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The effectiveness of a self-efficacy enhancement program on health behaviors and clinical outcomes in people with metabolic syndrome: A quasi-experimental study in Thailand

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Abstract

Background: Metabolic syndrome (MetS) is a cluster of chronic conditions, including obesity, hyperglycemia, hypertension, and dyslipidemia, known to significantly increase the risk of cardiovascular diseases (CVDs). Effective interventions are needed to control the progression of MetS.

Objective: This study aimed to determine the effectiveness of the Self-Efficacy Enhancement (SEE) program on health behaviors and clinical outcomes in individuals with Metabolic Syndrome (MetS).

Methods: A quasi-experimental study with a two-group pretest-posttest design was conducted from September 2023 to January 2024. A purposive sample of 70 participants with MetS was recruited from two healthcare settings in Thailand. Participants were divided into two groups: an experimental group (n = 35) and a control group (n = 35). The experimental group received the SEE program based on Self-Efficacy Theory, while the control group received only routine nursing care for 12 weeks. Data were collected using a Personal Information questionnaire, a Health Behavior questionnaire, and clinical outcome assessments, including waist circumference (WC), blood pressure (BP), fasting plasma glucose (FPG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL cholesterol), and non-high-density lipoprotein cholesterol (non-HDL cholesterol), before and after the 12-week program. Data were analyzed using descriptive statistics, paired t-test, independent t-test, Wilcoxon signed-rank test, Mann-Whitney U-test, and ANCOVA.

Results: Following the SEE program, the experimental group exhibited significant improvements in health behaviors (t = -12.830, p <0.001), a reduction in WC (t = 3.809, p <0.001), decreased SBP (z = -4.554, p <0.001) and DBP (t = -5.178, p <0.001), and an increase in HDL cholesterol (z = -3.193, p <0.001) compared to baseline measures. Furthermore, compared to the control group, the experimental group demonstrated significantly improved health behaviors (F = 193.86, p <0.001), lower WC (F = 19.58, p <0.001), lower FPG (F = 12.39, p <0.001), lower SBP (F = 25.04, p <0.001), lower DBP (F = 19.49, p <0.001), and lower non-HDL cholesterol (F = 8.49, p <0.01). Partial eta-squared (η^2) indicated large effects for health behaviors, WC, FPG, SBP, DBP, TC, and HDL cholesterol; non-HDL cholesterol showed a medium effect. TC and HDL cholesterol showed no significant change after completing the program.

Conclusion: The SEE program improved health behaviors and clinical outcomes, supporting its integration into standard MetS care in nursing practice. Through e-health, education, exercise guidance, role modeling, and support, the program can boost confidence in adopting healthier behaviors and reduce CVD risk. Future studies should explore extending the program duration, as the 12-week period may have been insufficient to observe significant changes.

Trial Registry Number: Thai Clinical Trials Registry (TCTR20250218014)

Keywords

Thailand; self-efficacy; metabolic syndrome; health behaviors; waist circumference; blood glucose; blood pressure; cholesterol; cardiovascular diseases; e-health

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Background

Metabolic syndrome (MetS) is a significant global public health concern, contributing substantially to the burden of non-communicable diseases (NCDs). Globally, the prevalence of MetS ranges from 12.5% to 31.4%, depending on the diagnostic criteria used (Noubiap et al., 2022). Furthermore, the prevalence of MetS-related risk factors, such as central obesity, hypertension, dyslipidemia, and hyperglycemia, has been reported to range from 24% to 45% (Noubiap et al., 2022). In Thailand, the 6th Thai National Health Examination Survey (2019–2020) revealed a 25% prevalence of MetS among individuals aged 15 years and older (Aekplakorn et al., 2021). This high prevalence contributes to increased rates of chronic diseases, including type 2 diabetes mellitus (T2DM) (Regufe et al., 2020), hypertension, and cardiovascular diseases (CVDs). Over 13 years, CVD incidents occurred in 16.2% of people with MetS, compared to 8.7% of those without MetS (Agboola et al., 2023).

MetS is defined as a cluster of coexisting conditions composed of obesity and at least two of the following components: elevated blood pressure (BP), fasting plasma glucose (FPG), or non-high-density lipoprotein cholesterol level (non-HDL cholesterol) (Dobrowolski et al., 2022). A 13-year prospective study found that individuals with MetS had a 1.32-fold higher risk of CVD events over 3.23 years and a 1.64-fold higher risk of CVD mortality over 3.73 years. Each additional MetS component increased the risk of CVD by 22% (Guembe et al., 2020). People with MetS also tend to require more medical services, which can exacerbate their financial strain (Sharma et al., 2020). Furthermore, the presence of MetS is associated with a diminished quality of life and compromised mental well-being (Liang et al., 2021; Marcos-Delgado et al., 2020).

Hence, controlling MetS components is a clinical challenge, with early intervention linked to a lower risk of CVD (Agboola et al., 2023). Health behavior modification is a cost-effective and sustainable strategy that includes a healthy diet, regular physical activity, emotional management, smoking cessation, and limiting alcohol consumption (Dobrowolski et al., 2022; Pearson et al., 2021). However, people with MetS have been unable to maintain effective health behaviors in previous studies (Silachaln et al., 2019; Supruang et al., 2020). Therefore, boosting confidence is key to enhancing and maintaining these behaviors.

Most previous intervention studies in people with MetS demonstrated improvements in health behaviors and clinical outcomes through educational and exercise programs, such as brisk walking for at least 30 minutes a day, ≥3 days per week, and/or supplemented by muscular strengthening activities (MSA). Education programs have been shown to improve health behaviors (Lee et al., 2014; Silachaln et al., 2019; Tipkanjanaraykha et al., 2016), and clinical outcomes including WC (Methakanjanasak & Sota, 2016; Silachaln et al., 2019), FPG, triglyceride (TG) (Tipkanjanaraykha et al., 2016), SBP (Lee et al., 2014; Methakanjanasak & Sota, 2016), DBP, and HDL cholesterol (Methakanjanasak & Sota, 2016). However, these interventions did not consistently yield significant improvements across all studies and outcomes. For example, some interventions failed to show significant changes in WC and FPG (Lee et al., 2014), SBP (Tipkanjanaraykha et al., 2016), DBP (Lee et al., 2014; Tipkanjanaraykha et al., 2016), TG, and HDL cholesterol (Lee et al., 2014; Tipkanjanaraykha et al., 2016).

