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Research Article

Mobile App–based Self-monitoring of Health Behaviors in Middle-aged Men After Myocardial Infarction: A One-year Randomized Controlled Trial

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S U M M A R Y

Purpose: Middle-aged men after myocardial infarction (MI), particularly those at risk for heart failure, require sustained health behaviors for effective long-term self-care. This study evaluated the 1-year efficacy of a mobile app–based weekly self-monitoring program grounded in the information-motivation-behavioral skills model.
Methods: A single-blind, randomized controlled trial was conducted with 68 post-MI men who underwent percutaneous coronary intervention and had a left ventricular ejection fraction < 50%. Participants were randomly assigned to the experimental group ($n = 35$), who used *With Your Heart*, a mobile app developed for this study. The app included a weekly self-monitoring checklist with algorithm-based feedback, and participants additionally received nurse counseling during outpatient visits every 3 months. The control group ($n = 33$) received standard lifestyle education through a leaflet at the baseline. Outcomes were measured at the baseline, 3 months, 6 months, and 12 months. Data were analyzed using repeated-measures analysis of variance to examine group × time interactions, with Bonferroni correction applied for *post hoc* comparisons.
Results: Average age of the experimental group was 58.01 (±8.52) years and 57.35 (±9.63) years in the control group. Overall, 85.3% experienced a first-time MI, whereas 14.7% had a recurrent MI. Significant group × time interaction effects were found for health behaviors ($F = 10.24$, $p<.001$) and illness perception ($F = 3.15$, $p = .026$). The experimental group demonstrated sustained improvements in health behaviors across all follow-up points and reduced negative illness perception at 3 and 6 months. Resilience was significantly higher in the experimental group overall, although no interaction effect was observed. Depression decreased over time in both groups, with no between-group differences.
Conclusion: Weekly app-based self-monitoring significantly improved health behaviors and favorably influenced psychological outcomes, particularly illness perception and resilience, in middle-aged post-MI men at risk for heart failure. These findings support app-based self-monitoring as a feasible digital healthcare strategy to promote lifestyle modification for at-risk patients during outpatient care.

Introduction

As the population ages, heart failure (HF) is rapidly increasing and represents a major global health burden [1]. In Korea, the prevalence of HF has tripled in recent years, with ischemic heart disease accounting for 37.6% of cases [2]. In a national cohort of 10,524 patients aged 40–69 years with myocardial infarction (MI),

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82.2% were men, and after 6 years, 5.2% developed HF [3]. Predictors of HF progression in post-MI patients include advanced age, hypertension, and structural changes such as reduced left ventricular ejection fraction (LVEF) [3,4]. MI is, therefore, a leading cause of HF, and prevention of progression requires not only medication adherence and risk factor control but also sustained lifestyle modification, particularly among patients with reduced LVEF [1,5,6]. Continuous self-care adherence is essential to prevent adverse outcomes in post-MI patients [7], underscoring the importance of effective nursing interventions.

However, many post-MI patients struggle with maintaining healthy behaviors and managing comorbidities despite treatment [5]. While rehabilitation programs often improve short-term adherence, sustaining long-term lifestyle changes such as diet and medication adherence remains difficult due to limited support and motivation [6]. A meta-analysis of randomized controlled trials found that nurse-led lifestyle interventions significantly reduced blood pressure, fasting blood glucose, total cholesterol, readmission rates, and psychological distress [8]. These findings underscore the need for continuous interventions that reinforce self-care in post-MI patients at risk for HF.

In a Korean acute MI registry study with 13,104 participants, 75.9% were men, with a mean age of 60.7 years, and 75.3% were smokers [9]. Compared with women, middle-aged men are more likely to exhibit lifestyle risk factors such as obesity and smoking, often as a means of coping with work-related stress and a company dinner culture that emphasizes alcohol consumption and social bonding [9,10]. This highlights the necessity of promoting healthy lifestyle modification among middle-aged men recovering from MI.

To maximize the efficacy of nursing interventions for lifestyle modification, it is important to consider psychological and motivational factors that influence self-care. Illness perception shapes perceived threat, control, and the necessity of action, with more accurate and less negative perceptions linked to better adherence and health-promoting behaviors [11,12]. Depression, present in about 20% of patients with cardiovascular disease and in up to two-thirds of patients after MI, is consistently associated with poor medication adherence, inadequate self-management, and worse outcomes [13]. Negative illness perceptions are further linked to greater depressive symptoms [14]. In contrast, resilience facilitates coping and resource utilization and is associated with improved health behaviors and reduced cardiovascular risk [15,16]. Therefore, including illness perception, depression, and resilience as secondary outcomes is justified as interventions for post-MI patients should address not only health behaviors but also these psychological factors that drive behavior change.

