Received: 22 January 2017 | Revised: 23 July 2017 | Accepted: 24 July 2017
DOI: 10.1111/nhs.12375

WILEY Nursing & Health Sciences

RESEARCH ARTICLE

Autonomy-supportive, Web-based lifestyle modification for cardiometabolic risk in postmenopausal women: Randomized trial

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Funding information
the National Research Foundation of Korea , Grant/Award number: NRF-2012R1A1A2003112; Ministry of Science, ICT, and Future Planning of the Republic of Korea

Abstract
The management of cardiometabolic risk factors, such as abdominal obesity, dyslipidemia, hypertension, and hyperglycemia, is essential for the health of postmenopausal women. In this study, we identified the effects of autonomy-supportive, Web-based lifestyle modification for the management cardiometabolic risk of postmenopausal women, and assessed the mediation effect of intrinsic motivation. This study was a randomized trial involving 71 postmenopausal Korean women. For the intervention group, we provided the Web-based autonomy supports for 12 weeks; however, for the control group, individual consultations on healthy lifestyle was conducted at the first meeting. In the intervention group, cardiometabolic risks ameliorated as follows: waist circumference and waist-to-height ratio decreased by 3.9 cm and 0.03 cm, respectively; triglycerides decreased by 8.5 mg/dl; triglycerides-to-high-density-lipoprotein cholesterol ratio decreased by 0.21; systolic blood pressure decreased by 3.3 mmHg, and the visceral adiposity index decreased. Among the subdomain of intrinsic motivation, perceived competence, effort/importance, and perceived choice showed an association with waist circumference changes. Web-based autonomy supports can be effective in implementation and maintenance, and the amelioration of cardiometabolic risk in postmenopausal women.

KEYWORDS
autonomy support, cardiometabolic risk, Korea, postmenopausal women, self-management, Web-based lifestyle modification

1 | INTRODUCTION

Chronic conditions, such as obesity, metabolic syndrome, and cardiovascular diseases, have a high prevalence in postmenopausal women; women in their 60s have a higher prevalence compared to those in their 50s (Kim & Kim, 2013). Considering that the average age for menopause is 49.3 years (Pyun et al., 2014), this higher prevalence of chronic conditions in the 60s suggests that the first 10 years after menopause is an important period for middle-aged women's health (Lobo et al., 2014).

Postmenopausal women have a high risk of abdominal obesity due to a deficiency of ovarian hormones (Meyer, Clegg, Prossnitz, Barton, 2011). The accumulation of fat in the abdomen is a major factor in increasing blood pressure and insulin resistance, which can progress to type 2 diabetes (Bonneau, Pedrozo, Berg, 2014; Chedraui et al., 2013). After menopause, low-density lipoprotein cholesterol (LDL-C) elevates with increasing abdominal circumference, while the ratio of high-density lipoprotein cholesterol (HDL-C) to LDL-C decreases (Franklin, Ploutz-Snyder, Kanaley, 2009).

Cardiometabolic risk factors (CMRF), such as abdominal obesity, dyslipidemia, hypertension, and hyperglycemia, are predictive factors for cardiovascular disease (Brunzell et al., 2008). The management of CMRF is essential for the health of postmenopausal women. Strategies to improve lifestyle habits, including an increase in physical activity and a balanced diet, are more effective than focusing on reducing body weight or waist circumference for CMRF management (Ross & Bradshaw, 2009). However, lifestyle habits formed over a long period are difficult to change, and continuous efforts and attention are required.

Lifestyle-modification programs that use the Internet or phones are being suggested as effective interventions, which can be provided to multiple people, irrespective of time and place (Webb, Joseph, Yardley, Michie, 2010). Additionally, for the integration of a healthy lifestyle, autonomy supports would be more effective strategies than external regulations (Tandon, Sharma, Mahajan, Mahajan, 2014).

The self-determination theory (SDT) can be a theoretical basis for autonomy supports. The SDT, a general theory of human motivation (Deci & Ryan, 2000), assumes that humans are dynamic organisms innately oriented to personal growth and well-being. It focuses on the extent to which a person's behavior is self-determined (e.g. autonomous) versus controlled. The SDT views perceived autonomy, competence, and relatedness as fundamental psychological needs (Deci & Ryan, 2000). Healthcare climates that support those needs facilitate the internalization of the autonomous regulation of health behavior and perceived competence that affect the initiation of change and persistence in health behaviors (Ng et al., 2012). Autonomy is the intention to decide the initiation, regulation, and persistence of behaviors for oneself. It can be expressed along a single scale, from intrinsic to extrinsic motivation. Intrinsic motivation is related to the feeling or perception that one is selecting behaviors based on personal importance or interest, while extrinsic motivation is related to the feeling or perception that one is selecting behaviors based on external pressure or rewards. Such motivations can shift in the direction of self-determined, intrinsic motivation through the processes of internalization and integration (Ryan & Deci, 2000). Competence is the feeling or perception that one can effectively deal with one's environment, and relatedness is the desire to experience close relationships with others (Deci & Ryan, 2000). Researchers insisted that competence and relatedness influence behaviors under the condition of self-determination (Deci & Ryan, 2000; Ryan & Deci, 2000). For example, even if one has the competence to perform a certain activity, if one perceives the performance of the activity as being due to pressure or reward, the behavior is unlikely to continue. Accordingly, self-determination can be the most important factor in explaining or predicting a certain behavior or the continuation of that behavior (Deci & Ryan, 2000; Ryan & Deci, 2000). Supporting autonomy can stimulate intrinsic motivation for behavior, as well as promoting competence and the persistence of active participation (Deci & Ryan, 2000; Ryan & Deci, 2000). The SDT hypothesizes that autonomy support either has a direct effect on behavior or influences behavior via self-determination, competence, and relatedness. Previous research reported that the SDT was effective in physical activity participation (Silva et al., 2010), the maintenance of body weight regulation (Silva et al., 2008), serum glucose regulation, and self-management in people with diabetes (Shigaki et al., 2010). However, until now, few studies have attempted self-directed interventions that use Web-based programs for the maintenance and promotion of health in postmenopausal women.

