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The effects of a 24-week interactive text message-based mobile health intervention for enhancing self-care behaviours of patients with heart failure: A quasi-experimental study

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Abstract

Aims: The aim of this study was to identify the effects of a 24-week interactive text message-based mobile health intervention (*called*) on enhancing the self-care behaviours of patients with heart failure.

Background: Whether text message-based mobile health intervention can be used to improve long-term adherence to self-care behaviours among heart failure patients remains unclear.

Design: A quasi-experimental study with a pretest–post-test design and repeated measures.

Methods: Data from 100 patients (mean age, 58.78 years; 83.0% men) were analysed. The intervention group ($n = 50$) used the program over 24 weeks, which consisted of weekly goal setting and interactive text messaging, while the control group ($n = 50$) received usual care. Trained research assistants collected data using self-reported Likert questionnaires. Primary (self-care behaviours) and secondary (health literacy, eHealth literacy, and disease knowledge) outcome variables were measured at baseline and at 1, 3 and 6 months after intervention for follow-up.

Results: The findings showed that the intervention group demonstrated significantly better self-care behaviours than the control group during the 6 months. Notably, the trajectory of self-care behaviours of the patients in the intervention group showed a steep rise between the first- and third-month follow-up, followed by high stability between the third- and sixth-month follow-up. In addition, the intervention group had significantly higher disease knowledge than the control group at the first- and sixth-month follow-up.

Conclusions: We found that the program, as an interactive text messaging service, may be an optimal strategy for improving long-term adherence to self-care behaviours through motivating and providing social support.

Guarantor—Youn-Jung Son.

Relevance to the Nursing Practice: The *WithUs* program can help nurses and other healthcare professionals to track patients' health indicators such as symptom severity, diet and physical activity. In addition, nurses can take an important role in evaluating the efficacy of the app in relation to patients' health outcome.

Patient or Public Contribution: Patients have completed a self-reported questionnaire after providing informed consent.

KEYWORDS
heart failure, mobile application, nonrandomized controlled trial, nursing, self-care behaviours

1 | INTRODUCTION

The global prevalence of heart failure (HF) is projected to rise due to its statistically significant association with an ageing population (Savarese et al., 2022). HF results in a high risk of hospital readmission and mortality among older adults (Lan et al., 2021). In Korea, the prevalence of HF has steadily increased from 1.48% in 2013 to 2.24% in 2018, primarily driven by the rapid growth of the older adult population (Park et al., 2021). Effective management of HF requires adherence to self-care behaviours, which are crucial for preventing adverse outcomes (Jaarsma et al., 2021). However, many patients with HF struggle to adhere to these behaviours due to the complex nature of HF self-care, which includes medication adherence, symptom monitoring and lifestyle modification (Pobrotyn et al., 2021). A well-informed and motivated HF patient is more likely to engage in self-care behaviours over time (Athilingam et al., 2017; Zhao et al., 2021). Mobile health (mHealth) interventions, particularly interactive text messaging, have been proposed as a potentially promising approach for enhancing HF self-care behaviours by providing timely advice and information (Athilingam et al., 2017; Bakogiannis et al., 2021). Interactive text messaging has been shown to contribute to changes in health behaviours and risk factor modification (Bezerra Giordan et al., 2022). However, the long-term effects of mHealth interventions on HF patient outcomes remain unclear, and data on the effectiveness of interactive text message mHealth interventions for improving self-care behaviours in HF patients are scarce. As nurses represent the largest group in healthcare delivery, their crucial role in assisting patients to optimize self-care necessitates a thorough evaluation of mHealth interventions' usefulness and efficacy concerning patient outcomes, ensuring seamless continuity of care.