Moreover, participants in several studies reported low confidence and feelings of unpreparedness to adopt and maintain healthy behaviors (Silachaln et al., 2019; Supruang et al., 2020). These findings suggest that while traditional educational and exercise-based interventions may be beneficial, they may not be sufficient for sustainable behavioral change. Therefore, enhancing individuals' confidence and motivation, key components of self-efficacy, has emerged as a critical factor in improving health behaviors and clinical outcomes in people with MetS. Interventions explicitly designed to strengthen self-efficacy may provide a more robust and sustainable impact than those focusing solely on knowledge or physical activity alone.

Enhancing self-efficacy is crucial for improving health behaviors and clinical outcomes in individuals with chronic diseases (Chan, 2021; Farley, 2020). According to Bandura (1997), people who successfully engage in health behaviors require confidence in their abilities. Self-efficacy is built on four primary sources of information: enactive mastery experience, vicarious experience, verbal persuasion, and physiological and affective states. Intervention studies focusing on SEE programs have shown positive results in various groups, including glycemic control in pre-diabetes and T2DM groups (Rojruangnon et al., 2021; Sandee et al., 2017; Tan et al., 2020), and BP control in pre-hypertension and hypertension groups (Phonkrut et al., 2021; Wutthitham et al., 2020). However, little is known about the effectiveness of the SEE program for individuals with MetS (Silachaln et al., 2019).

In the digital era, the LINE application, as an e-health platform for education and research follow-up, is an innovative and relevant tool in the Thai context. It has proven effective in managing chronic conditions (Hongchuvech et al., 2021). Studies on MetS-risk individuals (those with one or two MetS components) reported using the LINE application to improve patients' health outcomes (Hongchuvech et al., 2020; Maneenithiveth, 2020; Wungrath & Autorn, 2021). These programs include infographics, videos, reminders, and follow-up messages, leading to improvements in obesity (Hongchuvech et al., 2020), glycemic control (Maneenithiveth, 2020; Wungrath & Autorn, 2021), and lipid profile (Maneenithiveth, 2020). The LINE Official Account (LINE OA) is a valuable tool for delivering media content, offering features such as customizable menus that allow participants to access educational materials at their convenience, while also ensuring privacy in communication. Therefore, integrating LINE OA activities into the SEE program is an effective way to engage individuals with MetS, offering support, increasing motivation, and sustaining health behaviors.

Literature reviews found that the SEE program can lead to positive health outcomes for people with MetS and those at risk. However, the effectiveness varies based on program activities, duration, and the severity of MetS. Most SEE programs targeting individuals at risk for MetS, with one or two components, were typically conducted over short durations (6–8 weeks). These programs demonstrated significant clinical outcome improvements; however, there is insufficient evidence to support the effectiveness of the SEE program for individuals with MetS who have more complex comorbidities.

People with MetS present three or more components (Dobrowolski et al., 2022). Most educational and exercise programs involving MSA with brisk walking for at least 30 minutes (≥3 days per week) in people with MetS that were conducted over 12 weeks reported positive health outcomes (Lee et al., 2014; Methakanjanasak & Sota, 2016; Tipkanjanaraykha et al., 2016), similar to the MetS management recommendation guidelines of Dobrowolski et al. (2022). Health behavior modification in individuals with MetS may require a longer duration to achieve improved clinical outcomes compared to those at risk for developing MetS. Consequently, the 12-week SEE program based on Self-Efficacy Theory should be further examined to promote sustainable health behaviors in individuals with MetS.

There is limited evidence on the SEE program's effectiveness in improving blood glucose, BP, and lipid profiles in people with MetS (Phonkrut et al., 2021; Rojruangnon et al., 2021; Sandee et al., 2017; Silachaln et al., 2019; Tan et al., 2020; Wutthitham et al., 2020). Most prior interventions primarily focused on TG and HDL cholesterol (Lee et al., 2014; Methakanjanasak & Sota, 2016; Tipkanjanaraykha et al., 2016), while recent MetS criteria emphasize non-HDL cholesterol as a better indicator of CVD risk (Dobrowolski et al., 2022). Implementing the SEE program based on these updated criteria is essential. Additionally, utilizing LINE OA as an e-health intervention to enhance self-confidence and promote healthier behaviors among individuals with MetS necessitates the adoption of effective technological strategies. Currently, this approach is limited in Thailand, where traditional face-to-face education remains more common.

Significantly positive health behaviors and clinical outcomes for people with MetS, based on Self-Efficacy Theory, have not been widely supported in Thailand or internationally. This study aims to evaluate the effectiveness of the SEE program, which is grounded in Bandura's Self-Efficacy Theory (Bandura, 1997), the new definition and management guidelines of MetS by Dobrowolski et al. (2022), International Diabetes Federation [IDF] (2006), and relevant prior studies. Utilizing the LINE application for health communication and information dissemination, the study aims to compare health behaviors and clinical outcomes (WC, FPG, SBP, DBP, TC, HDL cholesterol, and non-HDL cholesterol) in people with MetS before and after SEE program participation, and between the SEE program and those who only receive routine nursing care.

Methods

Study Design

The experimental group received routine nursing care, along with the SEE program, over a 12-week period. This program included an educational component delivered both onsite and online via the LINE Official Account (LINE OA), featuring infographics and an exercise video. The activities included education sessions, an exercise regimen that combined MSA with brisk walking, role modeling, and follow-up communication via LINE OA through calls or messages. In contrast, the control group received only routine nursing care, which consisted of medication and health recommendations, with appointments scheduled based on their health status.