Therefore, in this study, we identified the effects of autonomy-supportive, Web-based lifestyle modification for the management of cardiometabolic risk for postmenopausal women, and assessed the mediation effect of intrinsic motivation.

2 | METHODS

This study was a randomized, clinical trial designed to test the effect of Web-based autonomy supports for lifestyle modification, grounded on the SDT, for postmenopausal women. The Catholic University Institutional Review Board approved the content and methods of the study (no. MC14ENSI0032). The study period was from May to September 2014. The trial was registered at Cris.Nih.go.kr (KCT0001448).

2.1 | Participants

We recruited postmenopausal women via telephone among volunteers at the Catholic University of Korea Seoul, St Mary's Hospital, who had participated in a previous study by authors (Kim & Kim, 2013). Inclusion criteria were as follows: (i) more than 1 year since last menstruation; (ii) fulfillment at least one of the National Cholesterol Education Program- Adult Treatment Panel III (NCEP-ATP III) criteria for metabolic syndrome (abdominal circumference >80 cm [for Asian origin], fasting blood glucose >100 mg/dl, blood pressure >130/85 mmHg, triglycerides >150 mg/dl, or HDL-C <50 mg/dl); and (iii) ability to use the internet or cellular phone. Exclusion criteria were: (i) a severe illness requiring treatment; (ii) symptoms of acute inflammation; (iii) diagnosis of cardiovascular disease in the past 6 months; (iv) medications, such as antidepressants, that could affect body weight; (v) alcohol or drug addiction; and (vi) participation in other clinical trials. Eligibility of the participants was determined based on the previous study (Kim & Kim, 2013).

The sample size for a repeated-measures analysis of variance (rmANOVA) was computed using G-power (version 3.1). With the integrated effect size of the Web-based intervention for lifestyle habits as 0.16 (Webb et al., 2010), the significance level at .05, test power at 0.8, and the number of measurements as two, the optimal sample size was 64. We recruited 78 participants, considering potential dropouts.

The participants were arbitrarily assigned into two groups (odd numbers and even numbers) using the random-number generator function in Microsoft Excel: the intervention and control groups. The number of initial participants was 44 and 34 in the intervention and control groups, respectively. However, the final number of participants was 41 for the intervention group and 30 for the control group due to seven dropouts who either had symptoms of inflammation or did not take the clinical examinations conducted after 12 weeks (Figure 1).

2.2 | Procedure

At the baseline assessment, all participants fasted for over 8 hours before attending the Catholic University of Korea Seoul, St Mary's Hospital, to undertake physical examinations, blood pressure measurement, and blood tests for the measurement of physiological parameters. An individual consultation on optimal body weight, basal metabolic rate, healthy eating, and physical activity was provided for approximately 30 min each to everyone in both groups. One researcher conducted all assessments and consultations. The researcher was blinded to the participants' groups.

A research assistant provided additional 30 min instructions about the Web-based program for the intervention group.