With rapid advances in digital healthcare, mobile health (mHealth) technologies such as wearable devices and smartphone applications (apps) are increasingly used in cardiovascular disease management [17]. Unlike brief and infrequent clinic-based encounters, mHealth programs provide continuous monitoring and support in daily life, extending the reach of secondary prevention. App-based interventions have improved adherence to healthy diet, physical activity, sedentary behavior, exercise capacity, and blood glucose control [18]. A meta-analysis of nurse-led remote interventions further showed that digital approaches enhanced quality of life through symptom monitoring and timely feedback in patients with chronic diseases [19]. Recent evidence indicates that smartphone app–based interventions enhance self-management behaviors and psychosocial outcomes in patients with coronary heart disease, with self-monitoring, feedback, and education identified as key components of effective mHealth programs [20,21]. Collectively, these findings suggest that mobile apps may play an important role in secondary cardiovascular prevention, particularly when sustained engagement and personalized features are combined with nurse support.

This study was guided by the information-motivation-behavioral skills (IMB) model [22], which posits that health behavior change occurs when patients are adequately informed, motivated, and equipped with the necessary skills. In this intervention, information was delivered through face-to-face education, a standardized leaflet, and in-app lifestyle resources. Motivation was enhanced by individualized nurse counseling and algorithm-based feedback aimed at improving cognitive and affective representations of illness (e.g., reducing negative illness perception) and addressing depressive symptoms that undermine adherence. Behavioral skills were strengthened by weekly app-based self-monitoring, which facilitated reflection, progress tracking, and action planning.

Despite growing evidence for mHealth interventions, little is known about their long-term psychological and behavioral effects in middle-aged men after MI, who often experience high stress, lifestyle risks, and limited access to conventional rehabilitation. Therefore, this study evaluated the 1-year effects of an IMB-based, app-supported weekly self-monitoring program on health behaviors (primary outcome) and on resilience, illness perception, and depression (secondary outcomes) in this risk group. The hypotheses of this study were as follows: compared with the control group, the experimental group would demonstrate significantly greater improvements over time (group $\times$ time interaction) in (1) health behaviors, (2) resilience, and (3) illness perception, as well as greater reductions in (4) depression.

Methods

Research design

In this study, we developed a smartphone app to improve health behaviors for self-care in post-MI male patients and verified its efficacy using a controlled experimental design with random assignment. This was a two-group, single-blind, randomized controlled study, registered in the Korea Clinical Research Information Service (http://www.cris.nih.go.kr), and the registration number was KCT0009112. This study adhered to the Consolidated Standards of Reporting Trials (CONSORT) guidelines.

Research participants

Eligible participants were male outpatients who underwent percutaneous coronary intervention after MI at two university hospitals in Seoul, Korea. Inclusion criteria were as follows: (1) LVEF <50% on echocardiography within 3 months of MI diagnosis, classified as Stage B HF (at risk) according to the American College of Cardiology/American Heart Association (ACC/AHA) guidelines, requiring lifestyle modification and self-care; (2) physician-confirmed early or risk-stage HF; (3) no ventricular assist device; (4) stable physical condition without cognitive dysfunction; and (5) ability to use a smartphone and willingness to participate. Exclusion criteria included participation in other structured exercise or cardiac rehabilitation programs. In the experimental group, adherence to the mobile app was monitored throughout the study. Participants were required to complete at least two-thirds ($\geq$66.7%) of the weekly self-monitoring checklists; failure to meet this threshold was regarded as insufficient participation and was considered a dropout. To provide objective evidence of app use, adherence was additionally tracked using in-app logs, including checklist completion rates and login frequency.

For sample size estimation, we used a repeated-measures within–between interaction analysis of variance (ANOVA) in

G*Power version 3.1.9 (Heinrich Heine University Düsseldorf, Düsseldorf, Germany). Based on prior literature reporting changes in self-care behaviors after 1 year of small-group education in post-MI patients [23], we assumed a conservative effect size of $f = 0.25$. With a power of .80, we assumed a two-sided significance level of .05, two groups, four repeated measurements, an assumed correlation among repeated measures of .50, and a nonsphericity correction of $\varepsilon = 1.00$. Under these assumptions, a minimum of 26 participants per group (52 in total) was required. To account for an anticipated dropout rate of 20%, we aimed to recruit at least 33 participants per group (66 in total). The final analyzed sample included 68 participants, exceeding this requirement.

After reviewing electronic medical records, 94 male patients met the eligibility criteria. Of these, 88 were randomized at a 1:1 ratio to the experimental or control group using computerized random numbers with permuted block randomization (block size = 4) [24]. The randomization sequence was generated by a researcher who was independent of patient enrollment. Allocation concealment was ensured by sequential assignment according to outpatient visit order using sealed opaque envelopes. After baseline assessment, a blinded research assistant administered the survey. All data collectors remained blinded to group assignments throughout the study to minimize bias. Over the 12-month study period, 20 patients dropped out and data from 68 patients (35 experimental, 33 control) were analyzed (Figure 1).

Research procedure

Development of the 'With Your Heart' app

A smartphone app, *With Your Heart*, was developed from February to June 2021 in collaboration with a developer following academic guidelines on post-MI self-care. The app was designed to enhance motivation for lifestyle modification and included a weekly checklist for self-reflection with algorithm-based individualized feedback. It was built on the android system and made available via Google Play (Google LLC, Mountain View, CA, USA), with both user and administrator interfaces supported by a management server and database. Participants logged in using their name and birthdate for self-monitoring, and their checklist results were graphically displayed for use during nurse counseling at outpatient visits every 3 months.