Sample/Participants

The sample in this study consisted of individuals with MetS. Potential participants were individuals with MetS who regularly attended non-communicable disease (NCD) clinics at two healthcare centers in Phrae Province, Thailand. Purposive sampling was applied to ensure the inclusion of individuals who met the specified clinical and demographic criteria. To reduce potential selection bias and enhance comparability, the two healthcare centers were randomly assigned to either the experimental group (Phrae Hospital Community Health Center, Rong Sor) or the control group (Thung Hong Health Promoting Hospital). In this study, randomization at the individual level was not feasible due to the limited number of individuals who met the inclusion criteria within the study period (September 2023 to January 2024).

The sample was selected through purposive sampling, adhering to the established inclusion criteria. The inclusion criteria were: (1) aged 18 years or older; (2) had MetS based on the new MetS criteria for at least 3 months (Dobrowolski et al., 2022)—a person had central obesity defined as WC ≥ 90 cm in males and ≥ 80 cm in females, which aligns with the WC definition for the Asian population by the International Diabetes Federation [IDF] (2006), or Body Mass Index (BMI) ≥ 30 kg/m², plus any two of the following three components: 2.1) prediabetes or diabetes: FPG ≥ 100 mg/dl or on glucose-lowering medication; 2.2) high blood pressure or hypertension: SBP ≥ 130 and/or DBP ≥ 85 mm Hg or on antihypertensive medication; 2.3) elevated non-HDL cholesterol ≥ 130 mg/dl or on lipid-lowering medication; (3) ability to communicate through the LINE application using their own internet to access educational materials; (4) ability to communicate in Thai; (5) willingness to participate in the study.

The effect size of this study was calculated using the equation from Glass (1976), based on a minimum effect size of each variable from relevant studies (Lee et al., 2014; Methakanjanasak & Sota, 2016; Silachaln et al., 2019; Tipkanjanaraykha et al., 2016). A power analysis using G-Power software version 3.1.9 indicated that 30 participants per group were sufficient for independent t-test statistic (effect size = -0.66, power = 0.80, p = 0.05). To prevent attrition, approximately 20% was added to each group, resulting in 36 participants per group, with a total of 72 participants across the two groups. Following enrollment, one participant withdrew due to relocation, making post-intervention blood testing at the 13th week infeasible. Additionally, one outlier was excluded from the control group analysis to maintain data integrity.

Instruments

The research utilized two types of instruments: one for data collection and the other for intervention. To evaluate content validity, the item-objective congruence (IOC) index score was assessed by three experts, including two nursing instructors and a registered nurse. Permission was obtained from the developers to use all instruments.

The data collection instruments included: The Personal Information Questionnaire, developed by the researchers, included seven items to collect demographic data such as gender, age, education level, marital status, average monthly family income, occupation, and number of MetS criteria.

The Health Behaviors Questionnaire, adapted from Boontein and Saneha (2017), consisted of 30 items rated on a

4-point Likert scale, from “1 = never perform” to “4 = regularly perform.” The total score ranged from 30 to 120 points, with higher scores indicating better health behaviors for MetS. The researchers adapted this questionnaire under supervisor guidance to fit the target group. The average IOC score was 0.78, with a Cronbach’s alpha of 0.74, indicating acceptable reliability.

Clinical outcomes were assessed by research assistants (RAs) and included the following: WC was measured using a waist tape measure, with cutoff values based on International Diabetes Federation [IDF] (2006) criteria for Asians: ≥ 90 cm for males and ≥ 80 cm for females. BP was measured using an automatic device (OMRON HEM-7156-A) calibrated according to the Association for the Advancement of Medical Instrumentation standards, with accuracy ±3 mm Hg. Elevated BP was defined as SBP ≥ 130 mm Hg and/or DBP ≥ 85 mm Hg (Dobrowolski et al., 2022). Blood samples for FPG and non-HDL cholesterol were analyzed by Nam Thong Lab Center, a certified clinic under Thailand’s Ministry of Public Health. Non-HDL cholesterol was calculated as TC minus HDL cholesterol (Dobrowolski et al., 2022; Pearson et al., 2021).

Intervention

The SEE program was developed based on Bandura’s Self-Efficacy Theory (Bandura, 1997) and previous studies, emphasizing the importance of increasing confidence in performing and maintaining healthy behaviors. The intervention focused on four primary sources: 1) Imparting knowledge through face-to-face educational sessions, focusing on five fundamental principles: diet, exercise, emotional management, abstaining from smoking, and alcohol avoidance. This component encompasses practical demonstrations of food selections and exercises comprising MSA and brisk walking, employing verbal persuasion with the physiological and affective state to bolster participants’ confidence and preparedness for the prescribed activities; 2) Conducting return demonstrations for food selections and exercises, utilizing mastery experiences deemed crucial in fostering healthy dietary habits and regular exercise routines. Participants were encouraged to engage in recommended exercises; 3) Leveraging role models to furnish vicarious experiences. Participants could glean insights from models sharing similar backgrounds who have effectively managed MetS components and could offer valuable strategies for self-improvement; 4) Disseminating messages, infographics, and videos of MetS and health behaviors modifications, complemented by follow-ups through the LINE OA, employing verbal persuasion with the physiological and affective state to review knowledge, encourage, and furnish feedback on participants’ health status. This follow-up process is designed to make participants feel supported and cared for, reinforcing their commitment to health behaviors.

