy milk since most of the fatty acids (80%) in soy milk were unsaturated fatty acids (13). Furthermore, participants liked soy milk which is nutritious and economical. The snacks could be divided into 5 types according to the cooking method, including boiling (53%), steaming (24%), stirring (21%), and syrup (2%).

A 24-hour recall by interview method was conducted in 3 consecutive days at baseline (week 0), week 3, and week 7, and then the intake was averaged over the 3 days of each period. However, to ensure that the participants provided complete data, they were also asked to keep an estimated record of all foods and beverages consumed in a dietary record form.

In addition, the intervention group was instructed to place all food leftovers and containers in a labeled plastic bag and to show them to the researchers to determine intakes. Dietary compliance was monitored using a daily snacks consumption record. All data were entered and calculated for energy and macronutrient intakes (e.g., protein, lipids, and carbohydrate) using the INMUCAL-Nutrient version 4.0 (Institute of Nutrition, Mahidol University, Thailand).

Body weight was evaluated using a calibrated electronic scale (Omron model HBF214, Japan). The participants were asked to wear light clothes without socks. Height was measured using a portable free-standing stadiometer and recorded to the nearest 0.1 cm. BMI was calculated using body weight (kg) divided by the square of height (m).

Triceps skinfold (TSF) was measured using a Fat-O-caliper (Takei Kikai Kogyo Co., Ltd.), and mid-arm circumference (MAC) was measured by a tape. The participants were in a standing position with their arm hanging relaxed during the measurements. TSF and MAC were performed at the midpoint between the tip of the acromion and olecranon process of the arm, measured three times for each participant, and the mean value was recorded. A TSF of less than 5 mm reflects low body fat stores (14). A MAC of 24.3 cm is the suggested cut-off to identify underweight in both men and women (15).

Grip strength was measured by a digital handgrip dynamometer (Camry, South El Monte, CA, USA) in a standing position and with the elbow in 90° flexion close to the body. Participants were allowed three maximal efforts, and the mean value was used. Low muscle strength is defined as handgrip strength < 28 kg for men and < 18 kg for women (16). All of the above measurements were assessed at weeks 0, 3, and 7.

Before the experiment, participants were asked to express their opinions about snack consumption. Opinions were assessed by the following questions: "How often do you eat snacks?" (1 = Do not eat, 2 = 1-2 times/week, 3 = 3-4 times/week, 4 = 5-6 times/week, 5 = Every day, and 6 = Other), "What are the top 3 snacks you like?", and "How much do you usually spend for a snack?" (1 = less than 10 baht, 2 = 10-15 baht, 3 = 15-20 baht, 4 = 20-25 baht, and 5 = more than 25 baht). In the last week of the intervention, they were asked about their willingness to eat snacks in the future by the following question: "Would you like to eat these desserts and drink soy milk in the future?" (1 = Yes, 2 = No) at the end of the study.

A five-point facial hedonic scale was used to evaluate the acceptability of desserts, including appearance, aroma, texture, taste, and overall acceptability (1 = Very bad, 2 = Bad, 3 = Okay, 4 = Good, 5 = Very good) (17).

Statistical analyses were performed using SPSS Version 22 (IBM SPSS Statistics, Chicago, IL, USA). The Shapiro-Wilk test of normality was run to determine whether data variables met parametric assumptions. Data were presented as mean ± SD for normal distribution or median and interquartile range (IQR) for non-normal distribution. The chi-square test or Mann-Whiney U test was used to examine the difference in characteristics between groups at baseline. Friedman test was employed for a within-group comparison of the effects of the intervention on anthropometry indices and dietary intakes at different time points. Concerning significant differences, a pairwise Dunn-Bonferroni Post-hoc test was applied to detect these differences. All tests were two-tailed, and a $P < 0.05$ was considered statistically significant. Kendall's W (coefficient of concordance) was used to calculate effect sizes for the Friedman test wherein values of 0.1, 0.3, and above 0.5 indicate a small effect, a moderate effect, and a strong (large) effect, respectively.

Results

Out of 34 participants, 31 completed the study (91%). Dropouts were participants who failed to complete the study because of relocation (intervention group, n = 1) and personal reasons (control group, n = 1 and intervention group, n = 1).