The app's weekly self-monitoring checklist includes the lifestyle recommendations for cardiovascular health organized by the Korea Disease Control and Prevention Agency [25]. The checklist consisted of 11 multiple-choice questions assessing self-care behaviors during the past week, with two additional questions for participants with diabetes. Participants selected one of four response options ("always," "often," "sometimes," or "never"). The questions are as follows: (1) Did you feel irritated or angry because something bothered you? (2) Did you take your prescribed medications at the prescribed times? (3) Did you experience chest pain or discomfort in daily life? 4) Did you experience shortness of breath in daily life? (5) Did you try to eat healthy foods (not too salty)? (6) Did you limit your intake of high-cholesterol foods? (7) Did you regularly perform muscle-strengthening exercises for at least 30 minutes? (8) Did you regularly perform aerobic exercise for at least 30 minutes? (9) Did you refrain from smoking? (10) Did you measure your blood pressure? (11) Did you measure your body weight? Two questions were added for diabetes management as follows: (12) How often did you consume snacks (e.g., bread, rice cakes, fruit) in addition to regular meals? (13) Did you check your blood glucose level every day as instructed by your physician?

Participants received immediate individualized feedback, including an animated nurse image and sound effects, based on their checklist results. This feedback was generated in a variety of messages using approximately 80 algorithms that address risk factors such as diabetes and smoking, thus increasing motivation for lifestyle modification. If a participant missed an item, a flashing '$\sqrt{}$' screen notification prompted them to review the checklist. The app offered additional information on improving behavior by clicking on unchecked items, along with feedback from the animated nurse. In addition, supplementary disease-related information was available for self-learning, covering topics such as MI treatment, complications, HF, dyslipidemia, and vascular age appraisal.

To establish the content validity of the developed mobile app, we invited seven experts (three cardiologists, three senior nurses with >10 years of cardiology experience, and one nursing professor). Five items addressed content clarity, accessibility, convenience, learning usefulness, and overall impression, and were evaluated using a 4-point Likert scale. The item-level content validity index (I-CVI) was calculated as the proportion of experts rating each item as 3 or 4, and the scale-level CVI (S-CVI/Ave) was calculated as the average of all I-CVIs. According to Lynn's criteria, an I-CVI $\geq$.78 and an S-CVI $\geq$.80 were considered acceptable [26]. The I-CVI values ranged from .86 to 1.00, and the overall S-CVI/Ave was .92, indicating excellent content validity. Based on expert feedback, we revised the login process and font size to improve usability. Subsequently, five post-MI outpatients pilot-tested the app, confirming usability after these revisions.

Intervention of the app 'With Your Heart'

The experimental group received 20 minutes of initial counseling education, including an educational leaflet explaining MI, treatment, and self-care behaviors. After an app tutorial, participants registered in the app and received text reminders for weekly self-monitoring. To encourage use of the app, text notifications were sent to smartphones once a week, and when necessary, researchers provided phone counseling. Participants had access to the app for 1 year (Table 1).

Once a week, when participants completed a self-monitoring checklist, they were informed of their status through various nurse animations and received praise, encouragement, and information on what to do next. The results of the checklist answered by the participants were transmitted and stored to the learning management system of the real-time app. The stored data were converted into graphics for use during nurse consultations. Starting 3 months into the study, the nurse researcher met with each participant every 3 months during their regular outpatient visits to provide health counseling based on these graphics.

The control group received the same educational leaflet on healthy lifestyle at the baseline and brief lifestyle-related counseling upon request. During routine outpatient visits every 3 months, participants also met with a nurse to complete study questionnaires. At these visits, they were able to ask simple questions, which were addressed with brief counseling.

Research variables

Health behaviors

With permission from the original author, we used Walker et al.'s Health-Promoting Lifestyle Profile [27], which had been adapted for Korean elderly populations through translation and back-translation [28]. The instrument consists of 25 items across five subdomains: health responsibility (6 items), exercise (4 items), eating habits (7 items), stress management (5 items), and no smoking (3 items). Each item is rated on a four-point self-report Likert scale (1 = never to 4 = always). Total scores range from 25 to 100, with higher scores indicating better health behaviors. At the