The SEE program was implemented for 12 weeks, including face-to-face educational sessions and an exercise regimen involving muscular strengthening activities (MSA) and brisk walking for at least 30 minutes daily, five days a week at home (Lee et al., 2014; Methakanjanasak & Sota, 2016; Tipkanjanaraykha et al., 2016). Three experts validated its health education content: two nurse instructors and a registered nurse, achieving an acceptable IOC score of 0.91. The program incorporated various materials, including a flip chart, role mode,l and exercise videos, MetS infographics, LINE OA, and a recording form. A sports development officer from the Sport Sciences Bureau, Department of Physical Education, assessed the exercise video. Moreover, the practical elements of health behavior modification, such as role modeling (Phonkrut et al., 2021; Rojruangnon et al., 2021; Sandee et al., 2017; Silachaln et al., 2019; Wutthitham et al., 2020) and follow-up activities (Silachaln et al., 2019; Tan et al., 2020) were influenced by an individual's self-efficacy. Integrating e-health resources, such as LINE OA can facilitate health behavior modification by disseminating health information, enabling online communication with customized feedback, and delivering prompts to improve clinical outcomes (Charoenwongsa et al., 2022; Hongchuvech et al., 2021; Maneenithiveth, 2020; Wungrath & Autorn, 2021). The program's activities were delivered in small groups to enhance communication, and the program provided all essential materials to participants, supporting long-term health behavior modification.

The 12-week SEE program implemented in this study was structured into three sessions, as shown in **Table 1**.

Session 1 (First Week: Face-to-Face Educational Session). The researchers informed participants with essential knowledge about MetS, covering its definition, causes, complications, and health behavior modification strategies, while they awaited their appointments with the physician. The information was delivered using a flip chart for 10 minutes, followed by a review activity where participants demonstrated their understanding of food selections using the flip chart for another 10 minutes. A five-minute role model video showcasing an individual successfully managing MetS was presented. Participants were also given a five-minute explanation of how to use the LINE OA. The session concluded with a demonstration of MSA and brisk walking, followed by a return demonstration from participants, lasting 10 minutes. Participants were encouraged to exercise for at least 30 minutes daily, five days a week, for 12 weeks at home.

Session 2 (Weeks 1, 3, 5, 7, 9, and 11: Online Education via LINE OA). An automated system was developed to deliver online health education through LINE OA. This system provided participants with infographics, exercise videos, and messages, enabling them to review health-related information conveniently. Additionally, participants could contribute additional content to the rich menu within the LINE OA system. This approach allowed for independent learning and facilitated engagement with health information at their own pace.

Session 3 (Weeks 2, 4, 6, 8, 10, and 12: Follow-up via LINE OA and Phone Calls). In this session, follow-up interactions were conducted via LINE OA messages and phone calls, each lasting 10 to 20 minutes. The researchers assessed participants’ adherence to health behavior modifications by inquiring about their physical activity frequency, dietary choices, mood, and habits related to smoking and alcohol consumption. Additionally, participants received solutions and positive reinforcement to help them sustain healthy behaviors. They were also encouraged to ask questions regarding health behavior modification through LINE OA, ensuring continuous support and motivation throughout the program.

Table 1 The self-efficacy enhancement program protocol

Activity (week)	Description of intervention	Duration
The Self-Efficacy Enhancement program by researchers (week 1-12)	**Session 1: (First week: Face-to-Face Educational Sessions)**	
	• Provide information about MetS using a flip chart	10 minutes
	• Return demonstration of food selections using a flip chart	10 minutes
	• Show VDO of a role model successfully managing MetS	5 minutes
	• Practice using LINE OA	5 minutes
	• Demonstrate and return demonstration of MSA with brisk walking and encouraged to exercise for at least 30 minutes a day, five days a week, at home for 12 weeks	10 minutes
	Session 2: (Weeks 1, 3, 5, 7, 9, and 11: Online Education via LINE OA)	
	• Deliver online education, including infographics and exercise videos	
	• Send messages to review information and contribute additional content to the rich menu	
	• Provide the opportunity to study health information via the rich menu independently	
	Session 3 (Week 2, 4, 6, 8, 10, and 12: Follow-up via LINE OA and Phone Call)	10 to 20 minutes
	• Follow-up sessions on health behavior modification through messages via LINE OA and phone calls	
	• Assess the potential for health behavior modification, including exercise, physical activity, dietary choices, mood, smoking, and alcohol consumption	
	• Encourage participants to maintain healthy behaviors by providing solutions and positive reinforcement. Additionally, motivate them to ask health behavior modification questions through LINE OA	

Data Collection

Medical records of people with MetS were reviewed to identify eligible participants. Registered nurses at each site conducted purposive sampling and matched participants by gender and age (within 5–10 years). Those interested were referred to the research team, which explained the study, activities, and withdrawal rights. Written informed consent was obtained. A total of 72 participants were enrolled, with 36 per group. The healthcare settings were randomly assigned to the control or experimental group. Data were collected by an independent research assistant (RA) with experience in chronic disease, who was blinded to the group assignment. Data collection occurred in weeks 1 and 13, including demographics (week 1 only), health behavior scores, and clinical outcomes (WC, FPG, SBP, DBP, TC, HDL, and non-HDL cholesterol).

Data Analysis

Data were analyzed using SPSS version 29. Descriptive statistics (frequency, percentage, mean, SD) were used. Chi-square tests compared categorical personal variables, and Fisher's exact test was used for occupations. An independent *t*-test analyzed age. The Shapiro-Wilk test was used to assess normality (N <50). At baseline, an independent *t*-test was used to compare SBP, DBP, TC, and non-HDL cholesterol; the Mann-Whitney U-test was employed for WC, FPG, and HDL cholesterol due to non-normal distributions. Within the experimental group, a paired *t*-test was used to analyze WC, FPG, DBP, TC, and non-HDL cholesterol. The Wilcoxon signed-rank test was used to assess SBP and HDL cholesterol due to non-normality. Lipid profile differences at baseline were controlled using ANCOVA, with baseline data as covariates. ANCOVA compared post-intervention health behaviors and clinical outcomes between groups, adjusting for baseline differences.

Ethical Considerations

This study was approved by the Human Research Ethics Committee of the Faculty of Medicine Ramathibodi Hospital, Mahidol University (COA No. MURA2023/540), and the Ethical Committee of Phrae Hospital (COA No. 59/2023). Participants received complete information about the study, including procedures, benefits, and rights (e.g., the right to withdraw without consequences). Informed consent was obtained. All data were kept confidential and reported in aggregate.

