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The effects of the DASH diet education program with omega-3 fatty acid supplementation on metabolic syndrome parameters in elderly women with abdominal obesity

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BACKGROUND/OBJECTIVES: The purpose of this study was to investigate the overall effects of a tailored Dietary Approaches to Stop Hypertension (DASH) nutritional intervention program which included omega-3 fatty acids supplementation, on dietary self-efficacy, dietary knowledge, and dietary behaviors in Korean elderly women with abdominal obesity. Furthermore, we investigated the effects of the program on metabolic syndrome parameters including the antioxidant capacities in these subjects.
SUBJECTS/METHODS: A randomized, controlled trial was conducted for 8 weeks. The experimental group (n = 21) received a weekly tailored nutritional program for 8 weeks and the control group (n = 18) received only one educational session. The clinical survey was conducted before and after the intervention period.
RESULTS: After the intervention, dietary self-efficacy ($P = 0.023$), frequency of fruit intake ($P = 0.019$), and dietary fiber intake ($P = 0.044$) were higher in the experimental group than in the control group. The oxidative stress ($P < 0.001$) was lower in the experimental group than in the control group. Moreover, low density lipoprotein (LDL) cholesterol ($P = 0.023$) had significantly decreased in the experimental group but not in the control group after the intervention.
CONCLUSIONS: The intervention program including omega-3 fatty acid supplementation had a positive effect on dietary self-efficacy, dietary behaviors, and oxidative stress among aged women with abdominal obesity.

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INTRODUCTION

The metabolic syndrome (MetS) is common in Korean elderly people [1]. MetS is defined as a cluster of glucose intolerance, hypertension, dyslipidemia and abdominal obesity with insulin resistance of pathogenesis [2]. Abdominal obesity accompanied by insulin resistance and low-grade inflammation is a key factor in the development of MetS [2]. Moreover, MetS has been known to be associated with development of type 2 diabetes, cardiovascular disease (CVD), and all-cause mortality [3], with a tendency to be found more so in women with abdominal obesity after menopause [1].

A previous study reported that the Dietary Approaches to Stop Hypertension (DASH), including a diet rich in fruits, vegetables, and low-fat foods, was effective in decreasing MetS risks [4], which may have been due to the improvement of the antioxidant status of the subjects with MetS [5,6]. It has been reported, however, that Korean elderly women consume a lower quantity of antioxidant nutrients than the recommended daily intake [7], particularly elderly women with low income or with poor dental status [8].

Insulin resistance and impaired glucose tolerance association with proinflammatory cytokines from adipocytes in abdominal obesity possibly accelerate loss of muscle mass and additional weight gain [2]. So, dietary pattern is important to prevent loss of muscle mass and decrease inflammation cytokines [9]. However, the Korean diet is traditionally high in plant protein like soybean and soy foods which tend to be deficient in a source of high-biological-value protein [9]. Therefore, consuming good quality protein such as milk products, non fatty meat, fish, or omega-3 (ω-3) fatty acid is important in the elderly [9], particularly so in postmenopausal women who have a reduced intake of vitamin A, C, E, and ω-3 fatty acid [10].

According to a previous study, daily supplementation with ω-3 fatty acid (1.8g) for 2 months reduced triglyceride levels (TG), an inflammation marker in postmenopausal women with type 2 diabetes [11]. The ω-3 fatty acid has been reported to decrease TG, platelet aggregation and adhesion, blood pressure, and levels of inflammation markers [12]. To date, however, no intervention studies have been performed to demonstrate the

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effects of the DASH diet education program on MetS in Korean elderly individuals. Since elderly women may have difficulties in correcting eating habits due to taste degradation [13] and poor dental condition, it may be necessary to supplement antioxidant nutrients such as vitamin A, C, E or ω-3 fatty acid to resolve MetS [10].

Providing a DASH diet education program with ω-3 fatty acid supplementation could possibly result in a synergistic action and exert beneficial effects on MetS. The addition of supplement such as ω-3 fatty acid enriched tomato juice or vegetable juice to DASH diet education were reported to be more effective on Mets parameters compared to the control group, who were served only DASH diet counseling [11,14]. We, therefore, investigated the effect of a tailored DASH nutritional intervention program, including supplementation with ω-3 fatty acid, on dietary knowledge, behaviors, metabolic syndrome parameters, low density lipoprotein (LDL) level and antioxidant capacity in Korean elderly women with abdominal obesity. We adapted self-efficacy promotion strategies that have been reported to be effective in changing the behavior of the elderly [15].