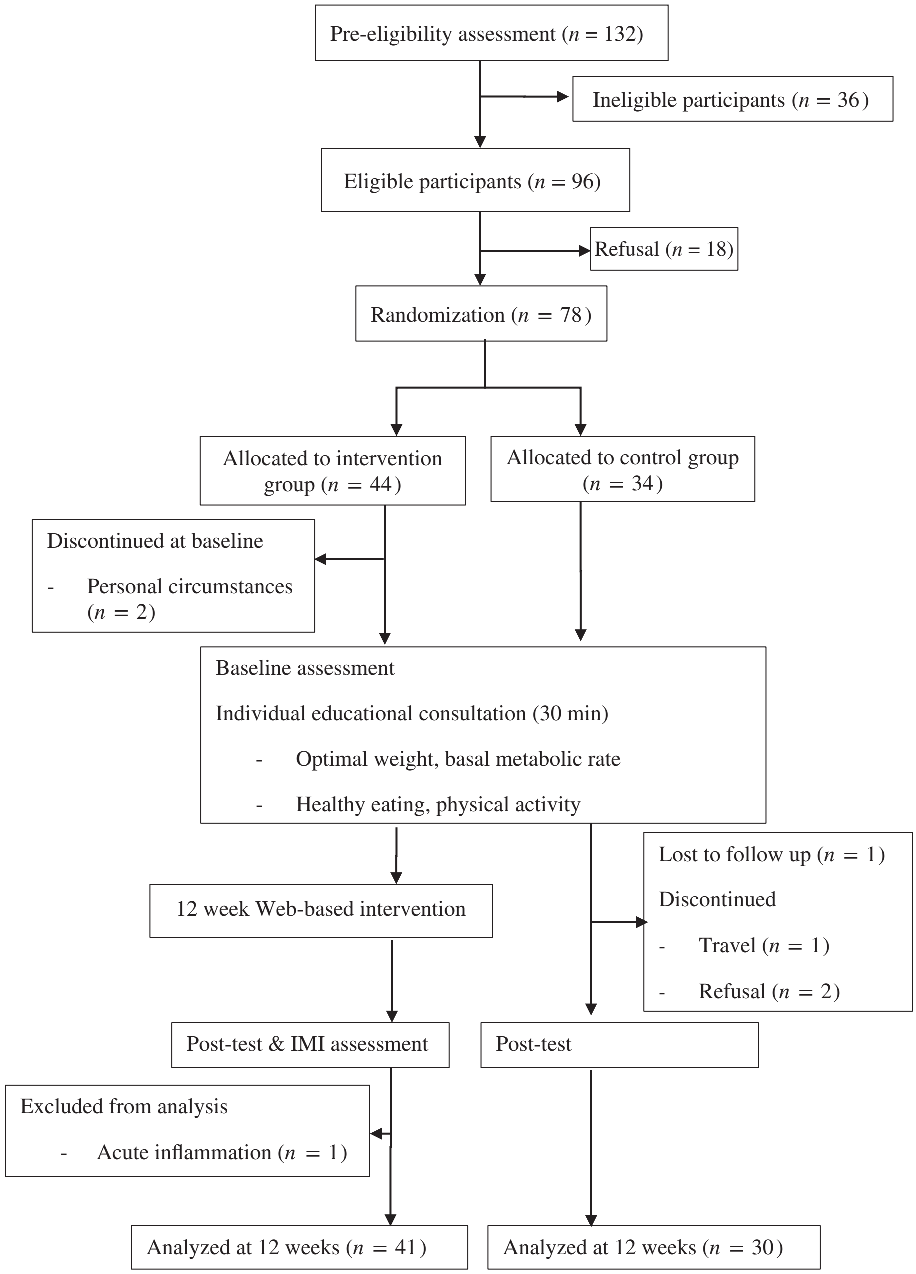

FIGURE 1 Flowchart of the study participants. IMI, Intrinsic Motivation Inventory

Post-test was implemented after 12 weeks in an identical manner to baseline assessment for everyone in both the intervention and control groups, and the intervention group completed the Intrinsic Motivation Inventory (IMI).

2.3 | Autonomy-supportive, Web-based intervention

Based on the SDT, an autonomy-supportive, Web-based intervention, DIETEX, (www.dietex.co.kr) was developed in Korean so that participants could improve their lifestyle habits by following the processes of assessment, diagnosis, planning, implementation, and evaluation. The validity of the contents and composition of DIETEX was verified across 20 conferences by two nursing professors, one endocrinologist, and two computer programmers.

In the assessment and diagnosis stages, participants checked individual health status, based on the results of the baseline assessment, and examined problematic lifestyle habits through the Web.

The planning stage involved health planning to solve the problems discovered in the assessment and diagnosis stages. In the DIETEX program, the lifestyle-modification strategies were recommended by the Korean Society of Lipidology and Atherosclerosis (www.lipid.or.kr), Korean Diabetes Association (www.diabetes.or.kr), and The Korean Society of Hypertension (www.koreanhypertension.org). Participants were allowed to choose practical strategies best suited to them.

The implementation and evaluation stages involved making a "health contract" based on the plans that the participants themselves selected and established, putting this into action, and evaluating adherence and perceived difficulty related to implementation. For self-monitoring and researcher feedback, the participants were asked to submit information to the DIETEX health diary at least once per week during the 12 weeks (Bennett et al., 2010), including minutes of moderate-intensity physical activity per week, walking step counts per day, and scores out of 10 on self-evaluated adherence and perceived difficulty related to implementation. The feedback was provided in the form of both automated pop-up and customized comments, supporting autonomy based on the SDT. Autonomy supports included the provision of evidence, empathy, support, cooperation in discovering and solving problems, praise of good adherence, and emphasizing advantages (Kayser, Cossette, Alderson, 2014). The participants could contact the researcher through the Web whenever questions arose.

Participants who did not log into DIETEX for over 1 week were encouraged to by a text message or phone call.

2.4 | Measures

Height and body weight were measured to one decimal place using an automated measuring device. Participants stood on the scales in light clothing and bare feet, with heels, buttocks, back, and back of the head all touching the vertical plate. The measurement was then made with their arms hanging naturally in the direction of their legs, and looking straight ahead, after inhaling deeply. Body mass index (BMI) was calculated as body weight (kg)/height (m^2).