2 | BACKGROUND

Despite advances in medical and surgical therapies for HF, unanticipated hospital readmissions and high mortality rates continue to be statistically significant concerns worldwide (Lan et al., 2021; Park et al., 2021; Savarese et al., 2022). Lifelong self-care behaviours are regarded as an essential component of HF management, as optimal self-care can decrease the risk of adverse clinical outcomes, such as hospital readmission and death (Jaarsma et al., 2021; Meng et al., 2021). Nonetheless, numerous HF patients encounter substantial challenges in executing effective self-care behaviours, despite their benefits (Pobrotyn et al., 2021). In the context of HF, self-care behaviours encompass medication and treatment adherence as well as lifestyle modifications including regular exercise, water and sodium restriction, and self-monitoring of symptoms, body weight and blood pressure (Jaarsma et al., 2021; Meng et al., 2021). Factors such as patients' limited knowledge and motivation, complex regimens, and the difficulty of maintaining lifestyle changes may negatively impact adherence to HF self-care behaviours (Meng et al., 2021; Pobrotyn et al., 2021). Currently, a variety of interventions, such as face-to-face self-care education and motivational interviewing, have shown positive effects on HF patient outcomes, including quality of life, hospital readmission and mortality rates (Collins et al., 2021; Sokalski et al., 2020; Zhao et al., 2021). However, these healthcare professional-delivered interventions may not reach patients who reside in remote areas or those with physical limitations that prevent them from accessing hospitals.

In recent years, mHealth has emerged as a valuable supplement to traditional face-to-face interventions for individuals with cardiovascular diseases. It provides support for HF patients by facilitating self-care management through continuous monitoring, readily available healthcare resources and seamless communication between patients and healthcare providers, irrespective of time and location constraints (Athilingam et al., 2017;Bezerra Giordan et al., 2022 ; Indraratna et al., 2020). Previous studies have demonstrated that mHealth interventions for patients with HF provide the benefits of improved patient knowledge, health literacy and self-care abilities as well as positive clinical outcomes (Athilingam et al., 2017; Lin & Lou, 2021). However, recent reviews have indicated that mHealth-based self-care interventions struggle to deliver long-term benefits and consistent results (Bezerra Giordan et al., 2022; Indraratna et al., 2020). Existing mHealth interventions for HF self-care have predominantly focused on unidirectional information delivery and reminders, such as for medication adherence (Athilingam et al., 2018; Bezerra Giordan et al., 2022). Although some interactive mHealth interventions have employed text messages, telephone calls or emails, these interactions have been typically limited to one-time conversations

when necessary rather than being maintained on a regular basis (Dunn Lopez et al., 2021; Kitsiou et al., 2021). Numerous studies on mHealth-based HF self-management have underscored the importance of developing strategies to actively engage patients in daily HF self-care for long-term improved health outcomes (Athilingam et al., 2017; Bezerra Giordan et al., 2022). To achieve this objective, it is crucial to develop patient-centred mHealth interventions that foster long-term health behaviour change by empowering patients with the knowledge and motivation to take responsibility for their own health, ultimately promoting self-care behaviours (Kitsiou et al., 2021; Lin & Lou, 2021). However, the long-term effects of interactive mHealth interventions remain to be determined (Kitsiou et al., 2021).

In Korea, long-term mHealth services for self-care are in their infancy (Yi et al., 2018). Consequently, based on comprehensive literature reviews and findings from previous studies, we developed a 24-week interactive text message-based mHealth intervention designed to enhance HF self-care through patient-driven weekly goal setting and rule-based conversational agents. This intervention, which we called 'Welcome to Interactive Text Messaging for Improving Heart Failure Self-Care Unified Supporters' (), was grounded in the information-motivation-behaviour model (Athilingam et al., 2018), which posits that information, motivation and behavioural skills are essential for behaviour change. This study aimed to actively engage patients in long-term HF self-management to improve health-related quality of life.

3 | THE STUDY

3.1 | Aims

The purpose of this study is to examine the effectiveness of the 24-week program in patients with HF. Specifically, we hypothesized that patients with HF who were involved in the program for 6 months would score higher in self-care behaviours as the primary outcome variable than those who received routine care. In terms of secondary outcome variables, we further hypothesized that they would report better health literacy, electronic health literacy (eHealth literacy) and disease knowledge. Additionally, subgroup analysis was conducted to explore the difference in post-test scores of outcome variables after the intervention, based on age (<60 vs. ≥60 years).