The purpose of the study was to investigate the effects of a tailored DASH nutritional intervention program, including ω-3 fatty acid supplementation, on dietary self-efficacy, dietary knowledge, dietary behaviors, MetS parameters and antioxidant capacity in Korean elderly women with abdominal obesity.

SUBJECTS AND METHODS

Study design

A randomized, controlled trial was conducted for 8 weeks at a local senior welfare center in Seoul. The tailored DASH nutritional intervention program consisted of DASH diet education with ω-3 fatty acid supplementation. For DASH diet education, we used sources of self-efficacy, which consisted of verbal persuasion, improvement of both physical and emotional states, mastery experience, and social modeling (Table 1) [15].

Subjects

The institutional review board at Seoul National University approved the study (2011-64). Subjects from a local senior welfare center who wished to participate in the study were enrolled on a voluntary basis after seeing the advertisement posted at the center. Informed consent was obtained from the participants before commencement of the study. The inclusion criteria were women, aged ≥ 60, and waist circumference (WC) ≥ 85 cm. We included women, aged ≥ 60 since the previous study reported that those over 60 years old with abdominal obesity were more likely to have higher TG than those without [16] and the Korean national pension uses criteria for elderly as > 60 years old [17]. Subjects already diagnosed with diabetes mellitus (DM) or CVD were excluded since they may have difficulties in changing dietary behavior. The subjects were also excluded if they had dementia severe enough to preclude a reliable interview, which was determined by the Korean version

Table 1. Tailored nutritional intervention program used in the study

Session	Source of self-efficacy	Contents of the intervention
1	Improving physical and emotional states Mastery experience	• Introduce the program and make a plan with the participants. • Provide ω-3 fatty acid capsules.
2	Improving physical and emotional states Verbal persuasion	• Provide individual telephone counseling before attending that day.† • Assess ω-3 fatty acid side effects and provide ω-3 fatty acid capsules.† • Education on metabolic syndrome.
3	Verbal persuasion	• Explain the blood and physical examination results.
4	Verbal persuasion	• Provide information about their nutrient intakes. • Provide information about their nutrient status. • Compare their nutrient intakes to the recommended values. • Encourage them to eat nutrients they are deficient in. • Provide information about the national food support program.
5	Mastery experience Verbal persuasion	• Let the participants express their achievements. • Educate them about the DASH diet. • Educate them about the DASH guidelines. - Practice choosing a preferred food among various suggestions. - Suggest desirable cooking methods. • Verify barriers to their diet. • Educate them about the good and bad side of holiday foods. • Set up goals using the DASH diet guideline by themselves.
6	Mastery experience Verbal persuasion Social modeling	• Let the participants express their achievements. • Practice the DASH diet menu configuration. • Form supportive relationships.
7	Mastery experience Verbal persuasion	• Let the participants express their achievements. • Set up strategies for the DASH diet compliance through the researcher and participant. - Check their actual food items from shopping. - Provide individual feedback about the items and the way to overcome barriers. - Provide 'dietary management for metabolic syndrome' flier and ask them to place it on their home refrigerator.
8	Verbal persuasion Mastery experience	• Let the participants express their dietary changes after attending the program. • Provide information on foods rich in ω-3 fatty acid.
Completion	Mastery experience	• Compare pre- and post-results.

† Repeated for weeks 2 to 8.

of the Mini Mental State Examination (MMSE) [18].

Study procedures

This study was an 8-week parallel-group randomized controlled trial. The data was collected between January and March 2012.

The experimental group received an individualized weekly DASH nutritional education including ω-3 fatty acid supplementation (Chong Kun Dang Healthcare, premium omega-3 gold, 20 kcal, ω-3 fatty acids 1.008 g, 0.2% vitamin E) in a welfare center for 15 minutes. The ω-3 fatty acid supplements were packed and given to the participants after the education program every week. The participants were advised to take the ω-3 fatty acids and then asked to report any side effects such as abdominal discomfort. To monitor their compliance, the subjects were told to bring any remaining pills back to be counted.

The control group received only one educational session regarding the DASH diet and metabolic syndrome on the 4th week for an hour. The ω-3 fatty acid supplements were given after the study was over.

The interview was performed by the researchers and research assistants before and after the intervention period. One-on-one interviews with the subjects were performed. To increase the inter-rater's reliability of assessments, a formal training session was held prior to the interviews. Subsequently, each rater's initial interview sessions were supervised at the data collection site by the author, and any disagreements were resolved by discussion.