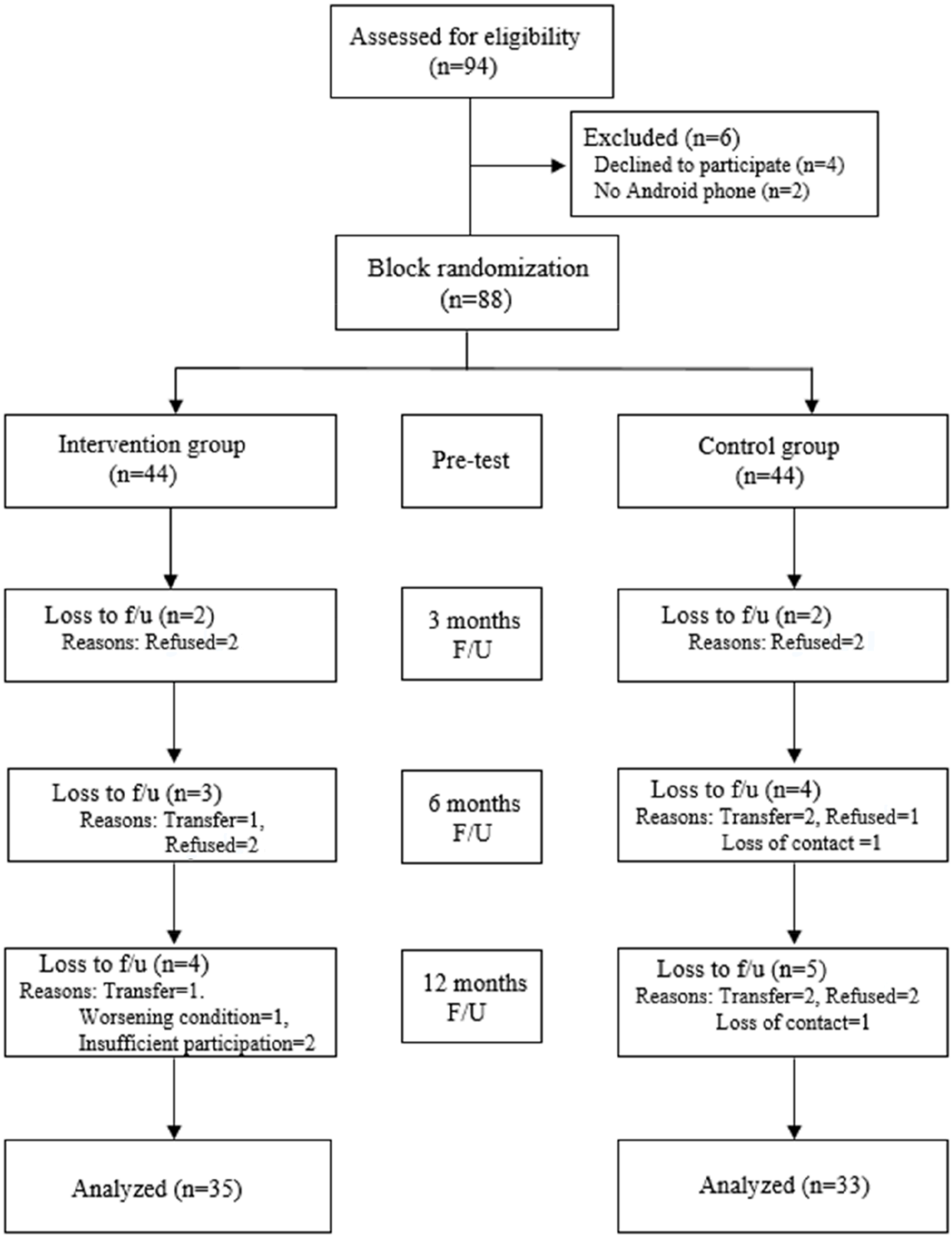

Figure 1. CONSORT flow diagram of the study.

time of development, the tool demonstrated a Cronbach α of .82 [27]. In the present study, Cronbach α was .92, with subscale values ranging from .82 to .91.

Resilience

With permission from the original author, we used the resilience tool developed by Shin [29] for patients with cardiovascular disease. This self-report questionnaire consists of 25 items across seven subdomains: supportive relationships (6 items), health practice ability (4 items), control ability (5 items), positive attitude (4 items), restoration beliefs (2 items), relationship with medical staff (2 items), and confidence to overcome (2 items). Each item is rated on a five-point Likert scale (*1 = strongly disagree to 5 = strongly agree*). Total scores range from 25 to 125, with higher scores indicating greater resilience. The instrument showed a Cronbach α of .84 at development [29]. In this study, Cronbach α was .94, and subscale values ranged from .78 to .89.

Illness perception

The illness perception was assessed using the Brief Illness Perception Questionnaire developed by Broadbent et al. [30], which was modified and validated in Korean by Seong [31]. We obtained permission from the author to use the tool. This tool comprises eight items with three reverse-scored items, each scored from 0 to 10. It ranges from 0 to 80; the higher the total score, the more negative the illness perception (i.e., perceived as threatening). At the time of development, the tool's Cronbach α was .73 [30], and in this study, Cronbach α was .70.

Table 1 *Contents of the Mobile App-based Self-Monitoring Intervention.*

Category	Self-monitoring using *'With Your Heart'* app		Nurse-led counseling & feedback
	Weekly self-care behavior check	Information for self-leaning	
Pretest	- Research enrollment - Pre-survey on research variables - Face-to-face education using an educational leaflet - Training on how to use the app		
Intervention using the smartphone app	- Monitoring health behavior using weekly checklist - Record any unusual changes in symptoms	- Myocardial infarction & healthy life - Complications & prognosis of myocardial infarction - Hypertension & diabetes	- Reminder text message sent every Sunday - Immediate text feedback by an animated nurse based on an algorithm that reflects the checklist results - Telephone consultation when necessary on app use
Nurse-led consultation (2 times)		- Heart failure - Dyslipidemia - My vascular age	- Individual face-to-face counseling based on the result of a self-checklist with graphic data during outpatient visits - Helping participants identify their strengths and barriers and encouraging healthy behaviors
Posttest - Post-survey on research variables - Gratitude for prior investigation and research cooperation			

Depression

Depression was measured using the Korean-validated version of the Patient Health Questionnaire-9 [32], originally developed by Kroenke et al. [33] This instrument consists of nine items scored on a 4-point Likert scale: 0 (*not at all*), 1 (*several days*), 2 (*more than half the days*), and 3 (*nearly every day*). The total score ranges from 0 to 27, with higher scores indicating more severe depressive symptoms. Cronbach α was .89 in the original validation study [33] and .91 in the present study.

