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Research Article

Effects of a nutrition education program on metabolic syndrome risk factors in middle-aged Korean adults: an intervention study

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Objectives: This study was conducted to evaluate the effects of a nutrition education program on metabolic syndrome in middle-aged Korean adults.
Methods: A total of 411 Korean adults 30–59 years of age were allocated randomly into three groups: the nutrition education group for promoting Han-sik consumption (HG), the nutrition education group for eating balanced diet (EG), and the control group (CG). The HG and EG received four face-to-face nutrition education sessions over 16 weeks to improve nutritional problems based on the individual's usual diet. Effectiveness of the program was evaluated with the differences of self-reported dietary behaviors, dietary intakes, anthropometric measurements and biochemical indices between the baseline and the end of the nutrition education program. The changes within groups were analyzed using paired t-test and McNemar test and effectiveness among three groups was analyzed by repeated analysis of variance.
Results: After the nutrition education, the percentages of participants who achieved the recommended food group consumption in the Korean Food Guidance Systems significantly increased in HG (P = 0.022). Body weight (P = 0.007), body mass index (P = 0.002), and triglycerides (P = 0.002) significantly decreased in HG. Waist circumference and diastolic blood pressure decreased in all three groups (P < 0.05).
Conclusions: This study found that tailored nutrition education program for middle aged Korean adults showed beneficial effects on improving dietary behaviors and metabolic syndrome risk factors. Further studies are needed to assess the long-term effects of the nutrition education programs on metabolic syndrome risks.

Keywords: nutrition education; Han-sik; eating a balanced diet; metabolic syndrome; middle-aged Korean adults

INTRODUCTION

Metabolic syndrome is a cluster of metabolic risk factors associated with increased risk of atherosclerotic cardiovascular diseases and type 2 diabetes mellitus [1,2]. Diagnostic risk factors for metabolic syndrome include elevated waist circumference, triglycerides, blood pressure, and fasting glucose and reduced high-density lipoprotein (HDL) cholesterol [2]. In Korea, prevalence of metabolic syndrome has increased substantially along with an increase in high blood pressure and high fasting glucose level [3].

Diet can have a significant impact on risk factors for metabolic syndrome. In the United States, the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) recommended therapeutic lifestyle changes (TLC) that included reducing saturated fat and cholesterol intakes, increasing dietary fiber, and adjusting total caloric intake to maintain a desirable body weight [1].

Several studies have reported that nutritional education can bring about beneficial effects on metabolic syndrome risk factors in various populations regardless of duration of the nutrition education. After 1-year of nutrition education in 54,385 adults aged 20–64 in Korea, the prevalence of metabolic syndrome components decreased significantly [4]. Another study conducted a nutritional education program on metabolic syndrome among 153 diabetic patients aged 20–79 in Kenya and found a significant reduction in body mass index (BMI) and low-density lipoprotein (LDL) cholesterol levels after 8 weeks of education [5]. A study on a 1-year nutritional education program for metabolic syndrome in 456 obese patients aged 18–77 in Spain also reported significant declines in body weight, body fat, and visceral fat [6]. Furthermore, results from a meta-analysis showed that tailored nutrition education was more effective in increasing fruits and vegetables consumption and reducing the percentage of energy from fat compared with generic nutrition education [7].

The “Han-sik,” a traditional Korean diet, is characterized mainly by a high proportion of grains and vegetables, a low proportion of animal foods, and cooking methods such as boiling or blanching in water rather than deep-frying or stir-frying in oil [8-10]. Due to its distinctive composition of major foods and the cooking style, Han-sik has been culturally recognized as a relatively healthy dietary pattern, comparable to the Dietary Approaches to Stop Hypertension (DASH) diet or a prudent dietary pattern [11,12]. However, scientific evidence on the beneficial effects of increasing Han-sik consumption through nutrition education programs on metabolic syndrome is very limited. Therefore, this study aimed to assess the effects of a nutrition education program on metabolic syndrome risk factors in middle-aged Korean adults.

METHODS

Ethics statement

All participants were provided written informed consent. The study protocol, approved by the Institutional Review Board of Jesaeng Hospital in Korea (IRB No. IMG 09-01), involved subject analysis conducted on the per-protocol (PP) set.

1. Participants

The target population of the nutrition education program was middle aged Korean adults. The sample size was determined to be 405 participants based on the result of previous studies, with a power of 80% and a type I error of 5% [13,14]. This calculation, performed using G*Power 3.1.9.7 software, meets the necessary sample size requirements for this study [15,16]. Study subjects were recruited at one hospital in South Korea, between July 2011–2012. A total of 411 subjects aged 30–59 years with two or more metabolic syndrome risk factors as detected in a general health screening examination, and who were not taking medications were selected. Metabolic syndrome was defined based on the NCEP ATP III, with the exception of the abdominal obesity criterion [2]. The Korean Society for the Study of Obesity (KOSSO)’s definition of abdominal obesity was used in this study [17]. Those who had three or more of the following five components were defined as having metabolic syndrome: abnormal blood glucose (fasting blood glucose ≥ 100 mg/dL), elevated blood pressure (≥ 130/85 mmHg), low serum HDL-cholesterol (< 50 mg/dL for women, < 40 mg/dL for men), hypertriglyceridemia (≥ 150 mg/dL), and abdominal obesity

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(waist circumference ≥ 85 cm for women, ≥ 90 cm for men).

The 411 subjects were stratified by gender and randomly assigned into three groups: the nutrition education group promoting Han-sik consumption (HG), the nutrition education group for eating a balanced diet (EG), and the control group with no intervention (CG; Figure 1).

2. Nutrition education program

Nutrition education to manage metabolic syndrome risk factors was focused on the individual's dietary problems based on the baseline dietary survey. The nutrition education was performed by trained dietitians. The HG and EG included meeting face-to-face with the trained dietitian four times in the 16 weeks according to the study protocol.