Measurements

The subjects were interviewed using a structured questionnaire to obtain sociodemographic and lifestyle data, including age, family structure (living alone/living with other family members), years of formal education (0/1-6/7-9/10-13/≥ 4), economic status determined by national basic livelihood security recipient status (yes/no), job status (yes/no), current smoking (yes/no), current drinking (yes/no), current medication (antihypertensive drugs, antihyperlipidemic drugs, thyroid hormones), oral health status [(missing teeth (yes/no), and chewing difficulty (yes/no)].

Dietary self efficacy

Dietary self-efficacy is defined as an individual's belief in his or her ability to exhibit a particular dietary behavior even in a challenging situation [19]. In the present study, the Child Dietary Self-efficacy Scale (CDSS) Questionnaire was modified to measure dietary self-efficacy [20]. It consisted of a 4-point Likert scale that assesses usual habits (4 items) and food choices (3 items), with higher scores indicating greater self-efficacy (0-28 points, Cronbach's $\alpha = 0.74$).

Diet knowledge

Diet knowledge was measured with a DASH diet knowledge scale, which consisted of 10 items (0-10 points, Cronbach's $\alpha = 0.80$) [21].

Dietary behaviors

Dietary behaviors were evaluated within 3 categories: DASH diet compliance, food consumption, and nutrient intake. The DASH diet compliance scale consisted of a 5-point Likert scale (9 items)(9-45 points, Cronbach's $\alpha = 0.63$), with higher scores indicating better compliance.

To obtain the data on food consumption and nutrient intake, 3-day dietary record was adopted. At the time of enrollment, participants received detailed written direction for 3-day dietary record (2 weekdays, 1 weekend day or holiday). Using food models and a portion-size booklet that included common Korean foods, utensils, and portion sizes to represent the amount of food intake, the subjects were instructed how to complete the dietary record. The participants were asked to write down all the foods and drinks consumed during the 3 days, from the first to the last item consumed before going to bed and were asked to bring 3 days of food diaries on the data collection day. At the time of the data collection, the researchers and a dietician confirmed all the food records. When there were any doubts about said data, family members who lived with the participants were called to verify the food records ($n = 3$).

Based on this data, 4 food item consumption quantities (milk or dairy products ≥ once a day, soy or egg ≥ twice a week, meat or fish or chicken ≥ once a day, vegetable or fruit were frequency per week) were also recorded [22,23].

The average daily intake of nutrients from food (total calories, protein, lipids, carbohydrate, calcium, eicosapentaenoic acid [EPA], docosahexaenoic acid [DHA]) were also calculated by a computer-aided nutrition analysis program (CAN Pro) 3.0 [24]. A deficient intakes of each nutrient such as calcium, vitamin A, vitamin B_6, vitamin C, folate, dietary fiber, and potassium was defined when the subjects took in < 75% of its corresponding Korean dietary reference intake (DRI) [24]. A excess intake of sodium was defined by more than the Korean dietary reference intake [24,25].

MetS parameters

The MetS parameters consisted of diagnostic criteria of MetS. Other variables which were reported to be well correlated with MetS were also measured [5,26]. The diagnostic criteria of MetS, included waist circumference (WC) (≥ 85 cm), serum high density lipoprotein (HDL) (< 50mg/dL), TG (≥ 150 mg/dL), fasting blood glucose (FBS) (≥ 100 mg/dL), and systolic blood pressure (SBP) ≥ 130 mmHg or diastolic blood pressure (DBP) ≥ 85 mmHg or administration of an antihypertensive drug [1]. The other variables included LDL, the ferric reducing ability of plasma (FRAP) for antioxidant capacity, and thiobarbituric acid reactive substance (TBARS) for oxidative stress.

WC was measured based on the average of two measurements taken after inspiration and expiration at the midpoint between the lowest rib and the iliac crest [1]. To determine the BMI, each participant's height and weight were measured (DS-102, Dong Sahn Jenix, Seoul, Korea) (kg/m^2).

The participant's blood pressure was taken in the upper arm at the level of the heart, with the subject seated comfortably over 10 minutes (FT-500, Jawon Medical, Gyeongbuk, Korea) [1].