Table 1 showed baseline characteristics of participants, 77% and 23% of the participants were females (n = 24) and males (n = 7), respectively, with average age of 71.8 ± 4.8 years. Their body weight and height were 43.5 ± 5.6 kg and 151.1 ± 6.3 cm, respectively. Furthermore, their BMI, TSF (median ± IQR), MAC, and grip strength were 19.0 ± 2.1 kg/m^2, 20.0 ± 3.0 mm, 23.8 ± 2.1 cm, and 17.4 ± 3.4 kg, respectively. All anthropometric parameters were not different for the control and the intervention groups at baseline (week 0). In addition, the average daily energy intake was 1295 ± 189 kcal, and no differences were observed in the mean of energy, protein, and lipid intake between the control and the intervention groups at baseline except for carbohydrate intake ($P = 0.017$).

The intervention group had high dietary compliance (94% consumed), and their mean energy intake from the intervention snack was similar to the supply. Table 2 presents daily energy and macronutrient intakes at weeks 0, 3, and 7. In week 7 of the intervention, there were increased daily intakes of energy ($P < 0.001$, effect size: 0.884), lipid ($P < 0.010$, effect size: 0.813), and carbohydrate ($P < 0.010$, effect size: 0.618), indicating a large effect size. While protein intake was an increasing trend. Figure 1 illustrates the mean daily energy intake at weeks 0, 3, and 7. In the intervention group, daily energy intake increased approximately 316 ($P < 0.001$) and 214 kcal ($P = 0.006$) compared to week 0, while in the control group, daily energy and macronutrient intakes remained unchanged throughout the study.

Table 3 presents anthropometric parameters at weeks 0, 3, and 7. In the intervention group, there were 2%, 2%, and 4% increases in average body weight ($P < 0.001$, effect size: 0.314), BMI ($P = 0.009$, effect size: 0.314), and MAC ($P < 0.001$, effect size: 0.265), respectively, indicating a

Table 1. Baseline Characteristics of Participants

Variable	All (n = 31)	Control (n = 16)	Intervention (n = 15)	*P* Value
Age (years), mean ± SD	71.8 ± 4.8	71.5 ± 4.7	72.1 ± 5.0	0.682
Gender (female/male), mean ± SD	24/7	13/3	11/4	0.598
Body weight (kg), mean ± SD	43.5 ± 5.6	44.4 ± 5.0	42.5 ± 6.2	0.338
Height (cm), mean ± SD	151.1 ± 6.3	151.4 ± 5.1	150.8 ± 7.6	0.379
BMI (kg/m2), mean ± SD	19.0 ± 2.1	19.4 ± 2.4	18.6 ± 1.8	0.247
TSF (mm), median ± IQR	20.0 ± 3.0	20.0 ± 4.6	20.7 ± 4.0	0.151
MAC (cm), mean ± SD	23.8 ± 2.1	23.9 ± 2.1	23.6 ± 2.1	0.572
Grip strength (kg), mean ± SD	17.4 ± 3.4	17.4 ± 3.2	17.3 ± 3.7	0.953
Energy (kcal/day), mean ± SD	1295 ± 189	1242 ± 211	1351 ± 149	0.780
Protein (g), median ± IQR	49.5 ± 10.8	48.7 ± 10.8	50.4 ± 9.9	0.379
Lipid (g), mean ± SD	30.4 ± 8.4	30.8 ± 9.1	29.9 ± 7.9	0.892
Carbohydrate (g), mean ± SD	206.8 ± 32.7	195.1 ± 36.6	219.4 ± 23.1	0.017

Note. SD: Standard deviation; IQR: Interquartile range; BMI: Body mass index; TSF: Triceps skinfold; MAC: Mid-arm circumference.
Chi-square test or Mann-Whiney U test was used to examine the difference in characteristics between groups at baseline ($P < 0.05$).

Table 2. Daily Macronutrient Intakes at Weeks 0, 3, and 7

Variable	Control Group (n = 16)			*P* Value	Effect Size	Intervention Group (n = 15)			*P* Value	Effect Size
	Week 0	Week 3	Week 7			Week 0	Week 3	Week 7		
Energy (kcal)	1295 ± 189	1242 ± 211	1303 ± 216	0.269	0.082	1351 ± 149^{a}	1667 ± 202^{b}	1565 ± 145^{b}	< 0.001	0.884
Protein (g)*	48.7 ± 10.8	52.6 ± 14.2	50.2 ± 15.7	0.269	0.082	50.4 ± 9.9	56.0 ± 10.2	54.6 ± 11.8	0.165	0.120
Lipid (g)	30.8 ± 9.1	37.5 ± 12.1	36.9 ± 11.4	0.099	0.145	29.9 ± 7.9^{a}	48.3 ± 11.5^{b}	44.6 ± 8.4^{b}	< 0.001	0.813
Carbohydrate (g)	195.1 ± 36.6	190.7 ± 25.7	192.5 ± 34.3	0.939	0.004	219.4 ± 23.1^{a}	254.3 ± 30.6^{b}	260.3 ± 25.5^{b}	< 0.001	0.618

Note. SD: Standard deviation; IQR: Interquartile range; Data are expressed in mean ± SD and *median ± IQR. Different superscripts ($^{a, b, c}$) denote significant difference within the group comparison based on Friedman test ($P < 0.05$). Effect size value of 0.1 indicates a small effect, 0.3 is a moderate effect, and above 0.5 is a large effect.