Sociodemographic and clinical characteristics of participants

Sociodemographic characteristics collected through electronic medical records and patient interviews included age, marital status, education level, monthly income, occupation, and cohabitation status. Clinical characteristics included smoking status, body mass index, comorbidities, past and family history of cardiovascular disease, New York Heart Association (NYHA) class, duration since MI diagnosis, presence of MI recurrence, and LVEF values.

Data Collection Data collection was conducted at two university hospitals in Seoul from August 2021 to August 2023. Cardiologists were briefed on the study protocol and assisted with patient registration. Eligible patients visiting the cardiology outpatient department were screened and enrolled with cardiologist confirmation. Participants were informed about the voluntary nature of participation in the study and their right to withdraw without consequences, and confidentiality was ensured. Follow-up surveys at 3, 6, and 12 months were scheduled at fixed intervals from each participant's enrollment date. The first author, a clinical nurse, administered baseline surveys. Research assistants received training to enhance inter-rater reliability and conducted follow-up surveys. To minimize bias, coding and statistical analysis were performed by an independent research assistant and the corresponding author, neither of whom were involved in data collection.

Ethical consideration

This study was approved by the Institutional Review Board of the Hanyang University Hospital (HYUH-2020-12-025-008). Participants were informed of the study's purpose and procedures, provided written consent, and were assured they could withdraw at any time without disadvantage. Personal information was anonymized, used only for research purposes, and securely stored with access restricted to the researcher.

Data analysis

Data were analyzed using SPSS/WIN version 24.0 (IBM Corp., Armonk, NY, USA). Missing data occurred due to participant dropout during the follow-up period. Because repeated-measures ANOVA requires complete data across all measurement occasions, analyses were conducted using a per-protocol approach, including only participants who completed all follow-up assessments. No imputation methods were applied for missing data. The final analyzed sample, therefore, consisted of 68 participants. Valid participation in the smartphone app intervention was defined as completion of more than two-thirds of the weekly checklist items; only participants meeting this criterion were included in the per-protocol analysis.

Descriptive statistics were used to summarize participants' sociodemographic and clinical characteristics. Group differences at the baseline were assessed using χ^2 tests or independent *t* tests, with Fisher's exact test applied when expected cell counts were <5. Prior to conducting repeated-measures ANOVA, assumptions of normality and homogeneity were evaluated for all dependent variables. Normality was assessed using the Shapiro–Wilk test ($p > .05$ for all variables), inspection of Q–Q plots, and evaluation of skewness and kurtosis (absolute values < 2). Homogeneity of variances was tested using Levene's test, and sphericity was assessed with Mauchly's test. When the sphericity assumption was violated, the Greenhouse–Geisser correction was applied. Hypotheses were tested using repeated-measures ANOVA to evaluate group, time, and group × time interaction effects. When significant effects were identified, *post hoc* comparisons were conducted using Bonferroni-adjusted significance levels to control for Type I error. Independent *t* tests were additionally performed to compare mean differences between groups at each time point. Statistical significance was set at $p < .05$ (two-tailed).

Results

Participants' characteristics and homogeneity test

During the 12-month study period, nine participants in the experimental group (20.5%) and 11 participants in the control group (25.0%) dropped out due to discontinuation of participation, transfer to another hospital, worsening health condition, or invalid participation. In the experimental group, two participants at 3 months, three at 6 months, and four at 12 months dropped out, resulting in data from 35 participants being used in the final analysis. In the control group, two participants dropped out at 3 months, four at 6 months, five at 12 months, resulting in data from 33 participants being used in the final analysis (Figure 1).

At the baseline, the average age was 58.13 years (±8.52) in the experimental group and 57.35 years (±9.63) in the control group. Most participants were married and employed, and the majority had at least a high school education. About a third were of NYHA class II or III, while over half were current smokers. Approximately 83.8% of participants were diagnosed with ST-segment elevation myocardial infarction (STEMI), and 85.3% were first-time MI patients, with no significant difference between groups. At baseline, the mean LVEF (%) was 43.4 (±6.50) in the experimental group and 45.7 (±4.90) in the control group; the difference was not statistically significant ($t = -1.71$, df = 66, $p = .092$). Overall, 78% of participants had LVEF between 41–50% and 22% had LVEF <40%, indicating mild-to-moderate left ventricular dysfunction with no significant difference between the two groups (Table 2). No significant differences were found in the research variables of health behaviors, resilience, illness perception, and depression between the groups, confirming their homogeneity (Table 3).