Fasting blood samples were collected from each participant. After separating the serum by centrifugation, they were sent to Eone-laboratory (Incheon, Korea) to measure TG, HDL, FBS, and LDL by enzymatic colorimetric assay. We measured FRAP for antioxidant capacity and TBARS for oxidative stress. Briefly, FRAP reagent (24.609 g of sodium acetate buffer pH 3.6, 2.5 ml of 10 mM 2,4,6-tri(2-pyridil)-s-triazine (TPTZ) in 40 mM HCl, 20 mM ferric chloride solution) were mixed with 30 μl of plasma diluents. After a 15 min of incubation at 37°C, absorbance was read at 593 nm. FRAP values were measured by detection of the absorbance change of test sample as the reducing power of antioxidants present in the plasma comparing with that of trolox standard [27]. TBARS levels ware measured by a fluorometic method [28] and were expressed as an malondialdehyde (MDA) amount, using a freshly diluted malondialdehyde bisdimethylacetal as the standard. The absorbance of the supernatant was measured at 532 nm [28].

Statistical analyses

Statistical analyses were performed using the SPSS software package (version 18.0 for Windows, SPSS, Chicago, IL, USA). The reliability of the scales was assessed by Cronbach's alpha. A *t*-test was used to compare continuous variables whereas a χ^2-test was used to compare the categorical data sets.

Data regarding pre- and post-intervention were compared using a McNemar test and paired *t*-test. The level of statistical significance was set at $P < 0.05$.

RESULTS

General characteristics of the subjects

Of the initial 67 subjects, 25 were excluded ($n = 6$, history of DM; $n = 7$, history of CVD; $n = 2$, dementia; $n = 2$, refusal of blood sampling; $n = 8$, involvement in another research project). The remaining 42 participants were randomly assigned to the experimental ($n = 21$) and control ($n = 21$) groups by the SPSS program.

Within the control group, 3 participants did not complete the study ($n = 1$, operation; $n = 2$, refusal of blood sampling). All of the subjects in the experimental group completed the study.

In the experimental group, the compliance rate of ω-3 fatty acid intake was 92.8% with no report of side effects. The amount of unsaturated fatty acids from ω -3 fatty acid supplements was not included in the nutrient intake analysis.

Before the intervention, the experimental and control groups did not differ in terms of demographic characteristics. The characteristics of the participants in two groups are shown in Table 2.

Dietary self-efficacy, diet knowledge, and dietary behaviors

After the intervention, dietary self-efficacy ($P = 0.002$) and DASH diet compliance ($P = 0.003$) were increased as compared to the baseline in the experimental group but not in the control group, although DASH diet knowledge was increased in both groups ($P = 0.013$, $P = 0.036$) (Table 3). Dietary self-efficacy was higher in the experimental group than in the control group ($P = 0.023$) whereas no statistical significance in DASH diet compliance was observed between the groups ($P = 0.127$) (Table 3). Among the food consumption, only fruit consumption was higher in the experimental group than in the control group

Table 2. Homogeneity test of clinical characteristics

Variables	Category	Exp. ($n = 21$)	Con. ($n = 18$)	χ^2/t	*P*-value
		N (%) or mean ± SD	*N* (%) or mean ± SD		
Age	Mean	73.0 ± 3.9	73.8 ± 5.8	-0.50	0.621
BMI (kg/m^2)	Mean	25.6 ± 2.5	25.3 ± 2.2	0.40	0.693
	< 23.0	3 (14.3)	3 (16.7)	0.16	0.922
	23.0-24.9	5 (23.8)	5 (27.8)		
	≥ 25.0	13 (61.9)	10 (55.6)		
Living alone	Yes	9 (42.9)	10 (55.6)	5.76	0.330
Years of formal education	0	2 (9.5)	5 (27.8)	3.21	0.524
	1-6	12 (57.1)	8 (44.4)		
	7-9	4 (19.0)	4 (22.2)		
	10-13	2 (9.5)	1 (5.6)		
National Basic Livelihood Security recipient (social safety net recipient status)	Yes	8 (38.1)	6 (33.3)	0.09	1.00
Job status	Yes	5 (23.8)	1 (5.6)	2.48	0.190
Current smoking	Yes	0 (0.0)	1 (5.6)	1.20	0.462
Current drinking	Yes	0 (0.0)	3 (17.6)	4.02	0.081
Current medication	Antihypertensive drug	9 (42.9)	10 (58.8)	0.63	0.527
	Antihyperlipidemic drug	4 (19.0)	2 (11.1)	0.47	0.667
	Thyroid hormone agent	3 (14.3)	0 (0.0)	2.79	0.235
Oral index	Missing teeth (yes)	13 (61.9)	13 (72.2)	0.46	0.734
	Chewing difficult (yes)	6 (28.6)	7 (38.9)	0.46	0.520
Physical activity (Mets/week)	Mean	2973.2 ± 3.0	2673.2 ± 3.3	0.30	0.768
	HEPA active	8 (38.1)	6 (33.3)	0.20	0.905
	Minimally active	9 (42.9)	9 (50.0)		
	Non-active	4 (19.0)	3 (16.7)		