1) First session - Setting dietary goals

In the first session, dietary goals were set for all HG and EG participants to manage metabolic syndrome risks. The dietary goals were established based on the dyslipidemia treatment guidelines, the Korean Food Guidance System (KFGS), Dietary Reference Intakes for Koreans, and a review of the literature. A detailed description of the process of establishing individual' dietary goals was published previously [18]. Briefly, the dietary goals include four topics with seven guidelines: 1) keep a healthy weight (maintain a healthy weight, appropriate caloric intake), 2) adhere to acceptable macronutrient intake ranges (15% to 20% of total calories from total fat, 60% to 65% of total calories from carbohydrate), 3) increase specific nutrient intake (25 g/d or more of dietary fiber intake in men, 20 g/d or more of dietary fiber in women), and 4) reduce specific nutrient intake (2 g/d or less of sodium intake, 200 mg/d or less of cholesterol intake).

Both the HG and EG groups were provided with educational materials for dietary practice. The educational materials for HG group included menu planning methods with examples based on KFGS using Han-sik [18,19]. In contrast, the educational materials for EG group included menu planning methods with examples based on the KFGS using a regular diet [18,19]. The KFGS outlines the basic principles of meal planning with major food groups such as 'grains', 'meat, fish, eggs, beans', 'vegetables', 'fruits', 'milk, dairy products', and 'oils, fats, sugars' [20]. The dietary goals and composition of the

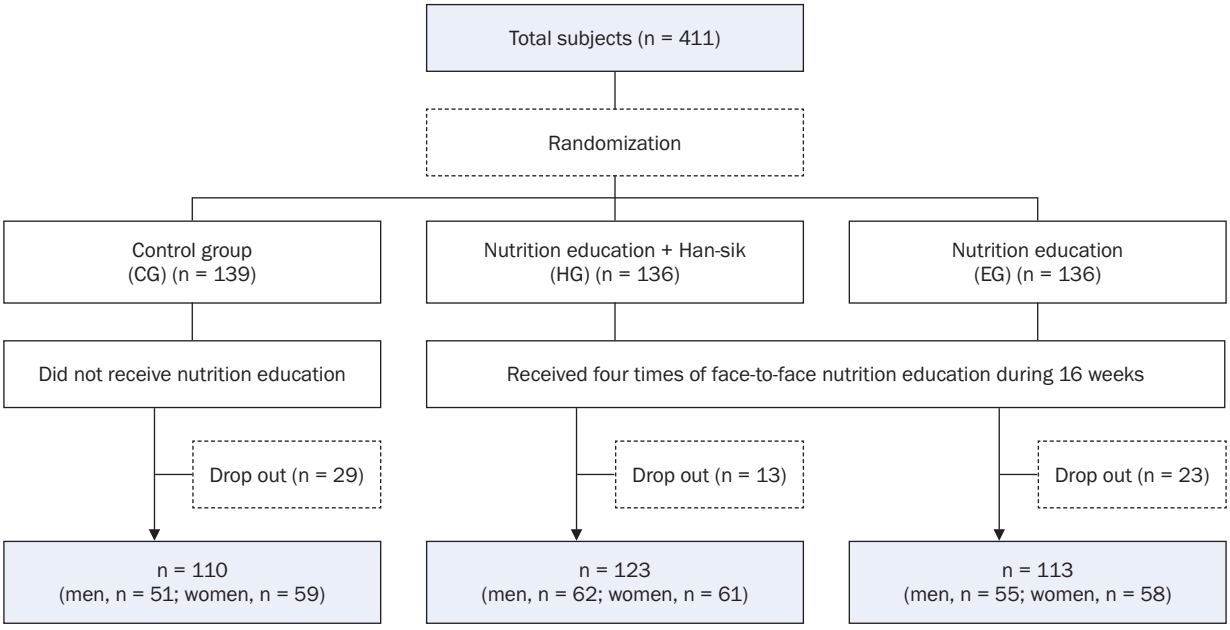

Fig. 1. Flow of the study process.
CG, control group with no intervention; HG, the nutrition education group for promoting the Han-sik consumption; EG, the nutrition education group for balanced diet.

nutrition education provided to both groups were identical; only the list of foods used in the menu planning differed (Figure 2) [18].

2) Remaining sessions - Tailored nutrition education

In the remaining three sessions, tailored nutrition education on personal dietary behaviors were provided for the HG and EG participants by trained dietitians, based on the personal dietary assessment results. During the

HG

EG

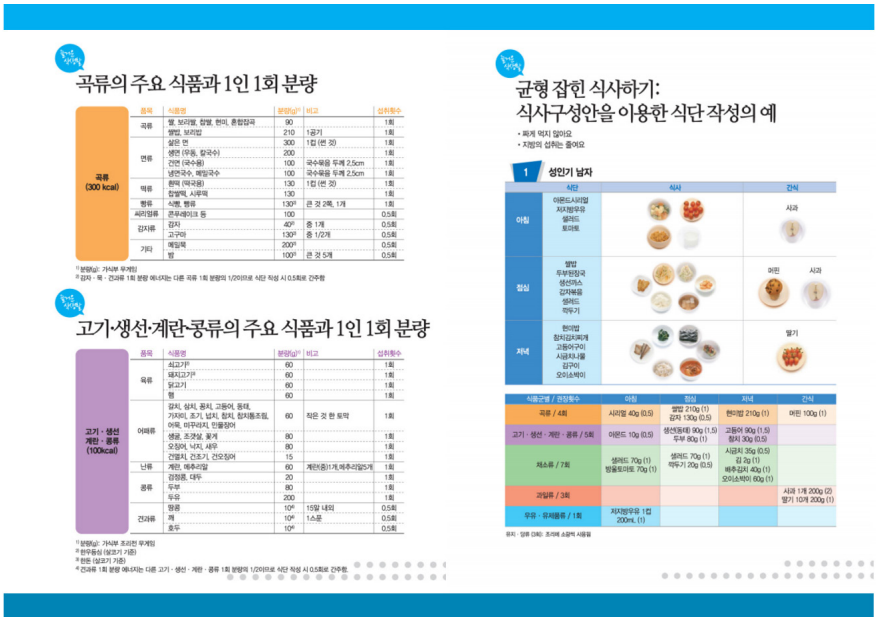

Fig. 2. Example of menu planning and presentation of single-serving sizes per meal for representative foods from both groups. HG, the nutrition education group for promoting Han-sik consumption; EG, the nutrition education group for balanced diet. Reproduced from Kang *et al*. (Korean J Nutr 2012; 45(6):552-561) [18].