A tape measure, marked with units of 0.1 cm, was used to measure waist circumference. Each participant stood straight with both feet together and both arms relaxed by their side. After finding by hand the lower edge of the participant's last rib on their side and the upper edge of their iliac crest, the circumference was measured horizontally between these two points. At this time, the participant wore a single layer of light clothing on top and was made to exhale gently. The waist-to-height ratio (WHtR) was calculated as waist circumference (cm)/height (cm).

The physical measurement was performed using identical instruments from 8.00 to 8.30 hours to reduce error. To minimize researcher bias, a researcher who was blinded to the participants' groups made all the measurements.

Lipid profile and serum glucose were measured with 5 ml venous blood sampled over 8 h of fasting, using enzymatic methods and the glucose oxidase method. The extracted blood samples were analyzed on the same morning to minimize measurement error.

Blood pressure was measured three times from the right arm at 5 min intervals using an automated blood pressure monitor, while the participant was seated, after resting for at least 5 min. An average was obtained from the second and third values.

The visceral adiposity index (VAI) was obtained using a formula with waist circumference, BMI, triglycerides, and HDL-C (Amato et al., 2010):

$$\mathrm{VAI} = \left\{\frac{\text{Waist circumference(cm)}}{36.58 + (1.89^{*}\mathrm{BMI}(\mathrm{kg/m^2}))}\right\} \times \left\{\frac{\text{Triglyceride(mmol/L)}}{0.81}\right\} \times \left\{\frac{1.52}{\mathrm{HDL(mmol/L)}}\right\}$$

2.5 | Intrinsic motivation

The IMI was developed by Ryan (1982) to evaluate intrinsic motivation for behavior changes after the intervention and it can be obtained freely from the website for research purposes (www.selfdeterminationtheory.org/questionnaires). Each item is answered from 1 (not at all) to 7 (very much), and higher score signify higher intrinsic motivation, and consists of seven subscales: interest/enjoyment, perceived competence, effort/importance, value/usefulness, pressure/tension, perceived choice, and relationship. The "interest/enjoyment" subscale assesses how much the participants feel joy and pleasure and have positive expectations for their activities. The "perceived competence" subscale assesses how much the participants feel skillful about the activity and proud of the results. The "effort/importance" subscale assesses how much the participants feel the task is important and how much energy the participants put into it. The "value/usefulness" subscale assesses how much the participants feel the activity could be beneficial and whether they intend to do the activity again in the future. The "pressure/tension" subscale assesses how much the participants feel nervous and feel pressure about the task. The "perceived choice" subscale measures how voluntary the activity of participants is. The "relationship" subscale measures familiarity and reliability with friends, family, and significant others that affect the activity. In the study, relationship considered only the relationship with the researcher who provided the intervention.

The instrument's validity has been tested in a study by McAuley, Duncan, and Tammen (1989). In Silva et al.'s study (2010), the instrument's internal consistency was shown by a Cronbach's alpha of .94

In the present study, we had completed the Korean version through the process of translation (English to Korean) and re-translation (Korean to English) and the 29 item version was partially amended to suit the research. After deletion of repeated items, the final instrument consisted of 20 items. The scores of each category came from the average of items. The content validity was examined by two nursing doctorates, two psychology doctorates, and two nursing professors, independently.

The reliability of the instrument was .87, based on Cronbach's alpha.

2.6 | Statistical analysis

Data were analyzed using SPSS. For equivalence testing between the intervention and control groups, χ^2- and *t*-tests were performed (assuming α = .05, two tailed test). To test the effect of the intervention, an rmANOVA was performed. With measurements only taken twice, it was not possible to test sphericity, and so Greenhouse–Geisser statistics were used. Post-hoc power analyses were performed to ascertain the adequacy of powers to detect group differences on each outcome variable. For assessment of the mediation effect of IMI, Pearson correlation coefficients were calculated. Complete case analysis was applied, as the dropout rate after randomization was less 10%.

3 | RESULTS

3.1 | Participants characteristics

There was no intergroup difference in participants' age, level of education, period of menopause, or in the CMRF measured before the intervention (Table 1).

3.2 | Lifestyle-modification strategies

Participants chose an average of 9.8 out of 14 dietary strategies for forming healthy diet habits, 2.8 out of six strategies for increasing physical activity, and 1.5 out of three strategies for daily life (Table 2).