4 | METHODS

4.1 | Study design and setting

We employed a quasi-experimental, repeated measures design with two groups at two acute care hospitals (with 420 and 800 beds) in metropolitan areas of Korea. The study adhered to the Consolidated Standards of Reporting Trials (CONSORT) reporting guidelines. The 24-week (Figure S1) was designed for smartphones utilizing the Android operating system, developed by a nursing professor as the principal investigator alongside a research team. The research team comprised a nursing professor, five cardiologists and two chatbot developers. The consisted of two components: (1) a basic encompassing essential program features (medication adherence reminders, hospital follow-up visits, symptom tracking and monitoring, sodium restriction, blood pressure, weight tracking, general information and personalized goals) and (2) an interactive text messaging (chatbot) integrated within the basic. The usability and pilot testing results of the *program* using a one-group pretest–post-test design showed that the novel app had overall good quality and a beneficial effect on self-care behaviours (Son & Kim, 2023). A detailed description of the development of the intervention and usability results is presented elsewhere (Son & Kim, 2023).

4.2 | Participants and data collection

We utilized a convenience sampling approach to recruit HF outpatients (mean age, 58.78 years; 83.0% men) for the study conducted between October 2020 and April 2021. Five cardiologists from two acute care hospitals assisted with participant recruitment by identifying potentially eligible patients and informing them about the study during the specified period. Baseline and follow-up data were collected by two research assistants, with the last follow-up conducted in October 2021. Patients were assigned to either the intervention group, which received the novel mHealth intervention (the program), or the control group, which received usual care. Inclusion criteria consisted of (1) being 40 years of age or older; (2) having a cardiologist-confirmed HF diagnosis; (3) presenting symptomatic HF with New York Heart Association (NYHA) functional class II and III; (4) possessing the ability to read, write and converse in Korean; and (5) owning an Android smartphone. Patients were excluded if they had (1) a history of cognitive impairment or dementia; (2) a history of renal failure, stroke, cancer, major psychiatric disorders, or delirium; or (3) a scheduled medical intervention, such as surgery, during the study period.

We estimated the sample size for repeated measures ANOVA using G* power 3.1.9.7 software. On applying the four qualities (power = 0.80, effect size (f) = 0.25, number of measurements = 4 and significance level (α) = 0.05) based on Cohen's criteria, it was found that a total of 82 patients were required. Considering a potential loss with a maximum dropout rate of 25% and missing data, we recruited 110 patients at baseline for this study. To avoid contamination of the study participants, they were first allotted to the intervention group ($n = 55$) and then to the control group ($n = 55$). Participants in the control group were purposively selected to match two demographic characteristics (age and sex) with the participants in the intervention group. The attribution rate during the study period was 9.1% ($n = 10$), resulting in a final analysis of data from 50 participants in each group (Figure 1).