Results

Participants in this study were 72 individuals with MetS, divided into two groups of 36 participants each: an experimental group from Phrae Hospital Community Health Center (Rong Sor) and a control group from Thung Hong Health Promoting Hospital. Although the two groups were drawn from different healthcare settings, both were in urban areas and shared comparable dietary practices. The majority of participants were older adults, typically presenting with four components of MetS (including obesity, hyperglycemia, hypertension, and dyslipidemia) and being unemployed. Both settings offered similar standards of nursing care and healthcare services, as they operated under the same administrative framework of the Ministry of Public Health, Thailand. These services included health education, annual blood testing, medical consultations for prescriptions, and ongoing management of chronic diseases. There was one dropout case from the experimental group due to the inconvenience of returning for blood testing at the end of the program, and one outlier participant from the control group was identified. Therefore, two cases were removed from the data analysis (2.78%, n = 1 in each group). Finally, 35 participants per group (N = 70) completed the study. Most participants in both the experimental and control groups were female (65.7% and 65.7%, respectively), with mean ages of 64.0 years (SD = 7.8) and 63.3 years (SD = 7.7), respectively. Most participants were married (68.6% and 42.9%) and unemployed (51.4% and 42.9%, respectively). The average monthly family income exceeded 10,000 baht for 45.7% and 37.1% of the respondents, respectively. Most participants met the four criteria of MetS (62.9% and 57.1%, respectively). All variables were similar between the two groups except for education level and marital status (Table 2).

Table 2 Demographic data of participants (*N* = 70)

Demographic data	Experimental group (*n* = 35)	Control group (*n* = 35)	Statistical value	*p*-value
	F (%)	*F* (%)		
Gender			0.000[a]	1.000
Male	12 (34.3)	12 (34.3)		
Female	23 (65.7)	23 (65.7)		
Age (years)	Mean = 64.0, SD = 7.8 (range = 44–78)	Mean = 63.3, SD = 7.7 (range = 48–75)	0.370[t]	0.712
Education level			15.759[a]	0.000**
Primary	10 (28.6)	24 (68.6)		
Secondary	10 (28.6)	9 (25.7)		
Tertiary	15 (42.9)	2 (5.7)		
Marital status			6.707[a]	0.037*
Single	8 (22.86)	9 (25.71)		
Married	24 (68.57)	15 (42.86)		
Widow/divorced	3 (8.57)	11 (31.43)		
Present occupation			8.197[b]	0.053
No work	18 (51.4)	15 (42.9)		
Employee	4 (11.4)	11 (31.4)		
Merchant	9 (25.7)	7 (20.0)		
Agriculture	0 (0.0)	1 (2.9)		
Government servant	4 (11.4)	1 (2.9)		
Family income (baht/month)			2.920[a]	0.232
<5,000	15 (40.0)	11 (31.4)		
5,000–10,000	5 (14.3)	11 (31.4)		
>10,000	16 (45.7)	13 (37.1)		
Smoking status			0.729[a]	0.393
Non-smoker	33 (94.3)	31 (88.6)		
Smoker	2 (5.7)	4 (11.4)		
Drinking status			1.061[a]	0.440
Non-drinker	26 (74.3)	22 (62.9)		
Drinker	9 (25.7)	13 (37.1)		
Hypertension			0.729[a]	0.673
Yes	33 (94.3)	31 (88.6)		
No	2 (5.7)	4 (11.4)		
Diabetes mellitus			0.952[a]	0.465
Yes	16 (45.7)	12 (34.3)		
No	19 (54.3)	23 (65.7)		
Impaired fasting glucose			0.000[a]	1.000
Yes	14 (40.0)	14 (40.0)		
No	21 (60.0)	21 (60.0)		
Dyslipidemia			2.917[a]	0.198
Yes	30 (85.7)	34 (97.1)		
No	5 (14.3)	1 (2.9)		
Number of MetS criteria			0.238[a]	0.808
3 criteria	13 (37.1)	15 (42.9)		
4 criteria	22 (62.9)	20 (57.1)		

Note: a = Chi-Square test, b = Fisher's exact test, *t* = Independent *t*-test, **p* <0.05, ** *p* <0.001

Table 3 Comparison of average health behaviors and clinical outcomes between the two groups at baseline (*N* = 70)

Dependent variables	Experimental group (*n* = 35)			Control group (*n* = 35)			Statistical value	*p*-value
	Range	Mean	SD	Range	Mean	SD		
Health behaviors (score)	59-110	85.80	10.06	73-105	88.80	8.01	-1.380[t]	0.172
WC (cm)	80-113	91.57	8.79	80-122	93.49	11.21	0.518[z]	0.605
FPG (ml/dl)	79-175	113.63	20.85	84-211	116.63	33.03	-0.517[z]	0.605
SBP (mmHg)	124-169	142.66	11.44	105-168	139.17	15.77	1.059[t]	0.294
DBP (mmHg)	67-101	83.23	7.73	61-103	84.89	10.37	-0.758[t]	0.451
TC (ml/dl)	132-272	196.69	32.48	150-272	212.97	32.44	-2.099[t]	0.040*
HDL cholesterol (ml/dl)	36-93	57.80	15.30	29-95	47.89	14.90	-2.938[z]	0.003**
Non-HDL cholesterol (ml/dl)	83-201	137.54	31.52	115-229	165.17	28.66	-3.837[t]	0.000***

Note: t = Independent *t*-test, *z* = Mann-Whitney U-test, * <0.05, **<0.01, ***<0.001

At baseline, health behaviors and clinical outcomes were not significantly different between groups (*p* >0.05), except for TC, HDL cholesterol, and non-HDL cholesterol, which were significantly different between the experimental and control groups (*p* <0.05) (Table 3).