TABLE 1 General and clinical characteristics of the participants

	Control (*n* = 30) Mean ± SD/N (%)	Intervention (*n* = 41)	t/χ^2	*P*-value
General characteristics				
Age (years)	59.5 ± 4.5	59.0 ± 4.5	0.51	.614
Educational level				
Elementary	0 (0)	1 (2.6)	6.52	.089
Middle school	4 (16.0)	1 (2.6)		
High school	11 (44.0)	12 (30.8)		
University	10 (40.0)	25 (64.0)		
Menopause (years)	51.0 ± 4.3	48.9 ± 6.2	1.50	.138
Postmenopausal years	8.5 ± 5.4	9.8 ± 8.2	0.71	.482
Obesity				
Weight (kg)	59.3 ± 5.1	58.3 ± 9.5	0.57	.569
BMI (kg/m^2)	23.9 ± 2.2	23.9 ± 3.6	0.05	.963
Waist circumference (cm)	84.4 ± 6.2	84.2 ± 7.3	0.11	.910
Waist-to-height ratio	0.54 ± 0.05	0.54 ± 0.05	0.27	.786
Lipid profile				
Triglycerides (mg/dl)	130.9 ± 83.3	116.9 ± 74.1	0.75	.456
HDL-C (mg/dl)	57.4 ± 15.6	59.1 ± 14.7	0.48	.633
Triglycerides-to-HDL-C ratio	2.78 ± 2.65	2.30 ± 2.62	0.76	.448
Blood pressure (mmHg)				
Systolic	115.7 ± 13.0	117.2 ± 13.6	0.47	.636
Diastolic	75.2 ± 9.2	75.6 ± 8.9	0.17	.863
Fasting blood glucose (mg/dl)	101.1 ± 14.3	101.8 ± 19.9	0.17	.867
Visceral adiposity index	2.38 ± 2.32	1.95 ± 2.22	0.79	.430
Metabolic syndrome[a]	11 (36.7)	10 (24.4)	1.25	.263

[a]≥ 3 risk factors. BMI, body mass index; HDL-C, high-density lipoprotein cholesterol; SD standard deviation.

Self-evaluated mean adherence scores for diet, physical activity, and daily life were 53.2, 55.9, and 51.9 out of 100, respectively. In addition, perceived difficulty related to implementation was 27.3. Self-reported minutes of moderate-intensity physical activity per week and walking steps per day were 48 and 8853, respectively (Table 2).

3.3 | Cardiometabolic risk factors

Body weight (*P* = .050) and BMI (*P* = .045) increased in both groups, but the increment was smaller in the intervention group (0.9 kg and 0.3 kg/m^2) compared to the control group (1.7 kg, and 0.6 kg/m^2), respectively. Waist circumference (*P* = .006) and WHtR (*P* = .005) decreased by 3.9 cm and 0.03 for the intervention group, respectively. Triglycerides decreased by 8.5 mg/dl in the intervention group, but increased 18.5 mg/dl in the control group (*P* = .022). Triglycerides/HLD-C ratio decreased by 0.21 for the intervention group (*P* = .045). Systolic blood pressure decreased by 3.3 mmHg for the intervention (*P* = .007). There was no significant change in diastolic blood pressure. Fasting blood glucose decreased by 4.9 and 0.9 mg/dl for the intervention and control groups, respectively, but these changes were not statistically significant. The VAI decreased by 0.28 for the intervention group, but for the control group, it increased by 0.37 (*P* = .045) (Table 3). Post-hoc power of all outcome variables ranged from 0.897 to 1.

3.4 | Intrinsic motivation

The mean intrinsic motivation for the intervention group after 12 weeks of the intervention was five out of seven points. Relationship was highest (6.3 ± 1.1), followed by perceived choice (4.4 ± 1.2); pressure/tension was the lowest (3.5 ± 1.4).

In the Pearson correlation analysis (Table 4), perceived competence was inversely associated with perceived difficulty related to the adherence (r = −0.40, *P* = .011). However, perceived competence was associated with minutes of moderate intensity physical activity per week (r = 0.34, *P* = .030), walking steps per day (r = −0.37, *P* = .019), and obesity changes in the BMI domain (r = 0.29, *P* = .048), waist circumference (r = 0.38, *P* = .008), and WHtR (r = 0.38, *P* = .008).

Effort/importance was associated with the self-rated diet adherence score (r = 0.32, *P* = .042) and waist circumference changes (r = 0.29, *P* = .049). However, it was inversely associated with perceived difficulty (r = −0.33, *P* = .040).

Value/usefulness was inversely associated with perceived difficulty (r = −0.35, *P* = .029) and systolic blood pressure change (r = −0.32, *P* = .028).

Pressure/tension correlated with obesity changes in the domains of waist circumference (r = −0.38, *P* = .008), WHtR (r = −0.36, *P* = .011), and the VAI (r = −0.39, *P* = .006). In addition, it

TABLE 2 Chosen strategies of diet, physical activity, and daily living (n = 41)