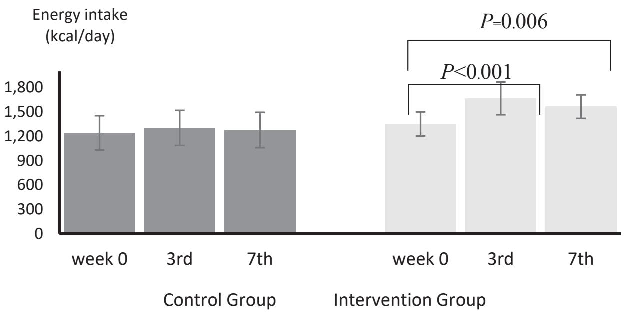

Figure 1. Mean Daily Energy Intake at Weeks 0, 3, and 7. *Note.* SD: Standard deviation. Data are expressed in mean ± SD. Significant difference within the group is based on pairwise Dunn-Bonferroni Post-hoc test ($P < 0.05$).

medium effect size, while, TSF and grip strength remained stable. In the control group, all the anthropometric parameters remained unchanged. Figure 2 shows a change of mean body weight (kg) at weeks 3 and 7 compared with week 0. In the intervention, the mean body weight increased nearly 0.8 kg at weeks 3 and 7 ($P = 0.019$ and $P = 0.041$, respectively), but it did not increase in the control group.

The participants' opinions about snack consumption were evaluated by the following questions: "How often do you eat snacks?" Most participants (44%) and 24% of them ate a snack every day and 3-4 days/week, respectively, while 18%, 12%, and 2% did not eat snack, eat 1-2 days/week, and eat snack 5-6 days/week, respectively. Concerning the question "What are the top 3 snacks you like?", the answers were categorized into four groups: The favorite snacks were traditional Thai dessert (34%), bread and crackers (28%), drinks such as soy milk, cows' milk, cocoa powder in milk, and the like (21%), and seasonal fruit (17%). With regard to the question "How much do you usually spend for a snack?", it was found that more than half of the participants (55%) usually spent 10-15 baht for a snack (per serving), less than 10 baht (27%), and 15-20 baht (18%).

An intervention snack provided mean daily energy of 548 ± 20 kcal, 10.7 ± 2.7 g protein, 20.3 ± 3.8 fat, 80.7 ± 10.0 g carbohydrate, and a protein, fat, carbohydrate energy ratio of 7:33:60. An example of some desserts, ingredients, energy, and macronutrient contents is provided in the supplementary file.

The overall acceptability scores in 34 kinds of desserts were found to be good with a mean ± SD of 4.19 ± 0.59. Appearance, aroma, texture, and taste scores were 3.95 ± 0.55, 3.92 ± 0.58, 4.08 ± 0.60, and 4.06 ± 0.62, respectively. Participants were asked for their opinion about their willingness to eat snacks and milk in the future, and the results indicated that all of them were willing to continue eating these items.

Discussion

This randomized controlled study with a 7-week intervention period investigated the effects of frequent snacks on energy intakes and nutritional status in

Table 3. Anthropometric Parameters at Weeks 0, 3, and 7

Variable	Control (n = 16)			*P* Value	Effect Size	Intervention (n = 15)			*P* Value	Effect Size
	Week 0	Week 3	Week 7			Week 0	Week 3	Week 7		
Body weight (kg)	44.4 ± 5.0	44.4 ± 5.3	44.5 ± 5.4	0.814	0.013	42.5 ± 6.2[a]	43.3 ± 6.2[b]	43.2 ± 6.5[b]	< 0.001	0.314
BMI (kg/m²)	19.4 ± 2.4	19.4 ± 2.4	19.4 ± 2.4	0.662	0.013	18.6 ± 1.8[a]	19.0 ± 1.8[b]	19.0 ± 1.9[b]	0.009	0.314
TSF (mm)*	20.0 ± 4.6	19.3 ± 4.8	19.5 ± 5.1	0.362	0.064	20.7 ± 4.0	21.0 ± 5.3	21.0 ± 5.0	0.620	0.032
MAC (cm)	23.9 ± 2.1	24.0 ± 2.2	24.2 ± 2.4	0.066	0.085	23.6 ± 2.1[a]	24.2 ± 2.0[a,b]	24.6 ± 2.2[b]	< 0.001	0.265
Grip strength (kg)	17.4 ± 3.2	17.7 ± 3.7	16.8 ± 3.7	0.117	0.134	17.3 ± 3.7	17.5 ± 3.7	17.4 ± 3.8	0.679	0.026