Comparisons of the mean scores of the health behaviors and clinical outcomes between the experimental group at baseline and after receiving the SEE program are presented in Table 4, using the Paired *t*-test and Wilcoxon signed-rank test. At the finishing of the program, the experimental group showed a significant improvement in health behaviors (t = -12.830, p <0.001), reduced WC (t = 3.809, p <0.001), lower SBP (z = -4.554, p <0.001), lower DBP (t = -5.178, p <0.001), and higher HDL cholesterol (z = -3.193, p <0.001) compared to baseline measurements. Effect sizes, as measured by Cohen's d and r, showed large effects for health behaviors, WC, SBP, DBP, HDL cholesterol, and non-HDL cholesterol, while SBP and DBP demonstrated medium effect sizes. However, there were no significant differences in FPG, TC, and non-HDL cholesterol at the end of the program.

Table 4 Comparison of average health behaviors and clinical outcomes at baseline and after conducting the program in the experimental group (n = 35)

Dependent variables	Before		After		Statistical value	*p*-value	Effect Size
	Mean	SD	Mean	SD			
Health behaviors (score)	85.80	10.06	105.89	5.96	-12.830^t	0.000**	-4.90^d
WC (cm)	91.57	8.79	88.46	8.89	3.809^t	0.001*	-31.10^d
FPG (ml/dl)	113.63	20.85	114.66	23.56	-0.527^t	0.602	0.38^d
SBP (mmHg)	142.66	11.44	114.66	23.56	-4.554^z	0.000**	-0.77^r
DBP (mmHg)	83.23	7.73	78.34	7.52	5.178^t	0.000**	23.29^d
TC (ml/dl)	196.69	32.48	193.86	39.24	0.549^t	0.587	-0.42^d
HDL cholesterol (ml/dl)	57.80	15.30	62.14	17.34	-3.193^z	0.001*	-0.54^r
non-HDL cholesterol (ml/dl)	137.54	31.52	135.46	32.91	0.575^t	0.569	-1.50^d

Note: t = Paired *t*-test, z = Wilcoxon signed rank test, d = effect size for Paired *t*-test, r = effect size for Wilcoxon signed rank test, * <0.01, **<0.001

Table 5 Comparison of average health behaviors and clinical outcomes after conducting the program between two groups (N = 70) using ANCOVA

Dependent variables	Source of variation	Sum of squares	*df*	Mean square	*F*	*p*-value	Effect size (η²)
Health behaviors (score)	SEE program	5279.44	1	5279.44	193.86	0.000**	0.750
	Pretest	638.07	1	638.07	23.43	0.000	0.650
	Error	1824.62	67	27.23			
	Total	673893.00	70				
WC (cm)	SEE program	270.91	1	270.91	19.58	0.000**	0.883
	Pretest	6426.13	1	6426.13	464.34	0.000	0.874
	Error	927.24	67	13.84			
	Total	592171.07	70				
FPG (mg/dL)	SEE program	2927.40	1	2927.40	12.39	0.000**	0.776
	Pretest	50524.37	1	50524.37	213.76	0.001	0.761
	Error	15836.09	67	236.36			
	Total	1123191.00	70				
SBP (mmHg)	SEE program	3873.33	1	3873.33	25.04	0.000**	0.502
	Pretest	7819.95	1	7819.95	50.54	0.000	0.430
	Error	10365.99	67	154.72			
	Total	1368298.00	70				
DBP (mmHg)	SEE program	681.19	1	681.19	19.49	0.000**	0.660
	Pretest	3533.32	1	3533.32	101.11	0.000	0.601
	Error	2341.31	67	34.94			
	Total	479035.00	70				
TC (mg/dL)	SEE program	494.51	1	494.51	0.615	0.436	0.479
	Pretest	43664.82	1	43664.82	54.29	0.000	0.448
	Error	53883.35	67	804.23			
	Total	2986757.00	70				
HDL cholesterol (mg/dL)	SEE program	10.38	1	10.38	0.156	0.694	0.777
	Pretest	13736.51	1	13736.51	206.27	0.000	0.755
	Error	4461.76	67	66.59			
	Total	247999.00	70				
Non-HDL cholesterol (mg/dL)	SEE program	9567.61	1	9567.61	8.49	0.005*	0.116
	Pretest	211.96	1	211.96	0.19	0.666	0.666
	Error	75542.61	67	1127.36			
	Total	1602156.00	70				

Note: * <0.01, **<0.001

Using ANCOVA to compare the significant difference in health behaviors and clinical outcomes between groups after controlling the covariance, the finding showed that the experimental group had significantly higher health behaviors (F = 193.86, p < 0.001), lower WC (F = 19.58, p <0.001), lower FPG (F = 12.39, p <0.001), lower SBP (F = 25.04, p <0.001), lower DBP (F = 19.49, p <0.001), and lower non-HDL cholesterol (F = 8.49, p <0.01) than the control group. Effect sizes, as measured by partial eta-squared (η²), indicated a large effect for health behaviors, WC, FPG, SBP, DBP, TC, and HDL cholesterol. In comparison, non-HDL cholesterol demonstrated a medium effect size. However, there were no significant differences in TC and HDL cholesterol after finishing the program (**Table 5**).

Additional findings from this study indicated that no participants experienced any side effects or harm because of participating in the SEE program. Participants' feedback suggested that the program was perceived as beneficial, particularly in enabling access to health information at any time and from anywhere. While many participants struggled to recall all the content presented on the first day, they valued the opportunity to revisit information through LINE OA, which offers a rich menu of topics to select from. Additionally, the program assisted participants in setting and achieving goals for managing MetS, functioning as a motivational tool, and engaging in healthy behaviors. Participants were also able to communicate directly with the researchers by sharing images of their meals or engaging in discussion on health-related topics, which fostered ongoing support and engagement. However, some participants expressed that using LINE OA can be challenging, especially because the small font sizes in infographics are hard to read for individuals with vision problems. Additionally, some participants reported difficulties in maintaining a consistent exercise routine.