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sessions, the individual consultation focused on helping the participants achieve their dietary goals such as appropriate caloric intake, macronutrient intake ranges, and adequate intakes of nutrients and food groups. The CG received no nutrition education.

3. Evaluation of the effectiveness of the nutrition education program

The effectiveness of the nutrition education program was evaluated using dietary behaviors, dietary intakes, anthropometric, and biochemical measurements.

1) Dietary behaviors

Dietary behaviors such as compliance with the dietary guidelines and food group guidance were measured using a questionnaire. The questionnaire included 12 questions with five answer categories (always = 5, frequently = 4, modestly = 3, seldom = 2, never = 1).

2) Dietary intake

The Dietary intake data were collected at three points (baseline, 8 weeks, and 16 weeks) with non-consecutive 3-day dietary records (two weekdays and one weekend day). Nutrient intakes were calculated using the CAN-pro 6.0 (Korean Nutrition Society). The intakes of six major food groups were calculated, and adherence score to KFGS was calculated as the percentage of food consumption by each food group relative to the recommended servings by age and sex [20,21]. The overall adherence of KFGS was evaluated as satisfying the following criteria in three or more food groups: 80% ≤ the adherence score of 'grains' and 'meat, fish, eggs, beans' < 120%, 80% ≤ the adherence score of 'vegetables', 'fruits', and 'milk, dairy products', and the adherence score of 'oils, fats, sugars' < 120% [20,21]. Han-sik usage was defined as the percentage of Han-sik items of all consumed dish items using Han-sik database [19].

3) Anthropometric and biochemical measurements

At baseline, 8 weeks and 16 weeks after the program, anthropometric and biochemical data were collected three points. All measurements were performed by trained health workers. The body weight and height were measured using an automatic height and weight scale (GL-150; G-Tech International). BMI was calculated as weight in kg divided by the square of height in meter. Waist circumference was measured using a tape measure at the narrowest part of the waist. Blood pressure was measured using automatic equipment (OMRON HEM-7220; OMRON Corp.). Blood samples were collected after at least 8 hours of fasting and analyzed by the Department of Laboratory Medicine at Jesaeng Hospital. The enzymatic colorimetric test (glycerol phosphate oxidase-p-aminophenazone, GPO-PAP), an enzymatic method, and Hexokinase-Glucose-6-Phosphate Dehydrogenase (HK-G6PD, UV) were used for measuring serum levels of triglycerides, HDL-cholesterol, and glucose, respectively.

4) Sociodemographic and lifestyle factors

Data on sociodemographic and lifestyle factors, such as sex, age, smoking status, alcohol drinking, physical activity, and dietary supplement use, were collected using a structured questionnaire. Smoking status was categorized as never smoked, quit smoking, or currently smoking. Alcohol intake at one time was grouped into four categories: do not drink, 1–2 glasses, 3–6 glasses, and 7 glasses or more. Physical activity was classified as 'regular' if the subject answered "yes" to moderate physical activity of at least 30 minutes at a time for 5 or more days per week or to intense physical activity of at least 20 minutes at a time for 3 or more days per week.

4. Statistical analyses

Data are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables. Baseline characteristics among three groups were compared using analysis of variance (ANOVA) and χ^2 test. The differences between values at baseline and the end of the nutrition education program within each group were analyzed using the paired t-test for continuous variables and the McNemar test for categorical variables. To evaluate the effectiveness of the nutrition education program among the three groups, repeated ANOVA was used. The SAS software (ver. 9.3; SAS Institute Inc.) was used for all statistical analyses. The level of significance was set at $P < 0.05$.

Table 1. Baseline characteristics of participants in three groups

	CG (n = 110)	HG (n = 123)	EG (n = 113)	*P*-value[1]
Age (year)	46.2 ± 7.9	45.6 ± 7.7	47.8 ± 7.3	0.083
Sex				
Men	51 (46.4)	62 (50.4)	55 (48.7)	0.827
Women	59 (53.6)	61 (49.6)	58 (51.3)	
Smoking status				
Never smoked	62 (56.4)	67 (54.5)	61 (54.0)	0.832
Former smoking	25 (22.7)	33 (26.8)	25 (22.1)	
Currently smoking	23 (20.9)	23 (18.7)	27 (23.9)	
Alcohol intake at one time				
Do not drink	8 (7.3)	12 (9.8)	8 (7.1)	0.927
1–2 glasses	38 (34.5)	37 (30.1)	38 (33.6)	
3–6 glasses	31 (28.2)	41 (33.3)	33 (29.2)	
7 glasses and more	33 (30.0)	33 (26.8)	34 (30.1)	
Physical activity				
Regular[2]	23 (20.9)	23 (18.7)	22 (19.5)	0.913
Dietary supplement use				
User	50 (45.5)	53 (43.1)	48 (42.5)	0.894
Metabolic syndrome[3]	66 (60.0)	64 (52.0)	63 (55.8)	0.474
Metabolic syndrome components[4]				
Impaired blood glucose	47 (42.7)	53 (43.1)	56 (49.6)	0.507
Elevated blood pressure	77 (70.0)	89 (72.4)	93 (82.3)	0.078
Low HDL-cholesterol	47 (42.7)	43 (35.0)	35 (31.0)	0.178
Hypertriglyceridemia	77 (70.0)	66 (53.7)	54 (47.8)	0.002
Abdominal obesity	75 (68.2)	87 (70.7)	72 (63.7)	0.510