Effects of mobile app intervention

Results of the repeated-measures ANOVA on the four research variables are summarized in Table 4. We examined differences over time, between groups, and group × time interactions to test the hypotheses. For health behaviors, a significant group × time interaction was found ($F = 10.24$, $p < .001$), supporting the hypothesis. In addition, there were significant main effects of time ($F = 13.33$, $p < .001$) and group ($F = 5.17$, $p = .026$). *Post hoc t* tests showed that the experimental group scored significantly higher than the control group at 3, 6, and 12 months (all $p < .05$). For resilience, no significant group × time interaction was observed; therefore, the hypothesis was not supported. A significant main effect of group was found ($F = 5.54$, $p = .022$), indicating that the experimental group reported higher resilience than the control group across all time points. For illness perception, a significant group × time interaction was observed ($F = 3.15$, $p = .026$), indicating that changes over time differed between groups. Accordingly, the hypothesis was supported. A significant main effect of time was also found ($F = 6.23$, $p < .001$), whereas the main effect of the group was not significant. *Post hoc* analyses revealed significant between-group differences at 3 and 6 months ($p < .05$), favoring the experimental group. For depression, scores in both groups decreased over time ($F = 3.55$, $p = .020$). However, neither the group × time interaction ($F = 0.74$, $p = .513$) nor the main effect of group ($F = 0.14$, $p = .708$) was significant. Therefore, the hypothesis for depression was not supported.

Discussion

In this study, we developed and evaluated a self-monitoring smartphone app in collaboration with an app developer to improve self-care in middle-aged men at risk for HF, validating its efficacy over a 1-year period. We selected a smartphone app as the intervention based on a systematic review of electronic device effectiveness in obesity interventions, which found that apps were particularly effective for men, who generally prefer self-monitoring and individualized feedback [34]. The experimental group self-monitored weekly using a checklist app, which strengthened their self-reflection and motivation to practice healthy behaviors. The app's use of a checklist is simple but we aimed to make healthy behavior a habit through repeated use every week. Utilizing algorithm-based text messages, an animated nurse provides individualized feedback, encouragement, and learning resources. Compared to previously reported mobile health interventions, our app demonstrates several distinctive features. While many prior programs focused primarily on exercise promotion [35] or short-term symptom monitoring [19], our app adopted a broader scope, incorporating weekly self-reflection

Table 2 *Homogeneity Test for Participant's Characteristics.*

Characteristics	Categories	Exp. ($n = 35$)	Con. ($n = 33$)	t/χ^2 or Fisher	p
		M±SD or n (%)			
Age (yr)		58.0 ± 8.5	57.3 ± 9.6	0.29	.772
Marital status	Married	21 (71.1)	24 (80.0)	0.72	.574
	Single/divorced	11 (28.9)	6 (20.0)		
Education	≤ Middle school	8 (21.1)	6 (20.0)	0.31	.949
	High school	13 (34.2)	12 (40.0)		
	≥ College	17 (44.7)	12 (40.0)		
Income (dollars)	≤4000/month	23 (60.5)	24 (80.0)	2.98	.115
	>4000/month	15 (39.5)	6 (20.0)		
Job	Yes	29 (76.3)	25 (83.3)	0.51	.556
	No	9 (23.7)	5 (16.7)		
Living together	Alone	4 (10.5)	3 (10.0)	0.01	1.000
	Spouse/children/family	34 (89.5)	27 (90.0)		
NYHA class	I	26 (68.4)	20 (66.7)	0.03	1.000
	II/III	12 (31.6)	10 (33.3)		
Smoking	None or ex-current	17 (44.7)	19 (63.3)	2.33	.149
		21 (55.3)	11 (36.7)		
Past history of CVD	Yes	24 (63.2)	17 (56.7)	0.30	.625
	No	17 (56.7)	13 (43.3)		
Family history of CVD	Yes	26 (68.4)	17 (56.7)	1.00	.448
	No	12 (31.6)	13 (43.3)		
Diagnosis	ST-elevation MI	30 (85.7)	27 (81.8)	0.01	1.000
	Non-ST-elevation MI	5 (14.3)	6 (18.2)		
MI type	First-time	29 (82.9)	29 (87.9)	0.34	.559
	Recurrent	6 (17.1)	4 (12.1)		
LVEF at baseline	M±SD	43.4 ± 6.5	45.7 ± 4.9	−1.71	.092
	41–49%	28 (80.0)	27 (81.8)	0.04	.849
	≤40%	7 (20.0)	6 (18.2)		

Note. Cont = control; CVD = cardiovascular disease; Exp = experimental; LVEF = left ventricular ejection fraction on echocardiography; M = Mean; MI = myocardial infarction; NYHA=New York Heart Association; SD = standard deviation.