Discussion

The SEE program significantly improved health behaviors and clinical outcomes among Thai individuals with MetS, leading to reductions in WC, SBP, DBP, FPG, and non-HDL cholesterol. Grounded in Bandura's Self-Efficacy Theory (Bandura, 1997), the program strengthened participants' confidence in adopting and maintaining healthier behaviors by incorporating four main sources: enactive mastery experiences, vicarious experiences, verbal persuasion, and physiological and affective states.

The face-to-face educational sessions in this study provided MetS-related knowledge on disease control and the performance of health behaviors, including food intake management, such as demonstrating appropriate food selection and decreasing the consumption of sweet, oily, and salty foods; engaging in regular exercise; emotional management; smoking cessation; and limiting alcohol consumption. These strategies, supported by verbal persuasion and affective engagement, align with previous studies demonstrating increased self-efficacy in practicing health behaviors (Rojruangnon et al., 2021; Wutthitham et al., 2020), significant improvements in health behaviors (Rojruangnon et al., 2021; Sandee et al., 2017; Silachaln et al., 2019), and reductions in WC (Silachaln et al., 2019), FPG (Rojruangnon et al., 2021; Sandee et al., 2017), SBP, and DBP (Wutthitham et al., 2020).

The SEE program integrated LINE OA as an e-health platform to provide educational content on MetS, including exercise videos and infographics, and to facilitate follow-ups. This further promoted self-confidence in changing and maintaining healthy behaviors through verbal persuasion, accompanied by physiological and affective reinforcement. The use of the LINE application as a digital health tool is particularly relevant in the Thai context, where it is widely adopted and accessible. The present findings align with previous interventions using the LINE application, which targeted individuals at risk for MetS. Notably, the program's use of infographics about MetS resulted in a significant reduction in FPG (Maneenithiveth, 2020). Weekly telephone follow-ups also contributed to improvements in health behaviors, significantly decreasing WC among people with MetS (Silachaln et al., 2019) and lowering HbA1c levels in older adults with diabetes (Tan et al., 2020). International studies have utilized health applications (Lee et al., 2020; Wong et al., 2021) and wearable devices (Lee et al., 2020) to collect health data, monitor activities, and deliver advice via text messages over 12 weeks, showing positive results in enhancing health behaviors and increasing participants' confidence in exercising.

Learning through a role model, exemplifying vicarious experience, can be highly effective for individuals from similar backgrounds who have successfully changed their lifestyles and improved their MetS profiles. Wutthitham et al. (2020) reported that role models increased participants' confidence in adopting healthy behaviors, such as reducing salt intake, exercising regularly, and managing emotions, resulting in improved SBP and DBP. Similarly, previous studies confirm the positive impact of role models on self-efficacy and their contribution to significant improvements in health behaviors (Rojruangnon et al., 2021; Sandee et al., 2017; Silachaln et al., 2019), reductions in WC (Silachaln et al., 2019), and FPG (Rojruangnon et al., 2021; Sandee et al., 2017).

Performing muscular strengthening activities (MSA) with brisk walking in this study improved WC, SBP, DBP, FPG, HDL cholesterol, and non-HDL cholesterol. Previous studies support these findings. Silachaln et al. (2019) reported significant WC reductions after an eight-week MSA program (30–45 minutes, 4–6 days per week). Lee et al. (2014) found that a 12-week walking program (30–50 minutes, three days per week) with health education reduced BMI and SBP. In the present study, participants were trained to perform MSA through brisk walking for at least 30 minutes a day, five days a week, over 12 weeks. To support their exercise routine, they received automated text message reminders via LINE OA, and researchers conducted follow-ups to record the duration and frequency of exercise using a researcher-designed form. However, the text message reminders alone might not have been sufficient to motivate participants to exercise consistently. MSA with brisk walking activates the metabolic process. Regular brisk walking helps convert blood sugar into glycogen for energy, reduces body fat and FPG, and improves blood vessel elasticity, musculoskeletal, and cardiovascular systems (Opoku et al., 2023). Moreover, MSA increases lean mass by reducing lipid tissue, and adipose tissue regulates insulin sensitivity and glycolytic capacity, thereby improving glucose metabolism (Grøntved et al., 2014).

The SEE program enhanced confidence through enactive mastery experiences supported by verbal persuasion, demonstrations, and return demonstrations. Repeated successful experiences and motivation helped participants maintain exercise behaviors. Participants gained self-confidence through structured activities, MetS knowledge sessions during the first week, ongoing education via LINE OA, and role modeling from peers.

However, participants in the experimental group did not demonstrate statistically significant reductions in FPG, TC, or non-HDL cholesterol over time, which contrasts with previous studies of the SEE program. Several factors may explain these differences. First, the present study primarily involved older adults, typically characterized by lower metabolic rates. In contrast, Rojruangnon et al. (2021) reported significant FPG improvements among younger adults with pre-diabetes and fewer MetS criteria. Older individuals often face physiological challenges in regulating glucose and lipid metabolism (Zhang et al., 2023). Similarly, Lee et al. (2014) found that older adults did not achieve significant reductions in FPG or TG following a 12-week walking program. Additionally, many participants in the current study had relatively well-controlled FPG levels at baseline, possibly limiting observable improvements.

The 12-week intervention duration may also have contributed to the lack of significant changes. Maneenithiveth (2020) reported improvements in FPG and TC after a six-month lifestyle modification program. A longer intervention, emphasizing dietary control and physical activity, may be required to yield measurable metabolic improvements in older adults with multiple MetS components.

Cultural dietary habits may have further influenced the non-significant changes. Although the program provided health education through multimedia, it did not restrict daily dietary intake. This decision aimed to preserve everyday eating patterns and reduce participant burden, but it introduced confounding variables. In Northern Thailand, staple foods like sticky rice and noodles are high in sugar and often prepared with oils, which can hinder glycemic control (Yeemard et al., 2022). Cultural festivals during data collection also affected adherence, especially regarding food choices. Sticky rice, for instance, was difficult to replace with alternatives like regular rice, which is viewed as less satisfying (Yeemard et al., 2022). These challenges suggest the need for culturally sensitive strategies in future interventions.