Exp = experimental group; Con = control group; SD = standard deviation; HEPA = Health Enhancing Physical Activity; Mets = metabolic equivalents

Table 3. Group Differences in dietary self-efficacy, knowledge, and behaviors

Characteristics	Group	Pre test	Post test	*Paired-t* (*P*-value)	Differences	*t* (*P*-value)
		Mean ± SD	Mean ± SD		Mean ± SD	
Dietary self-efficacy	Exp. (*n* = 21)	21.9 ± 3.3	24.3 ± 2.2	-3.63 (0.002)	-2.5 ± 3.1	-2.37 (0.023)
	Con. (*n* = 18)	21.3 ± 3.7	21.3 ± 3.0	0.00 (1.00)	0.0 ± 3.4	
Dietary knowledge						
DASH diet knowledge	Exp. (*n* = 21)	5.3 ± 3.2	7.2 ± 1.3	-2.72 (0.013)	-1.9 ± 3.3	-0.59 (0.561)
	Con. (*n* = 18)	5.4 ± 2.5	6.8 ± 1.3	-2.27 (0.036)	-1.4 ± 2.6	
Dietary behaviors						
DASH diet compliance	Exp. (*n* = 21)	32.0 ± 3.4	35.3 ± 3.6	-3.37 (0.003)	-3.3 ± 4.5	-1.56 (0.127)
	Con. (*n* = 18)	30.3 ± 6.0	31.3 ± 5.3	-0.89 (0.388)	-1.0 ± 4.8	
Food consumption						
Vegetables (frequency)	Exp. (*n* = 21)	5.1 ± 2.5	4.6 ± 2.2	0.73 (0.473)	0.5 ± 3.0	-0.57 (0.574)
	Con. (*n* = 18)	5.2 ± 4.5	4.1 ± 2.4	1.08 (0.294)	1.2 ± 4.6	
Fruits (frequency)	Exp. (*n* = 21)	5.7 ± 2.0	5.5 ± 2.3	0.30 (0.769)	0.1 ± 2.2	-2.49 (0.019)
	Con. (*n* = 18)	5.1 ± 2.4	2.6 ± 2.5	3.04 (0.007)	2.6 ± 3.6	
Nutrient intakes						
Calorie (kcal)	Exp. (*n* = 21)	1457.0 ± 350.4	1394.3 ± 407.4	0.78 (0.446)	62.7 ± 369.2	-0.66 (0.512)
	Con. (*n* = 18)	1378.7 ± 377.4	1230.9 ± 360.5	1.45 (0.166)	147.8 ± 433.7	
Protein (g)	Exp. (*n* = 21)	55.2 ± 16.9	54.2 ± 18.2	0.37 (0.718)	1.0 ± 12.8	-0.79 (0.435)
	Con. (*n* = 18)	52.6 ± 14.4	47.3 ± 17.1	1.08 (0.295)	5.3 ± 21.0	
Lipid (g)	Exp. (*n* = 21)	31.2 ± 13.3	32.7 ± 12.7	-0.64 (0.532)	-1.6 ± 11.2	-1.00 (0.325)
	Con. (*n* = 18)	28.7 ± 13.1	25.6 ± 12.3	0.74 (0.467)	3.1 ± 17.6	
Carbohydrate (g)	Exp. (*n* = 21)	239.4 ± 60.0	223.7 ± 65.9	1.02 (0.321)	15.6 ± 70.2	-0.55 (0.584)
	Con. (*n* = 18)	230.9 ± 68.5	203.3 ± 58.5	1.82 (0.086)	27.6 ± 64.3	
Calcium (mg)	Exp. (*n* = 21)	469.9 ± 187.6	493.7 ± 222.9	-0.48 (0.635)	-23.7 ± 225.6	-0.50 (0.619)
	Con. (*n* = 18)	384.9 ± 136.4	371.6 ± 170.9	0.24 (0.812)	13.3 ± 234.7	
20:5 EPA (mg)	Exp. (*n* = 21)	86.1 ± 17.3	187.5 ± 194.0	-1.57 (0.132)	-101.4 ± 296.2	0.18 (0.859)
	Con. (*n* = 18)	161.1 ± 322.6	386.7 ± 378.4	-1.82 (0.084)	-116.7 ± 223.7	
22:6 DHA (mg)	Exp. (*n* = 21)	22.7 ± 60.5	139.4 ± 203.2	-2.21 (0.041)	-225.6 ± 568.9	0.09 (0.930)
	Con. (*n* = 18)	38.9 ± 98.2	278.7 ± 382.0	-2.45 (0.025)	-239.8 ± 414.8	