Mean ± SD or n (%).
CG, control group with no intervention; HG, the nutrition education group for promoting the Han-sik consumption; EG, the nutrition education group for balanced diet; HDL, high-density lipoprotein.
[1]*P* from chi-square test in categorical variables and ANOVA in continuous variables (duncan's grouping).
[2]Moderate physical activity of at least 30 min at a time for 5 or more days per week or intense physical activity of at least 20 min at a time of 3 or more days per week.
[3]Metabolic syndrome, those who had three or more of the following five components.
[4]Impaired blood glucose (fasting blood glucose ≥ 100 mg/dL), elevated blood pressure (≥ 130/85 mmHg), low HDL-cholesterol (< 50 mg/dL for women, < 40 mg/dL for men), hypertriglyceridemia (≥ 150 mg/dL), and abdominal obesity (waist circumference ≥ 85 cm for women, ≥ 90 cm for men).

RESULTS

Among the 411 participants who initially joined the nutrition education program initially, 346 participants (84.2%) completed four sessions (Figure 1). Table 1 shows the baseline characteristics of the participants who completed the program. There were no significant differences in baseline characteristics among the three groups, except for the percentages of participants with hypertriglyceridemia.

Table 2 shows the changes in self-reported adherence to the dietary guidelines for Koreans after the provision of nutrition education. Analysis across two-time points indicates that dietary behaviors–such as adequate intake of milk and dairy products, regular intake of three meals a day, eating less fried foods, and reducing the amount of oil when cooking–showed significantly greater improvement in the HG and EG groups compared to the CG group (P for group-by-time interaction < 0.05).

The changes in nutrient intake and adherence score to KFGS after the nutrition education are shown in Table 3. Upon the completion of the nutrition education, there was a significant decrease in energy, carbohydrate, fat, and sodium in EG (P < 0.05). In turn, several adherence

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Table 2. Self-reported changes in dietary behaviors during nutrition education[1)]

	CG (n = 110)				HG (n = 123)				EG (n = 113)				
	Before	After	Difference	$P^{2)}$	Before	After	Difference	$P^{2)}$	Before	After	Difference	$P^{2)}$	$P^{3)}$
Adequate intake of various whole grains	3.2 ± 0.9	3.4 ± 0.9	0.2 ± 1.0	0.107	3.1 ± 1.0	3.2 ± 0.8	0.1 ± 1.0	0.129	3.2 ± 1.0	3.4 ± 0.9	0.2 ± 0.9	0.010	0.749
Adequate intake of green/orange vegetables	3.0 ± 0.8	3.0 ± 0.9	0.1 ± 0.9	0.460	2.6 ± 0.8	2.9 ± 0.7	0.3 ± 0.8	0.001	2.8 ± 0.9	3.0 ± 0.7	0.2 ± 0.9	0.019	0.242
Adequate intake of fruits	2.9 ± 0.9	3.0 ± 0.9	0.1 ± 0.9	0.534	3.0 ± 0.8	3.1 ± 0.8	0.1 ± 0.9	0.289	3.1 ± 0.9	3.1 ± 0.8	0.0 ± 1.0	0.844	0.672
Adequate intake of milk and dairy products	2.6 ± 1.0	2.7 ± 1.0	0.1 ± 1.1	0.335	2.6 ± 1.2	3.1 ± 0.9	0.5 ± 1.2	< 0.0001	2.6 ± 1.0	3.1 ± 0.9	0.5 ± 1.0	< 0.0001	0.005
Regular intake of three meals a day	3.0 ± 1.1	3.2 ± 1.0	0.2 ± 0.8	0.008	3.0 ± 1.2	3.3 ± 1.0	0.3 ± 0.9	0.001	3.0 ± 1.0	3.5 ± 1.0	0.5 ± 0.8	< 0.0001	0.042
Meals are composed of variety of side-dishes	3.0 ± 0.8	3.0 ± 0.8	0.1 ± 0.8	0.247	3.0 ± 0.9	3.0 ± 0.8	0.1 ± 0.9	0.412	2.9 ± 0.8	3.2 ± 0.7	0.3 ± 0.8	0.0002	0.082
Appropriate caloric intake needed for energy balance	3.0 ± 0.9	3.2 ± 0.9	0.2 ± 1.0	0.044	3.2 ± 1.0	3.2 ± 0.8	0.1 ± 1.0	0.441	3.0 ± 0.9	3.2 ± 0.8	0.2 ± 1.1	0.082	0.633
Do not add extra salt or soy sauce	3.5 ± 0.9	3.5 ± 1.0	0.1 ± 1.0	0.516	3.4 ± 1.0	3.6 ± 0.9	0.2 ± 1.1	0.023	3.3 ± 1.0	3.6 ± 0.9	0.3 ± 1.1	0.012	0.317
Make Kimchi as low salty	2.9 ± 0.8	3.1 ± 0.8	0.1 ± 0.9	0.085	2.9 ± 0.8	3.1 ± 0.8	0.2 ± 0.7	0.003	3.0 ± 1.0	3.3 ± 0.7	0.3 ± 0.9	0.0002	0.324
Eat less fatty meat	3.1 ± 1.1	3.3 ± 1.1	0.2 ± 0.9	0.043	3.0 ± 1.1	3.3 ± 1.0	0.3 ± 0.9	< 0.0001	3.2 ± 1.0	3.5 ± 0.9	0.4 ± 0.9	< 0.0001	0.286
Eat less fried foods	3.4 ± 1.0	3.5 ± 0.9	0.1 ± 0.9	0.326	3.2 ± 1.0	3.6 ± 0.9	0.4 ± 0.9	< 0.0001	3.2 ± 1.0	3.6 ± 0.8	0.4 ± 0.9	< 0.0001	0.009
Reduce the amount of oil when cooking	3.3 ± 0.8	3.4 ± 0.8	0.1 ± 0.8	0.181	3.1 ± 0.9	3.5 ± 0.7	0.4 ± 0.7	< 0.0001	3.2 ± 0.8	3.6 ± 0.7	0.4 ± 0.8	< 0.0001	0.011