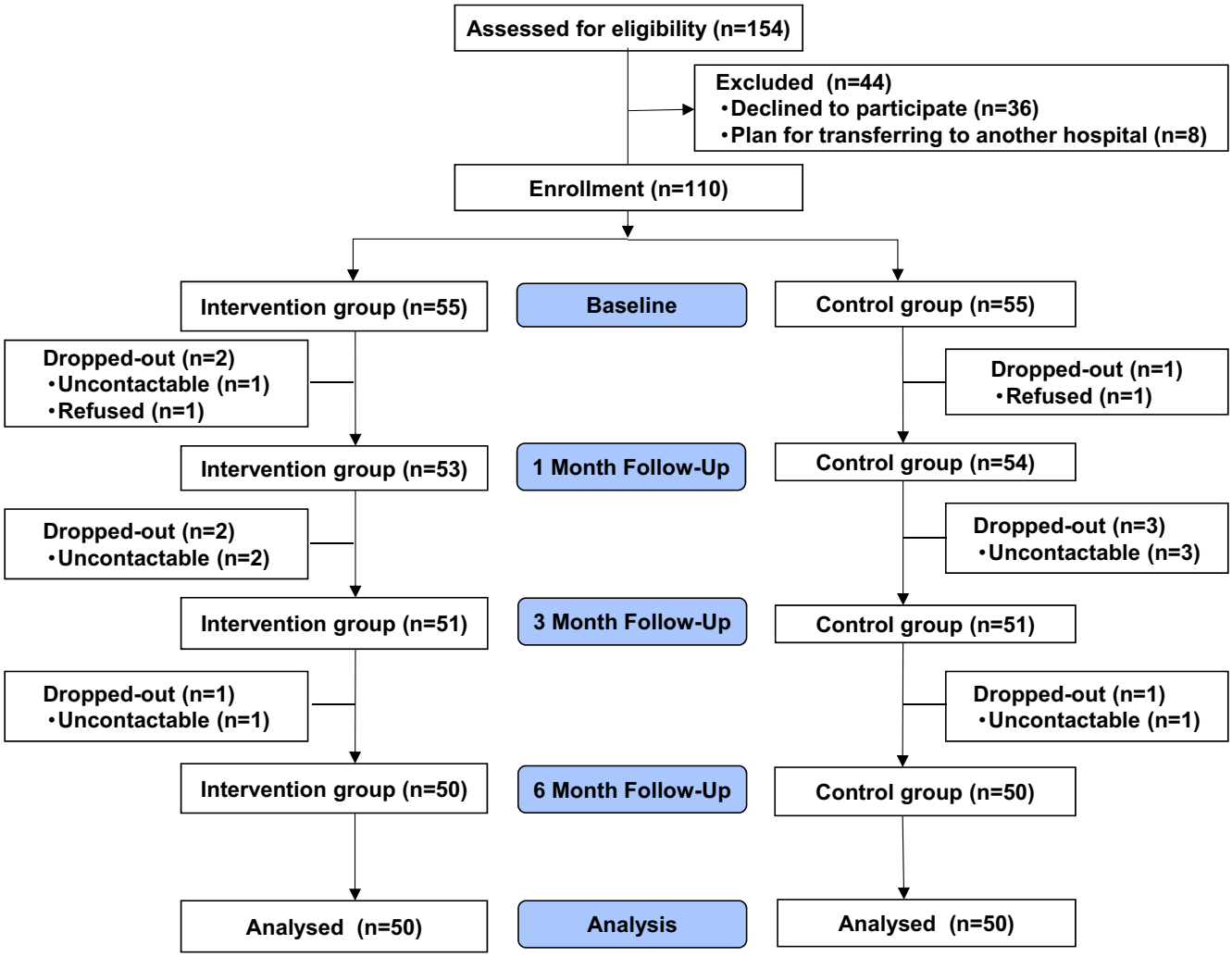

FIGURE 1 Flow diagram of patients through phases of a 2-group parallel quasi-experimental design.

4.3 | Intervention implementation

The *WithUs* program is mainly composed of two distinct functionalities. The first main function of the app is weekly goal setting driven by patients with HF, which can help them to be motivated to engage in self-care and promote health behaviour changes. Patients were asked to select one of the nine weekly goals from a default list of common goals related to HF self-care. For instance, 'I will take my medication on time'. If patients achieved their weekly goals for a 4-week period, a full-bloom sunflower was presented on the phone screen as a symbol of achievement. Six sunflowers indicated that the patients achieved all their weekly goals they set for 24 weeks. In addition, it provided information related to optimal self-care for HF, reminders such as medication and follow-up visits and a calendar for daily HF self-care log for self-monitoring (e.g., HF symptoms diary, daily weighing, sodium and water intake, physical activities, heart rate and blood pressure). The second main function of the app is a rule-based chatting bot. The prewritten scenario-based text message pool consisted of 69 questions and 108 responses. The questions were about greetings, encouraging patients to achieve their weekly goals and delivering the information they needed. Interactive text messaging was initiated and delivered through the chatbot app, with an average of seven messages sent three times a week for 24 weeks.