Exp = experimental group; Con = control group; Differences = differences (Pre-Post); SD = standard deviation; DASH = dietary approaches to stop hypertension; EPA = eicosapentaenoic acid; DHA = docosahexaenoic acid

Table 4. Comparison of the groups' Food consumption and Nutrient intakes

Characteristics	Time	Exp. (*n* = 21)	Con. (*n* = 18)	χ^2	*P*-value
		N (%)	*N* (%)		
Food consumption					
Dairy products (yes)	Pre	11 (52.4)	10 (55.6)	0.04	0.549
	Post	13 (61.9)	7 (38.9)	2.06	0.133
Soy or egg (yes)	Pre	19 (90.5)	16 (88.9)	0.03	0.636
	Post	19 (90.5)	13 (72.2)	2.19	0.144
Meat or fish or Chicken (yes)	Pre	2 (9.5)	4 (22.2)	1.20	0.258
	Post	3 (14.3)	0 (0.0)	2.79	0.146
Nutrient intakes					
Calcium Def (yes)	Pre	14 (66.7)	15 (83.3)	1.41	0.207
	Post	12 (57.1)	15 (83.3)	3.12	0.077
Vitamin A Def (yes)	Pre	8 (38.1)	9 (50.0)	0.56	0.336
	Post	9 (42.9)	10 (55.6)	0.63	0.320
Vitamin B_6 Def (yes)	Pre	3 (14.3)	4 (22.2)	0.42	0.682
	Post	3 (14.3)	4 (22.2)	0.42	0.409
Vitamin C Def (yes)	Pre	4 (19.0)	5 (27.8)	0.42	0.706
	Post	10 (47.6)	11 (61.1)	0.71	0.302
Folate Def (yes)	Pre	17 (81.0)	14 (77.8)	0.06	0.558
	Post	14 (66.7)	14 (77.8)	0.59	0.342
Fiber Def (yes)	Pre	5 (23.8)	6 (33.3)	0.04	0.723
	Post	4 (19.0)	9 (50.0)	4.18	0.044
Potassium Def (yes)	Pre	16 (76.2)	14 (77.8)	0.01	0.605
	Post	13 (61.9)	15 (83.3)	2.20	0.130
Sodium Exc (yes)	Pre	21 (100.0)	18 (100.0)		
	Post	21 (100.0)	18 (100.0)		

Exp = experimental group; Con = control group; Def = deficiency; Exc = Excess.

Table 5. Group Differences in MetS parameters

Characteristics		Group	Pre test	Post test	*Paired-t* (*P*-value)	Differences	*t* (*P*-value)
			Mean ± SD	Mean ± SD		Mean ± SD	
WC	(cm)	Exp. (*n* = 21)	88.8 ± 4.8	89.0 ± 6.2	-0.20 (0.842)	-0.2 ± 4.3	0.33 (0.743)
		Con. (*n* = 18)	89.5 ± 3.3	90.1 ± 3.6	-0.75 (0.466)	-0.6 ± 3.5	
FBS	(mg/dl)	Exp. (*n* = 21)	101.2 ± 10.0	103.1 ± 11.0	-1.51 (0.146)	2.0 ± 5.9	-0.69 (0.495)
		Con. (*n* = 18)	106.3 ± 11.9	109.9 ± 14.5	-1.70 (0.107)	3.6 ± 9.0	
HDL	(mg/dl)	Exp. (*n* = 21)	51.1 ± 11.0	49.1 ± 9.9	1.60 (0.126)	2.1 ± 6.0	0.66 (0.511)
		Con. (*n* = 18)	55.1 ± 11.6	54.7 ± 14.9	0.14 (0.887)	0.3 ± 10.1	
TG	(mg/dl)	Exp. (*n* = 21)	172.5 ± 83.5	117.1 ± 54.0	5.10 (< 0.001)	55.4 ± 49.8	1.63 (0.112)
		Con. (*n* = 18)	168.3 ± 76.1	139.2 ± 79.2	2.43 (0.027)	29.1 ± 50.9	
BP	SBP (mmHg)	Exp. (*n* = 21)	135.5 ± 13.4	130.5 ± 14.7	1.91 (0.071)	5.0 ± 12.0	0.39 (0.698)
		Con. (*n* = 18)	136.4 ± 13.5	133.1 ± 13.6	0.97 (0.346)	3.3 ± 14.6	
	DBP (mmHg)	Exp. (*n* = 21)	79.8 ± 11.4	75.5 ± 9.4	1.55 (0.137)	4.2 ± 12.5	1.25 (0.219)
		Con. (*n* = 18)	77.1 ± 9.2	77.4 ± 10.2	-0.14 (0.888)	-0.3 ± 9.9	
LDL	(mg/dl)	Exp. (*n* = 21)	112.1 ± 31.2	105.0 ± 37.2	2.46 (0.023)	7.1 ± 13.2	1.52 (0.136)
		Con. (*n* = 18)	113.2 ± 27.6	115.3 ± 28.5	-0.38 (0.706)	-2.2 ± 24.0	
FRAP	(μmol/L)	Exp. (*n* = 21)	0.37 ± 0.08	0.36 ± 0.09	0.18 (0.855)	0.0 ± 0.08	0.30 (0.765)
		Con. (*n* = 18)	0.35 ± 0.08	0.36 ± 0.09	-0.26 (0.801)	-0.0 ± 0.06	
TBARS	(μmol/L)	Exp. (*n* = 21)	6.40 ± 1.11	4.76 ± 1.81	4.56 (< 0.001)	1.7 ± 1.7	3.13 (0.004)
		Con. (*n* = 18)	6.23 ± 1.34	6.47 ± 2.48	-0.50 (0.627)	-0.2 ± 2.1	