Mean ± SD.
CG, control group; HG, the education to increase Han-sik consumption group; EG, the education to promote a balanced diet group.
[1)]The score was answered as follows keeping the guideline: always = 5, frequently = 4, modestly = 3, seldom = 2, never = 1.
[2)]*P* from paired t-test in each three groups.
[3)]*P* from repeated ANOVA, group-by-time.

scores to KFGS changed after nutrition education. The adherence score of 'oils, fats, sugars' in HG, 'grains', 'vegetables', 'oils, fats, sugars' in EG, and 'grains', 'meat, fish, eggs, beans', and 'oils, fats, sugars' in CG decreased ($P < 0.05$). The adherence score of 'milk, dairy products' increased significantly only in HG ($P = 0.001$) (P for group-by-time interaction < 0.05). Percentages of participants meeting the recommendations for three or more food groups significantly increased from 32.5% to 46.3% in HG following nutrition education ($P = 0.022$). Similarly, in the EG, the percentage increased from 38.9% to 50.4%, approaching significance with a P-value of 0.058. Han-sik consumption did not change in any groups.

After receiving nutrition education, the changes in anthropometric and biochemical markers are presented in Table 4. In the HG group, there were significant reductions in body weight (72.7 kg to 72.2 kg, $P = 0.007$), BMI (26.3 kg/m^2 to 26.1 kg/m^2, $P = 0.002$), and waist circumference (89.4 cm to 88.0 cm, $P < 0.0001$) following nutritional education. Additionally, there were significant decreases in triglycerides (175.0 mg/dL to 153.4 mg/dL, $P = 0.002$) and systolic- (132.9 mmHg to 129.5 mmHg, $P = 0.016$) and diastolic- (86.6 mmHg to 84.0 mmHg, $P = 0.009$) blood pressure within this group. In the EG group, waist circumference (88.4 cm to 86.8 cm, $P < 0.0001$) and systolic- (135.8 mmHg to 130.8 mmHg, $P < 0.0001$) and diastolic- (89.1 mmHg to 84.8 mmHg, $P < 0.0001$) blood pressure were significantly reduced, while HDL cholesterol (50.9 mg/dL to 49.2 mg/dL, $P = 0.037$) showed a slight decrease. In the CG group, there were slight reductions in waist circumference (90.3 cm to 89.1 cm, $P < 0.0001$) and diastolic blood pressure (89.0 mmHg to 86.9 mmHg, $P = 0.044$). However, no significant differences were observed in the group-by-time interaction across the three groups.

The changes in prevalence of metabolic syndrome and its risk factors among the three groups after nutrition education are presented in Figure 3. After nutrition education, positive changes in metabolic syndrome risk factors were shown. Prevalence of elevated blood pressure and abdominal obesity was significantly decreased in both HG and EG ($P < 0.05$). Prevalence of hypertriglyceridemia and abdominal obesity was significantly decreased in CG ($P < 0.05$). Percentages of participants who did not have metabolic syndrome risk factors or

Table 3. The changes of nutrients and food group intakes among three groups after nutrition education