For the intervention group, we first introduced the *WithUs* program, outlining its objectives and usage. The mHealth app was installed on patients' smartphones by creating new participant accounts. Research assistants then demonstrated how to utilize the app, providing supplementary leaflets and video clips. In case of any issues during the intervention, participants were given the research assistants' contact numbers. The intervention commenced with a welcome text message from the app 1 week after installation. Data for the intervention group were stored using integrated cloud services and a web dashboard, with access limited to researchers for monitoring app usage and collected data. The control group received standard care upon hospital discharge.

4.4 | Measures and outcome variables

At baseline, trained researchers collected self-reported patients' sociodemographic characteristics (age, sex, educational level, job, living arrangement and cognitive function), clinical information (time since HF diagnosis, left ventricular ejection fraction (LVEF) %) and comorbidities such as hypertension and diabetes mellitus, through electronic medical records. Baseline cognitive function was measured using the Korean version of the Mini-Mental State Examination (K-MMSE). The K-MMSE scores ranged from 0 to 30 (Kang et al., 1997).

The primary outcome variable was assessed using the Korean version of the European Heart Failure Self-Care Behavior Scale 9 (EHFScBS-9) (Son & Won, 2020). This nine-item scale measures the frequency of HF-related self-care behaviours, such as contacting healthcare professionals in response to symptoms such as shortness of breath, ankle swelling, weight gain and fatigue; self-monitoring weight; limiting fluid intake; adhering to a low-sodium diet; taking medications consistently; and exercising. Responses were scored on a 5-point Likert scale, with higher scores reflecting better self-care behaviours (Jaarsma et al., 2009). The Cronbach's alpha for the scale ranged from 0.77 to 0.81 during the follow-up period. Secondary outcome variables included health literacy, eHealth literacy and disease knowledge. Health literacy was screened using the Brief Health Literacy Screeners, comprising three items scored on a 5-point Likert scale (Chew et al., 2008): 'How often do you have someone help you read hospital materials?', 'How confident are you filling out medical forms by yourself?' and 'How often do you have problems learning about your medical condition because of difficulty understanding written information A higher score indicated a better ability to understand and appraise health information (Chew et al., 2008). To assess the ability to search and evaluate electronic health information, we used the Korean version of eHealth literacy (Kim & Son, 2017) originally developed by Norman and Skinner (2006). This scale includes eight items rated on a 5-point Likert scale. The first two items assess the perception of Internet-based information in general, while the remaining six items evaluate the combined knowledge, consumer comfort and perceived ability to find, assess and apply electronic health information. Higher scores suggest higher eHealth literacy. The scale's reliability ranged from 0.95 to 0.97 during the follow-up period.

Fir HF disease knowledge, we used the 10-item patient knowledge questionnaire, with responses in the form of '*yes*' or '*no*' (Lainscak & Keber, 2005). Each correct answer was awarded one point. The reliability value using the Kuder–Richardson Formula-20 (KR-20) ranged from 0.70 to 0.72 during the follow-up period. Primary and secondary outcome variables were assessed at all four-time points (baseline, at 1, 3 and 6 months after enrolment).

4.5 | Ethical consideration

The study protocol was approved by the Institutional Research Board (IRB) of Chung Ang University, Seoul, Korea (IRB: 1041078-202,009-HRSB-289-01). Participants were provided with an information sheet detailing the research purpose and their right to refuse or withdraw at any time without loss of benefits. The study did not contain data that could identify or trace an individual. Confidentiality was maintained by granting data access solely to the principal investigator. The research was conducted in accordance with the Declaration of Helsinki.

4.6 | Data analysis

The data were analysed using SPSS version 26.0 for Windows. Patient characteristics were described using *the mean* (standard deviation (SD)) or frequencies (percentages). Independent *t*-tests and chi-squared tests were *used* to *examine the* homogeneity between the intervention and control groups, *in terms of patients'* characteristics, self-care behaviours, health literacy, eHealth literacy and disease knowledge at baseline. *The* distributions for all outcome measures *were checked for normality using the* Kolmogorov–Smirnov normality test.