Table 3 *Homogeneity on the Research Variables.*

Characteristics	Categories	Exp. ($n = 35$)	Con. ($n = 33$)	*t*	*p*
		M±SD	M±SD		
Health behavior (range 25~100)	Total	61.26 ± 14.37	65.53 ± 14.08	−1.23	.224
	Health responsibility	15.11 ± 4.01	16.23 ± 3.89	−1.17	.248
	Exercise	9.66 ± 3.22	10.27 ± 3.72	−0.72	.473
	Eating habits	17.50 ± 5.02	18.37 ± 4.94	−0.71	479
	Stress management	12.37 ± 2.80	12.83 ± 3.34	−0.62	.535
	No smoking	6.63 ± 3.11	7.83 ± 3.66	−1.47	.148
Depression (range 0~27)		3.71 ± 5.05	4.10 ± 4.93	−0.32	.751
Illness perception (range 0~80)	Total	39.55 ± 8.12	39.43 ± 9.35	0.06	.955
	Negative (5 items, 0~50)	28.39 ± 8.21	28.00 ± 9.24	0.19	.853
	Positive (3 items, 0~30)	11.16 ± 4.21	11.43 ± 4.43	−0.26	.794
Resilience (range 25~125)	Total	93.92 ± 14.34	90.13 ± 15.95	1.03	.307
	Supportive relationship	22.45 ± 4.14	21.90 ± 4.76	0.51	.614
	Health practice ability	13.18 ± 4.28	12.63 ± 3.29	0.59	.560
	Control ability	18.87 ± 3.22	17.67 ± 3.68	1.43	.156
	Positive attitude	15.47 ± 2.67	14.90 ± 3.32	0.79	.432
	Restoration belief	8.39 ± 1.35	8.27 ± 1.39	0.38	.702
	Relationship with staffs	8.11 ± 1.47	7.77 ± 1.45	0.95	.346
	Confidence to overcome	7.45 ± 1.95	7.00 ± 1.98	0.93	.355

Note. Cont = control; Exp = experimental; M = mean; SD = standard deviation.

checklists across multiple lifestyle domains such as exercise, diet, smoking cessation, stress management, and symptom monitoring. During the participants' outpatient visits every 3 months, a nurse provided additional counseling and education based on the checklist results. This approach was informed by a 1-year qualitative study using a mobile app to promote exercise after cardiac rehabilitation, which found that individualized support from supervisors was essential for improving adherence [36]. The app's integration with quarterly nurse counseling addressed the limitation of many mobile programs that provided only automated reminders without personalized professional support [33]. In addition, the theoretical foundation in the IMB model differentiates our program from apps that lacked explicit behavioral theory, ensuring a systematic link between information provision, motivation (illness perception and depression), behavioral skills (self-monitoring), and outcomes (health behaviors, resilience). Future improvements may include features like real-time interaction via a chat function between nurses and patients.

The main results of hypothesis testing are discussed here. The most notable finding was the significant group × time interaction for health behaviors, demonstrating the sustained efficacy of the intervention. Participants in the experimental group improved consistently over 3, 6, and 12 months, whereas the control group showed little change. Our findings are consistent with previous app-based interventions that demonstrated favorable effects on diet, physical activity, sedentary behavior, exercise capacity, and glycemic control in patients with acute coronary syndrome [18]. They also align with evidence showing that patients' exercise performance significantly improved after receiving individualized app-based exercise guidance for 1 year following cardiac rehabilitation [35]. Similarly, a 4-year multicenter trial of smartphone apps in the United States reported that self-care significantly improved compared with controls, resulting in a reduced risk of readmission [37]. Together, these results reinforce the evidence that mobile apps can effectively support lifestyle modification in cardiovascular populations.

For illness perception, a significant group × time interaction was observed, with negative illness perception decreasing in the experimental group at 3 and 6 months, although the effect was not sustained at 12 months. These findings are consistent with prior evidence showing that structured education can improve patients' understanding of their illness [11,12]. Recent reviews further highlight the relevance of key mHealth intervention components. A systematic review and meta-analysis in patients with coronary heart disease reported improvements in medication adherence, physical activity, exercise capacity, and psychosocial outcomes with app-based interventions [20]. In addition, a scoping review identified self-monitoring, tailored feedback, and educational support as core components facilitating behavior change and disease understanding in cardiovascular self-management [21]. Taken together, these findings suggest that app-based self-monitoring combined with individualized education may support more

Table 4 *Effect of Mobile App-based Self-Monitoring Intervention on the Research Variables.*

Variables	Groups	Pretest	3 months	6 months	12 months	Source	F(*p*)
		M±SD					
Health behaviors	Exp. ($n = 35$)	62.53 ± 13.63	74.58 ± 9.61	75.81 ± 8.90	75.14 ± 11.23	Group	5.17 (.026)
	Cont. ($n = 33$) t(*p*)	65.53 ± 14.08	65.17 ± 13.14	66.80 ± 13.86	66.97 ± 14.58	Time	13.33 (<.001)
		−1.23 (0.22)	3.37 (<0.001)	3.22 (0.002)	2.70 (0.01)	Group x time	10.24 (<.001)
Resilience	Exp. ($n = 35$)	93.92 ± 14.34	99.61 ± 13.12	98.06 ± 14.19	99.34 ± 13.38	Group	5.54 (.022)
	Cont. ($n = 33$) t(*p*)	90.13 ± 15.95	90.53 ± 14.36	91.20 ± 15.83	89.90 ± 15.62	Time	1.93 (.134)
		1.03 (0.31)	2.72 (0.008)	1.88 (0.06)	2.68 (0.009)	Group x time	1.69 (.177)
Illness perception	Exp. ($n = 35$)	39.55 ± 8.12	33.24 ± 10.79	32.50 ± 11.24	34.03 ± 8.47	Group	3.32 (.073)
	Cont. ($n = 33$) t(*p*)	39.43 ± 9.35	39.47 ± 7.45	37.83 ± 9.37	36.10 ± 11.09	Time	6.23 (<.001)
		0.06 (0.06)	−2.69 (0.009)	−2.09 (0.04)	−0.87 (0.39)	Group x time	3.15 (.026)
Depression	Exp. ($n = 35$)	3.71 ± 5.05	2.87 ± 4.09	2.63 ± 3.16	3.00 ± 4.31	Group	0.14 (.708)
	Cont. ($n = 33$) t(*p*)	4.10 ± 4.93	3.87 ± 3.75	2.57 ± 2.43	2.90 ± 2.70	Time	3.55 (.020)
		−0.32 (0.75)	−1.04 (0.30)	0.09 (0.92)	0.11 (0.91)	Group x time	0.74 (.513)