	CG (n = 110)				HG (n = 123)				EG (n = 113)				$P^{2)}$
	Before	After	Difference	$P^{1)}$	Before	After	Difference	$P^{1)}$	Before	After	Difference	$P^{1)}$	
Nutrient intakes													
Energy (kcal)	1,789.1 ± 569.5	1,683.3 ± 555.0	−105.8 ± 575.4	0.164	1,802.0 ± 605.1	1,686.9 ± 475.6	−115.1 ± 608.8	0.099	1,752.7 ± 516.1	1,582.7 ± 356.3	−170.0 ± 471.5	0.004	0.644
Carbohydrate (g)	258.5 ± 91.3	239.0 ± 71.0	−19.5 ± 83.7	0.079	260.4 ± 83.6	249.7 ± 68.7	−10.7 ± 84.5	0.276	255.8 ± 67.4	238.6 ± 54.2	−17.2 ± 62.6	0.035	0.662
Protein (g)	68.2 ± 25.7	63.5 ± 26.1	−4.7 ± 26.4	0.182	69.6 ± 27.3	68.1 ± 26.4	−1.5 ± 32.3	0.656	66.5 ± 27.0	61.8 ± 18.5	−4.7 ± 28.3	0.124	0.625
Fat (g)	41.8 ± 18.6	40.0 ± 21.5	−1.8 ± 25.1	0.515	44.0 ± 20.8	40.0 ± 17.4	−4.0 ± 22.4	0.104	43.0 ± 19.7	35.8 ± 14.3	−7.2 ± 22.0	0.002	0.218
% CHO	61.9 ± 8.2	61.7 ± 9.1	−0.1 ± 10.3	0.914	61.2 ± 8.6	61.7 ± 7.5	0.5 ± 10.5	0.613	61.8 ± 7.9	62.8 ± 7.3	0.9 ± 9.9	0.350	0.733
% protein	16.2 ± 3.5	16.1 ± 3.7	−0.1 ± 4.3	0.796	16.2 ± 4.2	16.6 ± 3.6	0.3 ± 5.2	0.508	15.7 ± 3.4	16.3 ± 3.7	0.6 ± 4.6	0.204	0.509
% lipid	21.9 ± 6.4	22.2 ± 7.4	0.3 ± 8.9	0.788	22.6 ± 6.4	21.7 ± 6.3	−0.8 ± 7.8	0.292	22.5 ± 6.4	21.0 ± 6.1	−1.6 ± 8.1	0.064	0.260
Dietary fiber (g)	22.8 ± 8.4	22.3 ± 9.2	−0.5 ± 7.8	0.645	23.9 ± 9.8	22.6 ± 8.7	−1.4 ± 11.5	0.253	23.9 ± 9.2	23.3 ± 8.4	−0.6 ± 9.2	0.590	0.780
Sodium (g)	3.5 ± 1.4	3.2 ± 1.3	−0.3 ± 1.4	0.158	3.5 ± 1.5	3.2 ± 1.0	−0.3 ± 1.6	0.094	3.6 ± 1.7	3.1 ± 1.0	−0.5 ± 1.5	0.011	0.505
Cholesterol (mg)	160.9 ± 96.0	155.0 ± 108.3	−5.9 ± 130.3	0.670	171.1 ± 106.2	160.9 ± 95.4	−10.1 ± 137.9	0.432	166.8 ± 104.8	143.8 ± 93.3	−22.9 ± 145.8	0.084	0.630
% Han-sik intake[3)]	77.5 ± 13.1	77.9 ± 12.7	0.3 ± 11.8	0.762	76.1 ± 12.0	77.2 ± 11.3	1.1 ± 12.4	0.311	76.0 ± 11.0	76.4 ± 13.5	0.4 ± 12.2	0.743	0.850
Adherence score to the Korean Food Guidance System[4)]													
Grains (%)	82.3 ± 35.9	73.6 ± 27.5	−8.8 ± 33.1	0.007	80.3 ± 28.4	78.6 ± 24.5	−1.7 ± 28.0	0.507	77.8 ± 24.7	73.3 ± 21.0	−4.5 ± 23.3	0.044	0.162
Meat·fish·eggs·beans (%)	93.8 ± 43.4	83.1 ± 44.7	−10.7 ± 52.7	0.035	93.4 ± 50.6	84.0 ± 45.1	−9.4 ± 60.0	0.085	88.9 ± 47.2	82.7 ± 37.0	−6.2 ± 55.6	0.238	0.827
Vegetables (%)	94.3 ± 45.1	94.8 ± 44.7	0.5 ± 47.2	0.912	98.8 ± 47.1	106.8 ± 124.4	7.9 ± 135.4	0.517	100.6 ± 51.3	87.3 ± 33.9	−13.2 ± 46.0	0.003	0.184
Fruits (%)	57.3 ± 53.9	56.9 ± 70.2	−0.4 ± 68.7	0.954	56.9 ± 56.0	49.3 ± 48.2	−7.6 ± 61.1	0.169	68.0 ± 71.7	62.6 ± 63.0	−5.4 ± 74.4	0.442	0.711
Milk·dairy products (%)	44.0 ± 64.2	44.3 ± 54.5	0.3 ± 68.0	0.966	51.0 ± 74.6	73.6 ± 60.2	22.6 ± 76.1	0.001	55.2 ± 66.4	55.4 ± 45.9	0.1 ± 71.9	0.983	0.023
Oils·fats·sugars (%)	123.6 ± 71.5	108.3 ± 71.7	−15.3 ± 70.8	0.025	133.6 ± 70.8	102.1 ± 65.6	−31.5 ± 68.5	< 0.0001	124.0 ± 64.6	93.7 ± 51.7	−30.3 ± 68.3	< 0.0001	0.149
Overall[5)]	42 (38.2)	30 (27.3)	−12 (−10.9)	0.070[6)]	40 (32.5)	57 (46.3)	17 (13.8)	0.022[6)]	44 (38.9)	57 (50.4)	13 (11.5)	0.058[6)]	0.001[7)]

Mean ± SD or n (%).

CG, control group with no intervention; HG, the nutrition education group for promoting the Han-sik consumption; EG, the nutrition education group for balanced diet; CHO, carbohydrate.

[1)]*P* from paired t-test in each three groups.

[2)]*P* from repeated ANOVA, group-by-time.

[3)]The percentage of Han-sik items of all consumed dish items using Han-sik database.

[4)]Adherence score to the Korean Food Guidance System (KFGS) was defined as the percentage of consumed daily servings from each food groups to the recommended servings of the KFGS for each age group by sex.

[5)]The number of participants whose intakes of food group meet three or more in the KFGS: 80% ≤ the adherence score of 'grains' and 'meat, fish, eggs, beans' < 120%, 80% ≤ the adherence score of 'vegetables', 'fruits', and 'milk, dairy products', and the adherence score of 'oils, fats, sugars' < 120%.

[6)]*P* from McNemar test.

[7)]*P* from chi-square test at the end of the nutrition education program.

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Table 4. The changes in anthropometric and serum biochemistry among three groups after nutrition education