Repeated measures ANOVA was used to compare the changes in outcome variables between the two groups over 6 months. Next, between-group differences at different time points were evaluated using an independent *t*-test to examine whether there was a statistically significant group-by-time interaction effect. For the subgroup analysis, we used an independent t-test to compare the effects of the intervention on post-test scores for health literacy, disease knowledge and self-care behaviours, according to age group (<60 vs. ≥60 years). Regarding eHealth literacy, analysis of covariance (ANCOVA) was conducted because there was a statistically significant difference in baseline eHealth literacy by age group ($p < 0.001$). Thus, baseline eHealth literacy was adjusted as a covariate. The alpha level for statistical significance was set at $p < 0.05$.

5 | RESULTS

5.1 | Comparison of baseline patients' characteristics and outcome variables at baseline between two groups

Table 1 shows the baseline patient characteristics, disease knowledge and self-care behaviours in the intervention and control groups. For baseline characteristics of all participants, the mean age of the 100 patients was 58.78 (SD = 8.83). Most participants were men (83.0%), and 45% of participants had more than a college degree. More than half of the participants were employed (66.0%) and lived with spouse or family (80.0%). The mean score of cognitive function at baseline was 29.07 (SD = 1.53). Average time passed since HF diagnosis and LVEF was 4.67 years (SD = 4.04) and 43.02% (SD = 14.91), respectively. The proportions of comorbid hypertension and diabetes mellitus were 55.0% and 30.0%, respectively. There were no statistically significant differences in the baseline characteristics of patients between the intervention and control groups.

TABLE 1 Patients' characteristics and outcome variables at baseline between the intervention and control groups.

Baseline characteristics	Total sample ($N=100$) *n* (%) or Mean (SD)	Intervention Group ($n=50$) *n* (%) or Mean (SD)	Control Group ($n=50$) *n* (%) or Mean (SD)	t/χ^2 (p)
Age	*58.78 (8.83)*	*60.14 (8.83)*	*57.42 (9.71)*	1.55 (0.124)
Sex				0.71 (0.790)
Male	83 (83.0%)	41 (82.0%)	42 (84.0%)	
Female	17 (17.0%)	9 (18.0%)	8 (16.0%)	
Education level				2.59 (0.458)
≤ middle school	14 (14.0%)	7 (14.0%)	7 (14.0%)	
High school	41 (41.0%)	24 (48.0%)	17 (34.0%)	
≥ College	45 (45.0%)	19 (38.0%)	26 (52.0%)	
Job				0.18 (0.673)
Employed	66 (66.0%)	32 (64.0%)	34 (68.0%)	
Unemployed	34 (34.0%)	18 (36.0%)	16 (32.0%)	
Living with				
Alone	20 (20.0%)	11 (22.0%)	9 (18.0%)	0.18 (0.099)
Spouse or Family	80 (80.0%)	39 (78.2%)	41 (82.0%)	
Cognitive function	*29.07 (1.53)*	*29.19 (1.11)*	*28.94 (1.88)*	0.81 (0.418)
Time since HF diagnosis (year)	*4.67 (4.04)*	*4.51 (3.63)*	*5.15 (4.42)*	−1.19 (0.238)
Left ventricular ejection fraction (%)	*43.02 (14.91)*	*41.16 (13.34)*	*44.37 (16.57)*	−1.25 (0.250)
Hypertension				0.23 (0.932)
Yes	55 (55.0%)	28 (56.0%)	27 (54.0%)	
No	45 (45.0%)	22 (44.0%)	23 (46.0%)	
Diabetes mellitus				0.19 (0.663)
Yes	30 (30.0%)	14 (28.0%)	16 (32.0%)	
No	70 (70.0%)	36 (72.0%)	34 (68.0%)	
Outcome variables				
Self-care behaviours	*25.06 (7.01)*	*25.54 (7.80)*	*24.74 (6.37)*	0.56 (0.576)
Health literacy	*9.73 (1.51)*	*9.68 (1.38)*	*9.78 (1.63)*	−0.33 (0.741)
eHealth literacy	*24.95 (9.68)*	*24.32 (9.55)*	*25.58 (9.79)*	−0.65 (0.517)
Disease knowledge	*6.59 (2.35)*	*6.80 (2.25)*	*6.38 (2.48)*	0.89 (0.377)

Abbreviations: eHealth literacy, electronic health literacy; HF, heart failure; SD, standard deviation.
Mean and SD are presented in italics.