	Mean ± SD, N (%)
Healthy eating choices	
Chosen strategies[a]	9.8 ± 2.8
Adding wholegrain or multigrain foods to diet	38 (92.7)
Eating more vegetables	38 (92.7)
Eating light (80% of usual amount)	34 (82.9)
Limiting convenience or fast foods	31 (75.6)
Limiting sodium intake	30 (73.2)
Getting into a regular eating pattern	29 (70.7)
Eating a low-fat diet	29 (70.7)
Limiting savory snacks	29 (70.7)
Eating a low-carbohydrate diet	28 (68.3)
Limiting cholesterol intake	28 (68.3)
Avoiding the temptation to eat out	21 (51.2)
Consumption of 2+ servings of fish/week	20 (48.8)
Drinking 2 L water every day	20 (48.8)
Taking enough time to chew properly	16 (39.0)
Self-rating diet score	53.2 ± 18.4
Increasing physical activity	
Chosen strategies[a]	2.8 ± 1.2
Doing regular moderate-intensity physical activity	29 (70.7)
Self-reported minutes of moderate-intensity physical activity/week	48 ± 43
Taking public transit	29 (70.7)
Walking 5000 steps/day	26 (63.4)
Challenging 10 000 steps/day	11 (26.8)
Self-reported walking steps/week	8854 ± 5971
Increasing stair use	14 (34.1)
Practicing vigorous-intensity physical activity	3 (7.3)
Self-rating physical activity score	55.9 ± 19.2
Managing daily life	
Chosen strategies[a]	1.5 ± 1.1
Cutting down stress	33 (80.5)
Cutting down on alcohol	12 (29.3)
Quitting smoking	11 (26.8)
Self-rating daily living score	51.9 ± 17.2
Self-rated perceived difficulty related to the implementation	27.3 ± 21.7

[a] Multiple choices was possible. SD, standard deviation.

correlated with lipid profile changes in the triglyceride (r = –0.37, P = .009), HDL-C (r = 0.30, P = .041), triglycerides/HDL-C (r = –0.38, P = .007).

Perceived choice was associated with the number of chosen diet strategies (r = 0.35, P = .038), obesity changes in the weight domain (r = 0.35, P = .015), BMI (r = 0.37, P = .010), waist circumference (r = 0.33, P = .022), and WHtR (r = 0.33, P = .023). In addition, it was associated with triglyceride change (r = 0.33, P = .020) and systolic blood pressure change (r = 0.29, P = .044).

Relationship was associated with diastolic blood pressure change (r = 0.39, P = .006).

4 | DISCUSSION

The participants in this study tended to select strategies that were relatively easy to pursue. The score of perceived difficulty related to implementation was low, and no participants in the intervention group ceased the program during the 3 month study period. This shows that the freedom of choosing their strategies reduced the pressure of lifestyle modification and allowed participants to maintain the program.

Regarding obesity, both groups had increased body weight and BMI within the normal range. The intervention group exhibited a smaller increase compared with the control group. The participants in this study were not obese or had relatively low-grade obesity. This result is in apparent contrast to other studies, which reported a mean 2.5 kg decrease in body weight (Wieland et al., 2012). The discrepancy is attributed to the fact that the previous studies focused on body weight reduction of adults with a high-grade obesity. In addition, our results might have been affected by the Chuseok festival, which fell within the study period, during which the whole family gathers to enjoy food together. During this time, the participants tended to not follow the program. Future studies with the high-grade obese participants are necessary to examine the issues related to weight reduction using our program.

Waist circumference decreased by 3.9 cm in the intervention group compared to a 1.5 cm decrease in the control group. This is similar to the results of previous studies, which showed a mean waist circumference decrease of 3 cm (Wieland et al., 2012). We emphasize that waist circumference decreased even with a slight increase in body weight and BMI in our study. This indicates that postmenopausal women implementing healthy lifestyle habits could reduce their waist circumference, irrespective of changes in body weight (Church et al., 2009).

WHtR decreased by 0.03 in the intervention group, which is similar to a previous study that reported a 0.02 reduction in WHtR (Collins, Morgan, Hutchesson, Callister, 2013). WHtR is a better predictive factor of cardiometabolic disease compared to body weight or BMI (Martinez-Gonzalez et al., 2014), and critical value for predicting cardiovascular disease in Koreans has been reported as 0.51 for females (Park, Choi, Lee, Park, 2009). The decrease in WHtR for the intervention group from 0.54 to 0.51 after the intervention can be regarded as not only a superficial improvement in abdominal obesity but also a significant change regarding CMRF management.

While triglycerides increased by 14% for the control group, it decreased by 7% for the intervention group. This is similar to the approximately 0.2 mmol/L decrease found in a study that implemented 6 months of a lifestyle-modification program to 360 obese patients (Vetter et al., 2013). As triglycerides are important for the primary preventative management of cardiovascular diseases (Stauffer, Weisenfluh, Morrison, 2013), this result has clinical significance. Moreover, triglycerides/HDL-ratio was improved in the intervention group. This implies that our program can be useful in CMRF management, because triglycerides/HDL-ratio is a predictive factor for cardiovascular disease (Salazar et al., 2014) and an index for the early detection of insulin resistance (Du et al., 2014).