	CG (n = 110)				HG (n = 123)				EG (n = 113)				$P^{2)}$
	Before	After	Difference	$P^{1)}$	Before	After	Difference	$P^{1)}$	Before	After	Difference	$P^{1)}$	
Anthropometry													
Weight (kg)	72.4 ± 12.5	72.0 ± 12.5	−0.3 ± 2.6	0.204	72.7 ± 13.0	72.2 ± 12.7	−0.5 ± 2.1	0.007	69.7 ± 11.6	69.8 ± 11.5	0.1 ± 1.7	0.592	0.097
Body mass index (kg/m^2)	26.7 ± 3.6	26.6 ± 3.7	−0.2 ± 0.9	0.080	26.3 ± 2.9	26.1 ± 2.7	−0.2 ± 0.8	0.002	25.9 ± 2.8	25.9 ± 2.9	0.0 ± 0.7	0.929	0.084
Waist circumference (cm)	90.3 ± 9.0	89.1 ± 8.9	−1.3 ± 2.8	< 0.0001	89.4 ± 8.0	88.0 ± 7.7	−1.3 ± 2.2	< 0.0001	88.4 ± 7.1	86.8 ± 6.6	−1.6 ± 2.8	< 0.0001	0.632
Lipid profile													
HDL cholesterol (mg/dL)	48.5 ± 11.7	48.9 ± 11.1	0.4 ± 7.6	0.600	51.6 ± 12.1	51.3 ± 12.4	−0.2 ± 8.5	0.751	50.9 ± 10.9	49.2 ± 10.4	−1.7 ± 8.3	0.037	0.162
LDL cholesterol (mg/dL)	130.3 ± 33.7	131.7 ± 34.9	1.4 ± 22.5	0.515	134.0 ± 40.9	132.4 ± 32.1	−1.6 ± 35.7	0.618	126.1 ± 33.4	126.9 ± 34.2	0.7 ± 28.6	0.785	0.715
Triglycerides (mg/dL)	219.1 ± 144.0	204.9 ± 152.8	−14.2 ± 139.8	0.290	175.0 ± 95.0	153.4 ± 75.8	−21.6 ± 76.2	0.002	182.6 ± 123.7	183.3 ± 121.9	0.7 ± 103.1	0.943	0.281
Blood pressure													
Systolic blood pressure (mmHg)	133.2 ± 18.1	132.4 ± 17.9	−0.8 ± 14.6	0.553	132.9 ± 17.1	129.5 ± 17.2	−3.4 ± 15.3	0.016	135.8 ± 16.4	130.8 ± 16.0	−5.0 ± 14.3	< 0.0001	0.106
Diastolic blood pressure (mmHg)	89.0 ± 12.0	86.9 ± 11.8	−2.2 ± 11.1	0.044	86.6 ± 12.3	84.0 ± 11.7	−2.6 ± 10.9	0.009	89.1 ± 11.3	84.8 ± 12.2	−4.3 ± 10.4	< 0.0001	0.277
Glucose homeostasis													
Fasting blood glucose (mg/dL)	101.4 ± 17.1	100.8 ± 17.6	−0.6 ± 10.2	0.539	101.7 ± 18.6	100.7 ± 14.3	−1.0 ± 10.5	0.289	102.4 ± 14.9	103.3 ± 19.2	1.0 ± 9.9	0.296	0.297
Insulin (μU/mL)	8.3 ± 7.6	8.5 ± 6.5	0.3 ± 9.1	0.753	7.5 ± 4.1	8.3 ± 7.3	0.8 ± 6.7	0.170	7.5 ± 7.0	8.0 ± 5.5	0.6 ± 8.8	0.488	0.873
HbA1c (%)	5.7 ± 0.8	5.6 ± 0.7	0.0 ± 0.3	0.189	5.6 ± 0.7	5.6 ± 0.6	0.0 ± 0.3	0.404	5.7 ± 0.6	5.7 ± 0.6	0.0 ± 0.3	0.403	0.256

Mean ± SD.

CG, control group with no intervention; HG, the nutrition education group for promoting the Han-sik consumption; EG, the nutrition education group for balanced diet, HDL, high-density lipoprotein; LDL, low-density lipoprotein; HbA1c, hemoglobin A1c.

1) P from paired t-test in each three groups.

2) P from repeated ANOVA, group-by-time.

had only one risk factor were increased after the nutrition education from 0% at baseline to 26.8% in HG, 26.6% in EG, and 19.1% in CG (data not shown).

DISCUSSION

In this study, four sessions of tailored nutrition education for HG and EG for managing metabolic syndrome risk factors during the 16 weeks were applied to middle-aged Korean adults. The tailored nutrition education not only resulted in decreasing prevalence of metabolic syndrome risk factors by improving adherence to the KFGS but also fostered healthier dietary behaviors among participants. The nutrition education program was designed to address metabolic syndrome risk factors through personalized dietary interventions based on individual dietary assessments. The HG and EG received nutrition education through meetings face-to-face with trained dietitians according to the study protocol. The HG received educational materials on menu planning methods based on KFGS using Han-sik, while the EG used examples based on KFGS using a regular diet.

After receiving nutrition education, beneficial changes in dietary intake were observed. For instance, nutrition education resulted in decreased intakes of 'oils, fats, sugars.' Results from previous studies showed that 'oils, fats, sugars' intake was associated with metabolic syndrome risk factors [22,23]. Given that high dietary fat intake would be expected to affect insulin sensitivity and the risk of developing type 2 diabetes, it seems crucial to emphasize not only reducing total fat intake but also considering the types of fats consumed in dietary recommendations [22]. Additionally, excessive consumption of sugar and sugar-sweetened beverages may be related to elevated glucose levels [23]. The adherence to 'milk, dairy products' increased significantly in HG after nutrition education (P < 0.001). The Han-sik list used in nutrition education was selected from a Han-sik perception survey [18,19]. Although the response rate for milk as Han-sik was lower than 25.0%, the HG was encouraged to consume one serving of milk per day for a balanced diet due to previous studies that have reported beneficial effects of milk and dairy products for reducing metabolic syndrome risk [24-29]. Beneficial associations of adherence to the recommendations