Regarding baseline outcome variables, mean scores of self-care behaviours, health literacy, eHealth literacy and disease knowledge of the participants were 25.06 (SD = 7.01), 9.73 (SD = 1.51), 24.95 (SD = 9.68) and 6.69 (SD = 2.35), respectively. There were no statistically significant differences in self-care behaviours, functional health literacy, eHealth literacy or disease knowledge at baseline between the two groups (Table 1).

5.2 | Effects of the intervention on primary and second outcome variables

Figure 2 displays longitudinal changes in primary (self-care behaviours) and secondary outcome variables (health literacy, eHealth literacy and disease knowledge) between the intervention and the control groups. The mean scores of primary and secondary outcome variables in the intervention group were higher than the control group at 1-, 3- and 6-month follow-up. Notably, self-care behaviours of patients in the intervention group demonstrated a steep rise until 3 months after intervention and high stability between the third and sixth months. Moreover, there was a statistically significant difference between the intervention and the control group.

As shown in Table 2, there were statistically significant differences in self-care behaviours ($p<0.001$), health literacy ($p=0.004$), eHealth literacy ($p<0.001$) and disease knowledge ($p<0.001$) over time within each group. In the repeated measures ANOVA, we found that there was a statistically significant interaction between groups and time points in self-care behaviours ($p<0.001$), health literacy ($p=0.032$) and eHealth literacy ($p=0.021$). Thus, we conducted an independent t-test to compare post-test scores of these variables