Exp = experimental group; Con = control group; Differences = differences (Pre-Post); SD = standard deviation; WC = waist circumference; FBS = fasting blood glucose; HDL = high density lipoprotein; TG = triglyceride; SBP = systolic blood pressure; DBP = diastolic blood pressure; BP = blood pressure; LDL = low density lipoprotein; FRAP = ferric reducing ability of plasma; TBARS = thiobarbituric acid reactive substance.

($P = 0.019$) (Table 3). Among the nutrient intake, the deficiency rate was only lower in dietary fiber intake in the experimental group opposed to that in the control group ($P = 0.044$) whereas other nutrient intake levels did not differ between the groups (Table 4). Sodium intake was three times in excess of the Dietary Reference Intakes for Koreans (KDRI's) [29] in both groups at baseline and after the intervention (Table 4).

MetS parameters

TBARS was significantly lower in the experimental group than in the control group ($P = 0.004$) although no differences were found in FRAP after the intervention (Table 5). In the experimental group, the TG and LDL levels were lower after the intervention than before the intervention ($P < 0.001$, $P = 0.023$, respectively) (Table 5). No statistical differences were found in WC, FBS, HDL, TG, and BP between the two groups before and after the intervention (Table 5).

DISCUSSION

The purpose of this study was to investigate the effects of a tailored DASH nutritional education program including ω-3 fatty acid supplementation on MetS parameters in Korean elderly women with abdominal obesity.

We found that our intervention program was effective in increasing dietary self-efficacy and dietary behaviors. This is in agreement with a previous study suggesting that dietary compliance can be improved not just by obtaining dietary knowledge but also by increasing dietary self-efficacy [15]. The positive effect of the program may also have been due to the continuous verbal persuasion, improved physical and emotional states, and mastery experience. On the other hand, we found that dietary knowledge was increased but dietary self-efficacy and DASH diet compliance did not increase in the control group. One educational session given to the control group may have not been enough to increase dietary self-efficacy and compliance even though dietary knowledge was increased in these subjects.

We found that the TG and LDL levels had decreased in the experimental group after the intervention. It may have been due to several factors. First, ω-3 fatty acid supplementation may have improved the blood lipid profile. A previous study reported that ω-3 fatty acid decreased TG and LDL by inhibiting the enzyme 3-hydroxy-3methylglutaryl coenzyme A reductase, the rate-limiting enzyme in cholesterol synthesis [12]. Secondly, increased dietary intake of DHA in the experimental group may have played a role in decreasing TG, by modulating the degradation of chylomicron by activating lipoprotein lipase [30]. Interestingly, we also found increased dietary DHA intake with decreased TG in the control group as well.

Finally, increased dietary fiber intake in the experimental group may also have activated the bile acid metabolism, and altered serum sex hormone concentrations, which could have affected lipid metabolism [31].