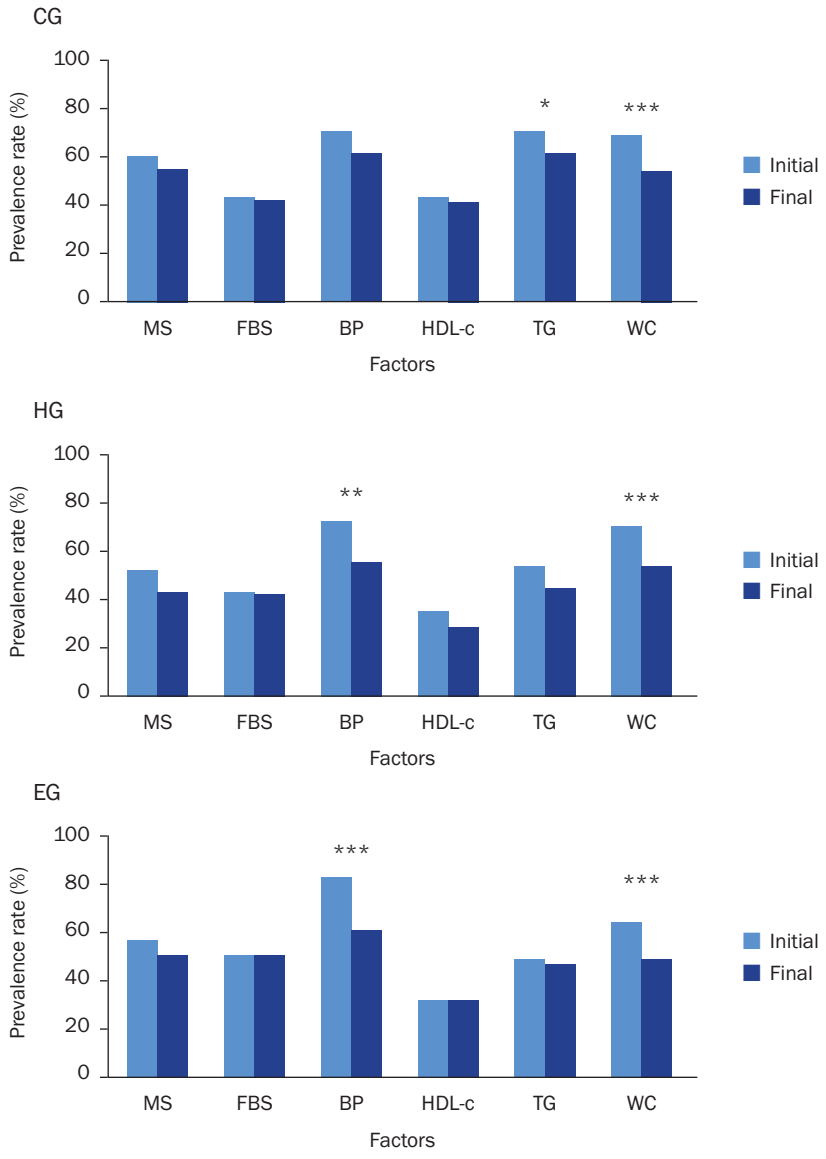

Fig. 3. The changes of prevalence of metabolic syndrome and its factors among three groups after nutrition education.
CG, control group with no intervention; HG, the nutrition education group for promoting the Han-sik consumption; EG, the nutrition education group for balanced diet; MS, metabolic syndrome; FBS, fasting blood glucose; BP, blood pressure; HDL-c, high-density lipoprotein-cholesterol; TG, triglyceride; WC, waist circumference.
MS, those who had three or more of the following five components; FBS (impaired blood glucose), fasting blood glucose ≥ 100 mg/dL; BP (elevated blood pressure) ≥ 130/85 mmHg; HDL-c (low HDL-cholesterol) < 50 mg/dL for women < 40 mg/dL for men; TG (hypertriglyceridemia) ≥ 150 mg/dL; WC (abdominal obesity) ≥ 85 cm for women ≥ 90 cm for men.
*P < 0.05, **P < 0.01, ***P < 0.001.

of 'milk, dairy products' with metabolic syndrome risk were observed in 596 Korean adults aged 30–59 years in a previous study [21].

At the end of the study, beneficial changes in anthropometric and serum biochemistry measurements were observed in both HG and EG. Body weight, body mass index, waist circumference, triglycerides, systolic and diastolic blood pressure were observed in HG. In EG, waist circumference, systolic and diastolic blood pressure decreased after nutrition education. The changes

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in metabolic syndrome risk factors were similar in both the HG and EG groups. This similarity may likely be attributed to the comparable nutrition education both groups received, aimed at preventing or managing metabolic syndrome risk factors. Specifically, the HG group benefited from increased consumption of Han-sik, while the EG group incorporated menu planning methods using a regular diet. Regarding Han-sik consumption, there was no significant increase in the Han-sik consumption rate following the nutrition education. However, it is noteworthy that the Han-sik consumption rate among the middle-aged Korean adults participating in this study remained high, comprising approximately 80% of their daily intake of dishes. The control group also showed some improvement in abdominal obesity and hypertriglyceridemia at the end of the study. Because all participants in this study might be motivated sufficiently to get a health examination by themselves three times.

A previous study conducted in Korea found that 10 women aged 50 to 60 years were divided into Han-sik and westernized Korean groups for two weeks of dietary intervention, and the Han-sik group downregulated eight plasma miRs associated with type 1 and type 2 diabetes [30]. However, this study differs from the previous study in that participants were not admitted to the hospital, engaged in their daily life, and provided nutritional counseling.

In a study conducted in foreign countries that did not consume Han-sik as the main meals, when providing Han-sik meals in 70 overweight or obese persons in Australia during 12 weeks, a significant decrease in waist circumference and fasting glucose was observed in the intervention group [31]. Another study using a randomized trial design assessed the effect of Korean diet, the 2010 Dietary Guidelines for Americans (DGA), and a typical American diet on caridometabolic risk factors reported that significant decrease of total cholesterol and LDL cholesterol in Korean diet and 2010 DGA groups among 31 overweight or obese adults in US [11].

Our study has several limitations. First, our nutrition education was only for four months, which may not be long enough to determine the intervention's effectiveness. When comparing the intervention group (HG and EG) and the control group, the differences in changes in dietary intakes and metabolic syndrome-related factors were smaller than those of the self-assessed dietary behavior changes. Secondly, this study focused on macronutrients and food group intakes in the nutrition education, which limited our ability to evaluate the effects of the nutrition education on the intakes of micronutrients such as vitamin D and folate. Third, this study was conducted using a selected sample living in a metropolitan area, and thus, the results may not be generalized to the Korean population as a whole. Nevertheless, the tailored nutrition education program for middle aged Korean adults showed beneficial effects on improving dietary behaviors and metabolic risk factors. Further studies are needed to assess the long-term effects of nutrition education programs on metabolic syndrome risks. Nutrition educations for various age groups are also required.

CONCLUSIONS

This study found that tailored nutrition education programs for middle-aged Korean adults showed beneficial effects on improving dietary behaviors and metabolic syndrome risk factors. Further studies are needed to assess the long-term effects of nutrition education programs on metabolic syndrome risks.

CONFLICT OF INTEREST

There are no financial or other issues that might lead to conflict of interest.

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DATA AVAILABILITY

Data sharing is not applicable.

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