Note. Cont = control; Exp = experimental; M = mean; SD = standard deviation.

adaptive illness perceptions, particularly in the early post-MI period. However, the attenuation of effects by 12 months in our study highlights the need for sustained reinforcement, such as real-time interactive counseling or adaptive educational modules.

For resilience, the group × time interaction was not significant and the primary hypothesis was not supported. Although the group × time interaction was non-significant, a significant main effect indicated that resilience scores were consistently higher in the experimental group across all time points. This suggests that the app may have provided supportive benefits for resilience but not in a time-dependent manner. This finding is consistent with previous work, including a study in young adults after MI in which a 3-month acceptance and commitment therapy program improved resilience compared with controls [38]. In our study, resilience may have been reinforced by regular self-monitoring combined with nurse support, which could enhance participants' sense of control and confidence. Since resilience is closely associated with self-care and health-promoting behaviors in cardiovascular patients [15,16,39], regular assessment is warranted, and further research should examine how mobile interventions can improve resilience longitudinally. The absence of significant interaction effects suggests that resilience may be a relatively stable trait that requires more intensive or prolonged interventions to achieve measurable time-dependent changes.

Lastly, depression levels declined over time in both groups but neither the group × time interaction nor the main effect of group was significant. This is consistent with a previous study in which a one-year educational program for post-MI patients did not significantly affect depression [40]. Most participants in our study were employed, middle-aged men (mean age 58 years), who initially reported higher distress due to shock and concern after MI but appeared to adapt over time, leading to decreased depression regardless of the intervention. Nevertheless, severe depression after MI has been shown to hinder psychological recovery [41] and self-care in cardiac rehabilitation [42]. These findings suggest that lifestyle-focused mobile programs alone may be insufficient to improve depression, highlighting the need to incorporate specialized mental health interventions into future app-based strategies.

Strengths and clinical implications

The main strength of this study is demonstrating the positive impact of a theory-based, lifestyle-focused mobile self-monitoring intervention on promoting healthy behaviors over a 1-year period. The target population—middle-aged men, who account for nearly half of MI cases [43]—often face occupational stress and unhealthy lifestyle habits. Given their long life expectancy and elevated risk of HF progression (Stage B HF), continuous preventive care is essential, particularly for those with persistent LVEF reduction who do not receive specialized cardiac rehabilitation. Our findings suggest that nurse-facilitated, smartphone-based self-monitoring can motivate sustained self-care in this high-risk group. With its feasibility, accessibility, and strong theoretical foundation, this approach represents a practical and scalable strategy for outpatient cardiovascular care.

Limitations

This study has several limitations. First, the generalizability of the findings is restricted by the small, all-male Korean sample. Second, although random allocation was performed, education and counseling for the experimental group were delivered by the researcher, which may have introduced bias due to lack of double blinding. Third, the app was limited to android devices and offered only basic interactive functions compared with more advanced telehealth platforms. Fourth, outcomes were assessed using self-report questionnaires, raising the possibility of response bias, particularly because the same variables were measured repeatedly at each time point. Fifth, although both groups met with nurses during outpatient visits every 3 months to complete study questionnaires and address brief questions, the experimental group received more structured and sustained attention through app-based monitoring and scheduled counseling. This imbalance may have introduced attention bias, potentially influencing psychological outcomes. Finally, the dropout rate exceeded 20% over the 1-year follow-up, which may have affected the results. Participants who dropped out were excluded from the analysis without imputation, which may have introduced attrition bias and affected the generalizability of the results. Future studies should incorporate larger and more diverse samples, objective outcomes such as biomarkers or wearable data, and enhanced app features including real-time interaction and psychological support modules.

Conclusion

Weekly *With Your Heart* app–based self-monitoring with tailored feedback and nurse counseling significantly improved health behaviors and reduced negative illness perception in middle-aged post–MI men at risk for HF. Resilience was higher in the experimental group overall, while depression decreased similarly in both groups. These findings indicate that nurse-facilitated, *With Your Heart* app–based self-monitoring is an effective strategy for promoting lifestyle modification, and future research should enhance interactive features and integrate psychological support to sustain long-term effects.

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Conflict of interest

All authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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