Systolic blood pressure decreased in the intervention group, although there was no change in diastolic blood pressure. This result differs from a previous study, which demonstrated an improvement

TABLE 3 Effects of the intervention on cardiometabolic risk

	Baseline	12 weeks later	F (*P*-value)		
	Mean ± SD		Time	Group	Time*Group
Obesity					
Weight (kg)					
Control	59.3 ± 5.1	61.0 ± 5.6	48.49 (.001)	0.52 (.474)	3.99 (.050)
Intervention	58.3 ± 9.5	59.2 ± 9.6			
Body mass index (kg/m^2)					
Control	23.9 ± 2.2	24.5 ± 2.4	45.86 (.001)	0.06 (.804)	4.17 (.045)
Intervention	23.9 ± 3.6	24.2 ± 3.6			
Waist circumference (cm)					
Control	84.4 ± 6.2	82.9 ± 6.9	39.0 (.001)	0.71 (.403)	8.1 (.006)
Intervention	84.2 ± 7.3	80.3 ± 7.8			
Waist-to-height ratio					
Control	0.54 ± 0.05	0.53 ± 0.05	41.31 (.001)	0.17 (.678)	8.25 (.005)
Intervention	0.54 ± 0.05	0.51 ± 0.05			
Visceral adiposity index					
Control	2.38 ± 2.32	2.75 ± 2.61	0.11 (.740)	2.32 (.132)	4.18 (.045)
Intervention	2.95 ± 2.22	1.67 ± 1.46			
Lipid profile					
Triglycerides (mg/dl)					
Control	130.9 ± 83.3	149.4 ± 92.7	0.77 (.383)	2.46 (.121)	5.52 (.022)
Intervention	116.9 ± 74.1	108.4 ± 60.0			
HDL-C (mg/dl)					
Control	57.4 ± 15.6	54.5 ± 15.2	9.95 (.002)	0.39 (.534)	0.22 (.644)
Intervention	59.1 ± 14.7	56.9 ± 12.8			
Triglyceride-to-HDL-C ratio					
Control	2.78 ± 2.65	3.13 ± 3.03	0.79 (.376)	2.18 (.144)	4.16 (.045)
Intervention	2.30 ± 2.62	2.09 ± 1.78			
Blood pressure (mmHg)					
Systolic					
Control	115.7 ± 13.0	117.9 ± 11.1	0.29 (.590)	0.20 (.659)	7.71 (.007)
Intervention	117.2 ± 13.6	113.9 ± 12.0			
Diastolic					
Control	75.2 ± 9.2	75.1 ± 8.7	1.42 (.238)	0.05 (.826)	1.12 (.293)
Intervention	75.6 ± 8.9	73.9 ± 8.4			
Fasting blood glucose (mg/dl)					
Control	101.1 ± 14.3	100.2 ± 12.9	4.13 (.046)	0.15 (.699)	2.02 (.160)
Intervention	101.8 ± 19.9	96.9 ± 11.4			

Control group, N = 30; intervention group, N = 41. HDL-C, high-density lipoprotein cholesterol; SD, standard deviation.

in both systolic and diastolic blood pressure (Oh, Kim, Park, Shim, 2011). Such a discrepancy could originate from a different initial blood pressure of the participants in two studies. The participants in this study had a relatively low mean blood pressure compared to the previous study. Further research will be necessary for patients with hypertension to confirm the effectiveness of the program.

Although fasting blood glucose reduction had no statistical significance, the fact that the intervention group decreased below 100 mg/dl had clinical significance. Because the blood glucose level was not high enough at the baseline assessment (101.8 mg/dl), further studies will be necessary for patients with type 2 diabetes.

The VAI is related to adipose tissue dysfunction. A previous study noted that there is weak dysfunction in adipose tissue when the VAI is 1.94–2.32, and moderate dysfunction when the VAI is 2.33–3.25 in adults aged 52–66 years (Amato & Giordano, 2014). The results of present study showed that the control group had no change in the VAI from a level that indicated moderate dysfunction of adipose tissue, whereas the intervention group improved from a moderate level of adipose tissue dysfunction to a level with no dysfunction, which has clinical significance.

The intrinsic motivation measured after 12 weeks of intervention was higher in relationship, value/usefulness, and interest/enjoyment, while it was lower in pressure/tension. These results indicate that participants perceived the necessity and importance of lifestyle modification by developing a close relationship with the researcher, and maintaininginterest and expectations for the program. However,

TABLE 4 Pearson correlation of intrinsic motivation with the lifestyle-modification intervention and cardiometabolic risk changes (n = 41)