While FPG showed significant group differences post-intervention, its reliability as a short-term indicator is limited. FPG levels can fluctuate due to recent food intake and other short-term factors. HbA1c, by contrast, reflects long-term glycemic control and may be a more appropriate biomarker in future research. Additionally, many participants had diabetes and comorbidities, including hypertension, dyslipidemia, and obesity, which complicate glucose regulation and often require more time to observe clinical improvements (Fahed et al., 2022). Longer intervention periods, extending beyond 12 weeks, are recommended for evaluating sustained outcomes.

There were no significant group differences in TC and HDL cholesterol. Most participants were older, had four MetS components, and consumed traditional oily foods during festivals, which may have influenced inflammation and adipose tissue dysfunction (Chia et al., 2018). Moreover, baseline TC and HDL cholesterol levels were within standard criteria (Anderson et al., 2016), potentially limiting post-intervention changes. These results align with previous findings (Maneenithiveth, 2020; Wong et al., 2021).

Non-HDL cholesterol, a significant CVD risk marker calculated as TC minus HDL cholesterol (Dobrowolski et al., 2022), showed notable differences between groups, suggesting the program's potential to reduce CVD risk. However, unlike LDL cholesterol, non-HDL cholesterol is not yet a common clinical endpoint in MetS studies. Maneenithiveth (2020), for example, focused on LDL cholesterol. Future research should consider validating non-HDL cholesterol as an outcome.

Participants were on various chronic medications, including for hypertension, diabetes, and dyslipidemia. Researchers collected data before and after the intervention, instructing participants to fast for eight hours prior to blood tests, which were conducted between 7:00 and 8:00 a.m. during medical appointments. Health behaviors related to diet and physical activity were self-reported and relied on participant honesty. While FPG and TC are sensitive to recent food intake, unmeasured variables, such as medication use, may have also influenced the outcomes. Future studies should integrate medication data into the analysis.

Although the SEE program promoted health behavior change among older adults with MetS, several areas for improvement emerged. Vision-related difficulties hindered some participants from engaging with infographics. Future interventions should consider voice-based content and accessible visual formats to enhance user experience. Additionally, online communication may lack emotional nuance compared to in-person interaction. Features like step counters, exercise logs, and clinical outcome tracking may enhance motivation and engagement. Incorporating wearable devices may further improve long-term adherence and outcomes.

Limitations of the Study

This study was conducted in a single province in Thailand, which may limit generalizability. The use of purposive sampling may have introduced selection bias, affecting internal validity. Future studies should use random sampling and ensure allocation concealment to minimize selection bias. Although spatial separation between study sites reduced contamination, consistency in context must be managed. Medication use data were not included, which may have influenced clinical outcomes. Lastly, the 12-week duration may have been insufficient to produce significant changes in certain cardiovascular markers. Longer interventions are needed for sustained improvements.

Implications for Nursing Practice

The findings from this study highlight several important implications for nursing practice and future research. Firstly, the SEE program demonstrated significant effectiveness in improving health behaviors and clinical outcomes among individuals with MetS. This suggests that the program could be integrated into routine nursing care as a structured behavioral intervention. Nurses, as primary healthcare providers, can deliver the SEE program through both in-person sessions and digital platforms, such as LINE OA, to extend support beyond clinical visits. This blended approach can promote sustained behavior change without increasing the burden on clinical staff, making it a practical strategy in resource-limited or high-volume healthcare settings.

Moreover, the study supports the role of e-health tools in facilitating health promotion. The LINE OA platform, widely used in Thailand, proved to be an accessible and acceptable method for delivering health education, tracking behaviors, and providing ongoing motivation. Its use in nursing practice can enhance continuity of care, especially in managing chronic diseases like MetS. However, as some participants faced challenges using visual infographics due to age-related vision problems, future implementations should consider accessibility by incorporating voice-over content or larger, more readable formats.

The program's theoretical foundation in Bandura's Self-Efficacy Theory highlights the importance of fostering confidence in patients' ability to engage in health-promoting behaviors. Nursing education and practice should emphasize the application of such behavior change theories. Nurses can utilize techniques such as role modeling, verbal encouragement, and guided skill-building to empower individuals to take ownership of their health. The emphasis on personalized support also aligns with the principles of holistic and patient-centered nursing care.

Cultural factors played a significant role in the program's outcomes. Dietary patterns, particularly the consumption of sticky rice and oily foods during festivals, impacted participants' ability to adhere to dietary recommendations. Therefore, it is essential that nurses are culturally competent and capable of delivering context-sensitive advice that respects local traditions while promoting healthier alternatives. This approach can increase patient engagement and long-term adherence to recommended behaviors.

Conclusion

The SEE program for individuals with MetS improved health behaviors and had a positive impact on central obesity, blood glucose, blood pressure, and lipid profiles. However, no significant changes in FPG, TC, or non-HDL cholesterol were found compared to baseline, possibly due to the short program duration. No significant differences in TC and HDL cholesterol were found between groups, potentially due to medication factors, although these values remained within normal ranges. Importantly, the experimental group showed a significant decrease in non-HDL cholesterol, indicating reduced CVD risk. Future research should extend the program duration beyond 12 weeks, include additional markers such as HbA1c, and monitor medication adjustments to better evaluate clinical outcomes.

Declaration of Conflicting Interest

No conflict of interest to declare.

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Authors' Contributions

All authors contributed equally to the substantial involvement in the conception and design of the research, data acquisition and analysis, drafting and revising of the manuscript, final approval of the version to be published, and assuming accountability for all aspects of the work.

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Data Availability

The dataset generated during and analyzed during the current study is available from the corresponding author upon reasonable request.

Declaration of Use of AI in Scientific Writing

None to declare.

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