Note. SD: Standard deviation; IQR: Interquartile range; BMI: Body mass index; TSF: Triceps skinfold; MAC: Mid-arm circumference. Data are expressed in mean ± SD, *median ± IQR. Different superscripts ([a, b, c]) indicate significant difference within the group comparison based on Friedman test ($P < 0.05$). Effect size value of 0.1 indicates a small effect, 0.3 is a moderate effect, and above 0.5 is a large effect.

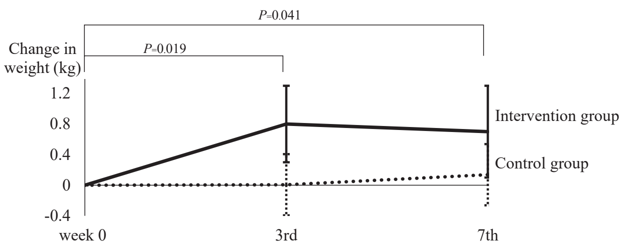

Figure 2. Change of Mean Body Weight (kg) at Weeks 3 and 7 Compared With Week 0. *Note*. SD: Standard deviation; Data are expressed in mean ± SD. Significant difference within the group is based on pairwise Dunn Bonferroni Post-hoc test ($P < 0.05$).

community-dwelling older adults at risk of malnutrition. We found that providing frequent snacks was an effective way to improve energy intakes and nutritional status.

In the current study, in the intervention group, there was an increased of daily energy intake ($P < 0.001$, effect size: 0.884) and the energy requirements were met, recommending 1539 and 1744 kcal/day for female and male adults aged 71 years and older with light activity, respectively (18). On the other hand, the control group had an average daily energy intake that remained consistently lower than the recommended requirements (consumed 1277 ± 218 to 1303 ± 216 kcal/day) during the study. This may be due to the beneficial effect of frequent snacks as a good source of energy and nutrients. Generally, older adults have less appetite with early satiety and consume smaller meals than young adults due to physiological changes, including gastrointestinal dysfunction such as maldigestion and malabsorption, dental problems such as loss of teeth that impact oral function, and dry mouth syndrome that affects the perception of taste and smell (19,20). These may suggest that older adults are unable to meet their nutritional requirements through the regular 3 main meals Therefore, providing frequent snacks may be a good choice for undernourished older adults as snacks can contribute up to nearly a quarter of daily energy intake.

A variety of intervention snacks with different colors and appearances was prepared in this study, which may have contributed to the participants' satisfaction and encouraged them to consume more. This is reflected in the current study that the compliance with the intervention snacks was considerable, and the intervention group consumed almost all of them, accounting for 94% of supplied calories. This is consistent with previous studies that reported the variety and palatability of snacks contribute to the satisfaction of older adults and increase of intake (21-23).

In this study, the intervention snacks were prepared based on participants' preferences and familiarity. They had soft or tender textures and were easy to chew by cutting ingredients into small pieces or bite-sizes, cooking methods (e.g., boiling, steaming, stirring, and syrup until the texture was softened or tender), being broken apart with the side of a fork. These methods may have been appropriate for our participants who had dental problems such as tooth decay, loss of teeth, and gingivitis. We found that the participants were well satisfied with the texture of the snacks. A small number of the participants were sensitive to the smell of soybeans and disliked it. Therefore, we tried to improve the aroma through a simple and common method by adding fresh pandan leaves, while cooking it helped reduce the smell of soybean and increase the pleasant aroma in the snacks. Using this method, the participants accepted the smell of soybean-based snacks to a great extent. After evaluating the acceptability of the snacks, we found that the participants were well satisfied with the taste and overall appeal of the snacks.