We found that serum TBARS was also lower in the experimental group than in the control group. Serum TBARS, which is an indicator of oxidative stress, is considered to play an important role in the pathogenesis of diabetes-induced CVD, which is invariably associated with an abnormal blood lipid profile, insulin resistance, and metabolic syndrome [32]. The decrease in serum TBARS is probably attributable to the increased fruit consumption as well as the ω-3 fatty acid supplementation. The carotenoids and phenolic molecules contained in fruit are known to reduce oxidative stress [33]. Although the antioxidant effects of ω-3 fatty acids are not as clear as fruits, ω-3 fatty acids have been reported to reduce the circulating serum LDL cholesterol that carries cholesterol into the bloodstream to oxidized LDL (LDL_{ox}) [34] and then reduce the oxidative stress in the adipose tissue [30]. The low TBARS in the experimental group may also have been due to Vit E contained in ω-3 fatty acids, although Vit E dose (0.2%) was minute. We do not have a clear explanation regarding why no significant difference in the FRAP level was found in the two groups. It could be attributed to the old age of our subjects since the elderly tend to have decreased levels of antioxidant capacity and activation of antioxidant enzymes [35]. It may also have been due to the low dosage of ω-3 fatty acids. Previously, it was found that a high dose (3 g/day) of ω-3 fatty acid capsule supplementation for 2 months increased circulating glutathione peroxidase and superoxide dismutase activity in addition to increasing FRAP and reducing serum malondialdehyde concentrations [32].

We found, however, that BP was not decreased in the experimental group after the intervention although the DASH diet has been known to lower BP [36]. This discrepancy may be due to the following factors: First of all, many of our subjects were already taking antihypertensive drugs (experimental group, $n = 9$, 42.9%; control group, $n = 10$, 58.8%), so the effects of education may have been limited. In further analysis, we found that BP in the patients who were not taking antihypertensive drugs decreased in the experimental group to a marginally significant level ($P = 0.09$), whereas no changes in BP were found in the control group.

Secondly, the calcium and potassium intake levels, which were reported to promote sodium excretion, did not increase in our study [36]. Upon further analysis, we found that the experimental group had increased their frequency of dairy intake ($P = 0.007$); However, this may have not been sufficient to increase their calcium intake significantly. Actually, the average calcium intake of the experimental group was 493.7 mg, which was far less than the recommended daily intake of 700 mg [29].

On the other hand, the lack of an increase in potassium intake may have been related to the data collection season, which happens to be the winter, when fruit and vegetable prices are higher than during other seasons [37]. Moreover, many subjects in our study were of low economic status (National Basic Livelihood Security recipient, 38%), likely limiting their ability to purchase fresh fruits and vegetables. Thirdly, the lack of a decrease in BP may have been due to a high quantity of sodium consumption. The amount of sodium intake in the control and experimental groups was higher than the recommended daily intake both before and after the intervention. This was an unexpected result since the participants were instructed to limit their intake of soup or stew, and were encouraged to increase their raw vegetable intake. Considering the fact that it is difficult to change dietary habits in the elderly due in part to the decreased number of taste buds, and decreased salt-taste acuity [38], strategies to increase calcium and potassium intake rather than decrease sodium intake may need to be developed. Finally, since we did not investigate the level of physical activity in these patients, we cannot rule out the possibility of a positive relationship between low physical activity and the lack of a change in the BP in these groups.

Our study has a number of strengths. This is the first attempt to investigate the effects of the DASH nutritional program with ω-3 fatty acid supplementation on MetS parameters including antioxidant capacity. Our study also included self-efficacy and dietary behaviors as mediating factors for measuring outcomes which were MetS parameters and other related variables such as LDL, TBARS and FRAP. Nonetheless, our study has several limitations. First, we cannot determine whether the decrease in TG and oxidative stress was due to the effects of the ω-3 fatty acid supplementation or the DASH diet. It may have been due to the synergistic action of our DASH educational program and ω-3 fatty acid supplementation. Previously, amelioration of CVD risk factors was observed following the intake of ω-3 fatty acid enriched juice after previous plain juice consumption [10]. Secondly, our results cannot be generalized for all elderly Koreans. Although the study subjects were recruited on a voluntary basis, our subjects were healthier than the general elderly population.

In conclusion, the DASH diet intervention program including ω-3 fatty acid supplementation had positive effects: increasing dietary self-efficacy, improving dietary behaviors, decreasing LDL, and decreasing oxidative stress among aged women with abdominal obesity.

Future research should focus on the long-term effect of a dietary education program and ω-3 fatty acid supplementation on MetS parameters in elderly and further identify the mechanisms of decreased oxidative stress in these subjects.

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