		Interest/ enjoyment	Perceived competence	Effort/ importance	Value/ usefulness	Pressure/ tension	Perceived choice	Relationship
		Pearson r (P-value)						
No. chosen strategies	Diet	0.06 (.725)	−0.02 (.924)	0.12 (.477)	0.19 (.267)	−0.06 (.725)	**0.35 (.038)**	0.25 (.135)
	Physical activity	0.05 (.770)	−0.15 (.386)	0.16 (.363)	0.01 (.973)	−0.18 (.295)	0.28 (.101)	−0.08 (.638)
	Daily living	0.13 (.453)	−0.24 (.162)	0.10 (.546)	0.16 (.357)	−0.08 (.624)	0.13 (.437)	−0.02 (.927)
Adherence score	Diet	0.14 (.392)	0.30 (.057)	**0.32 (.042)**	−0.12 (.465)	−0.03 (.861)	0.08 (.632)	−0.30 (.061)
	Physical activity	0.20 (.224)	0.22 (.163)	0.21 (.183)	−0.07 (.669)	−0.15 (.370)	0.15 (.345)	−0.12 (.456)
	Daily living	0.14 (.387)	0.15 (.344)	0.18 (.273)	0.02 (.919)	−0.06 (.721)	0.04 (.825)	−0.19 (.249)
Perceived difficulties		−0.28 (.081)	**−0.40 (.011)**	**−0.33 (.040)**	**−0.35 (.029)**	0.14 (.398)	−0.26 (.107)	−0.30 (.065)
Moderate-intensity Physical activity		0.08 (.631)	**0.34 (.030)**	−0.23 (.151)	−0.02 (.912)	−0.02 (.895)	−0.11 (.506)	0.14 (.401)
Walking steps		0.08 (.620)	**0.37 (.019)**	−0.03 (.842)	0.06 (.727)	0.00 (.977)	0.09 (.582)	0.20 (.226)
Obesity changes	Weight	0.23 (.119)	0.24 (.102)	0.18 (.211)	0.10 (.518)	−0.28 (.051)	**0.35 (.015)**	0.08 (.578)
	BMI	0.22 (.136)	**0.29 (.048)**	0.19 (.199)	0.07 (.630)	−0.28 (.057)	**0.37 (.010)**	0.08 (.581)
	WC	0.23 (.118)	**0.38 (.008)**	**0.29 (.049)**	0.01 (.964)	**−0.38 (.008)**	**0.33 (.022)**	0.09 (.550)
	WHtR	0.22 (.139)	**0.38 (.008)**	0.28 (.051)	0.02 (.918)	**−0.36 (.011)**	**0.33 (.023)**	0.08 (.586)
	VAI	0.27 (.061)	0.26 (.075)	0.09 (.533)	0.00 (.985)	**−0.39 (.006)**	0.26 (.074)	0.12 (.417)
Changes of lipid profile	TG	0.30 (.039)	0.24 (.106)	0.11 (.473)	−0.02 (.911)	**−0.37 (.009)**	**0.33 (.020)**	0.10 (.483)
	HDL-C	−0.12 (.407)	−0.09 (.522)	0.02 (.914)	0.16 (.275)	**0.30 (.041)**	−0.03 (.856)	0.08 (.586)
	Triglyceride/ HDL-C	0.27 (.060)	0.26 (.080)	0.10 (.499)	0.00 (.975)	**−0.38 (.007)**	0.26 (.072)	0.13 (.370)
BP changes	SBP	−0.06 (.691)	0.20 (.174)	0.06 (.686)	**−0.32 (.028)**	−0.04 (.781)	**0.29 (.044)**	0.33 (.024)
	DBP	−0.02 (.915)	0.07 (.637)	0.06 (.693)	−0.14 (.330)	0.15 (.302)	0.20 (.165)	**0.39 (.006)**
Fasting blood glucose change		0.26 (.074)	0.20 (.167)	0.05 (.728)	−0.03 (.861)	−0.22 (.132)	0.11 (.474)	0.02 (.899)

Bold values are statistically significant. BMI, body mass index; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; SBP, systolic blood pressure; VAI, visceral adiposity index; WC, waist circumference; WHtR, waist-to-height ratio.

perceived competence was relatively low, and this might be affected by the fact that participants have many opportunities to eat out in groups, making it more difficult to maintain healthy eating habits that they had planned. Although participants could perceive the necessity and importance of the plan, they were unable to implement it actively, and this might have had a negative influence on perceived competence.

Perceived competence, effort/importance, value/usefulness, and perceived choice showed an association with cardiometabolic risk changes. These results imply that for active adherence of participants to the lifestyle-modification program, it is important to consider intrinsic motivations. Moreover, if the intervention focuses on the encouragement of intrinsic motivations, it would be more effective.

4.1 | Limitations

Due to the nature of the interventions, it was not possible for the participants to be blinded to the groups. This could influence participants' expectancy for the result. The study participants were recruited from volunteers of the hospital, who had a relatively high economic and educational level, so caution is necessary when producing a generalized interpretation of the results. In addition, there are limitations in understanding the exact effects of the intervention, as the clinical severity of the participants was not high enough.

5 | CONCLUSION

Implementing a healthy diet and maintaining a physically-active lifestyle is a repetitive and tiring process that requires considerable effort. Web-based autonomy supports based on the SDT can be effective for implementation and maintenance, and amelioration of CMRF in postmenopausal women. The perceived value of health, usefulness of a program, and interest and enjoyment that participants feel about a program can all lead to motivation to continue a lifestyle-modification program. However, self-regulation and feedback for the implementation are more important than interest, enjoyment, or challenging oneself for adherence and persistence.

ACKNOWLEDGMENT

This study was supported by the Basic Science Research Program through the National Research Foundation of Korea, funded by the Ministry of Science, ICT, and Future Planning of the Republic of Korea (no. NRF-2012R1A1A2003112).

AUTHOR CONTRIBUTIONS

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How to cite this article: Kim H-R, Kim H-S. Autonomy-supportive, Web-based lifestyle modification for cardiometabolic risk in postmenopausal women: Randomized trial. *Nurs Health Sci*. 2017;19:509–517. https://doi.org/10.1111/nhs.12375