Some studies have reported that snacks were associated with increased energy and protein intake and prevented weight loss in hospitalized older adults at risk of malnutrition (24-26). Results of this study are in line with some studies. For example, a study provided energy-rich and protein-fortified snacks (approximately 500 kcal and 30 g of protein per day) in 46 hospitalized older adult patients with mean age of 68.7 ± 13.2 years. Through the intervention, daily energy intake and protein intake increased from 74% to 109% ($P < 0.00$) and from 49% to 88% ($P < 0.00$) of requirements, respectively (27). The protein provided by that study was almost 3 times higher than that provided in our study which may be due to the fact that the participants in that study were hospitalized patients with more serious health conditions, needing more protein than those in our study who were community-dwelling older adults without serious health conditions.

Another study evaluated the influence of snacking on energy intake in 2002 older Americans aged 65 and over using 24-hour recall data from the National health survey. Results showed that, in older adults at risk of malnutrition, snacking contributed to higher daily intakes of energy, carbohydrate, lipid, and protein compared to no snacking (28). We assume that snacking is a crucial dietary pattern of older adults that may encourage them to eat adequate energy and nutrients.

Although, in this study, the intervention group was found to slightly decrease its basic meals (usual diet) consumption from baseline to the last week of each experimental phase, the total energy intake in the intervention group still increased by approximately 300 kcal per day and met the recommended level. This may be because of the fact that the participants preferred snacks and ate almost 500 kcal/day, leading to a satiety feeling and reduced consumption at the next basic meal. A similar trend was reported in some studies (29).

In the present study, older adults at risk of malnutrition provided with snacks for the first 3 weeks exhibited the significant gain body weight of almost 0.8 kg. However, other parameters such as TSF, MAC, and grip strength were tended to increase but were not significant. Therefore, we continued the study for a total of 7 weeks. The results by the intervention snack indicated that there was an increase in body weight ($P<0.001$, effect size: 0.314), BMI ($P=0.009$, effect size: 0.314), and MAC ($P<0.001$, effect size: 0.265), while no statistically significant changes were observed in anthropometric parameters in the control group.

These findings are consistent with a study (30) that provided snacks (approximately 145 kcal and 6.3 g of protein/5 days per week) for 4 weeks among community-dwelling older adults (mean age of 81.3 ± 10.9 years). After intervention, mean body weight increased approximately 0.7 kg ($P=0.008$), and BMI increased by 0.78 ± 1.16 kg/m^2 ($P=0.039$).

The considerable strengths of the current study are as follows. The first point is that this study sufficiently showed that the cost of snacks was affordable similar to the possible price that participants usually spent on snacks, and all participants were willing to continue eating snacks in the future. Therefore, this may be an alternative strategy to suggest in community-dwelling older adults at risk of malnutrition to increase energy and nutritional status.

Another remarkable strength of the current study is that participants' snack preferences were studied and used in the planning of the intervention snack, while this was not found in other previous studies. Furthermore, according to the findings, this is the first study conducted in Chiang Mai in the northern region of Thailand. The current study has also obvious strengths in terms of adapting local menus and employing readily available and familiar local ingredients. For all items in this study, we followed a traditional cooking method taught by local cookers. The general characteristics of all the adapted menus are similar to the local traditional menus. As a result, the sample group readily accepted these items.

On the other hand, the current study suffers from some weaknesses as we discovered. The created menus may have a flavor that slightly differed from the original as a result of some ingredients added to enrich the nutritional value. The next limitation is related to the small sample size which may decrease the strength of the study; further, the intervention period was only 7 weeks that may be too short to detect changes in the body composition or functional status such as TSF and grip strength. Therefore, further study is suggested to confirm these results in a larger group with longer duration. However, these findings are crucial due to the high prevalence of undernutrition and its risks among older adults. Dietitians and other health care providers can apply this information to effective meal planning and dietary counseling among community-dwelling older adults at risk of malnutrition.

Conclusion

Given the results of the current study over a 7-week intervention period, we have shown a simple way of providing frequent snacks that were effective to increase energy intakes, meet recommended requirements, and improve nutritional status in community-dwelling older adults at risk of malnutrition.

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Authors' Contribution

YC (first author): Introduction writer/methodologist/discussion writer/main researcher (55%); JW (second author): Methodologist/discussion writer/assistant researcher (10%); ST (third author): Methodologist/discussion writer (10%); CP (forth author): Methodologist/discussion writer (10%); SY (fifth author): Methodologist/discussion writer (15%).

Conflict of Interests

Authors declare that they have no conflict of interests.

Ethical Permissions

The study protocol and procedures were approved by the Ethical Committee of the Faculty of Public Health, Chiang Mai University, Thailand. Protocol number ET019/2020 was conducted in accordance with the Helsinki Declaration of 1975.

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Supplementary files

Supplementary file contains Table S1.

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