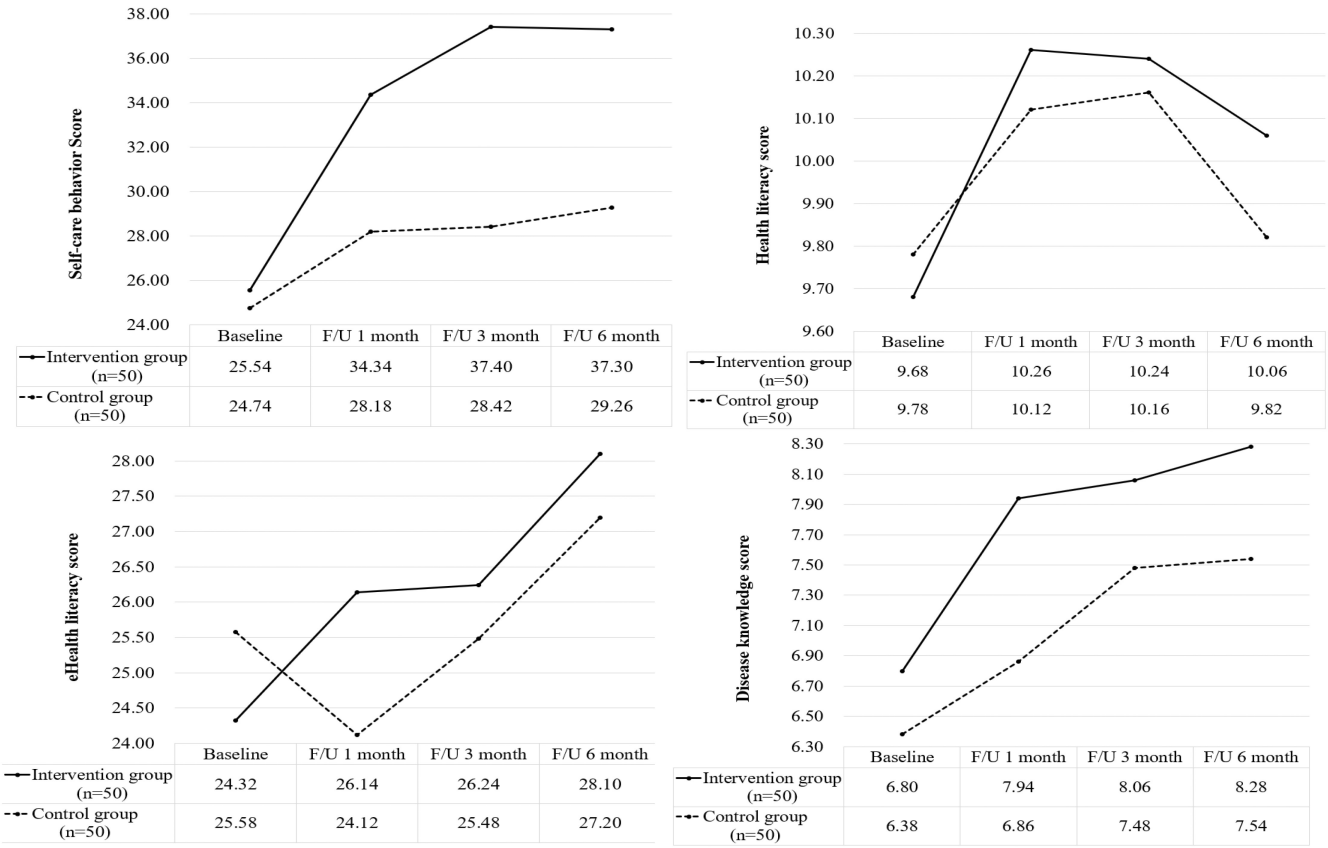

FIGURE 2 Longitudinal trajectories of self-care behaviours, health literacy, eHealth literacy and disease knowledge in the intervention and control groups.

TABLE 2 Comparison of post-test scores on outcome variables between the intervention and the control groups.

Outcome variables	Group	Baseline Mean (SD)	F/u at 1 month Mean (SD)	F/u at 3 months Mean (SD)	F/u at 6 months Mean (SD)	Differences Within group[b]
Self-care behaviours	Intervention ($n=50$)	25.54 (7.80)	34.34 (6.48)	37.40 (6.66)	37.30 (5.92)	68.38 (<0.001)
	Control ($n=50$)	24.74 (6.37)	28.18 (5.55)	28.42 (6.09)	29.26 (6.69)	
	Differences between groups[a]	0.56 (0.576)	5.11(<0.001)	7.03 (<0.001)	6.36 (<0.001)	
Health literacy	Intervention ($n=50$)	9.68 (1.38)	10.26 (0.92)	10.24 (1.11)	10.06 (1.33)	4.48 (0.004)
	Control ($n=50$)	9.78 (1.63)	10.12 (1.09)	10.16(1.03)	9.82 (1.120)	
	Differences between groups[a]	−0.33 (0.741)	0.69 (0.492)	0.37 (0.711)	0.98 (0.328)	
eHealth literacy	Intervention ($n=50$)	24.32 (9.55)	26.14 (9.74)	26.24 (9.76)	28.10 (9.16)	8.13 (<0.001)
	Control ($n=50$)	25.58 (9.79)	24.12 (8.72)	25.48 (8.53)	27.20 (8.73)	
	Differences between groups[a]	−0.65 (0.517)	1.09 (0.277)	0.41 (0.679)	0.50 (0.616)	
Disease knowledge	Intervention ($n=50$)	6.80 (2.25)	7.94 (1.49)	8.06 (1.71)	8.28 (1.56)	25.67 (<0.001)
	Control ($n=50$)	6.38 (2.48)	6.86 (2.07)	7.48 (1.75)	7.54 (1.82)	
	Differences between groups[a]	0.89 (0.377)	2.99 (0.004)	1.68 (0.097)	2.17 (0.032)	

Abbreviations: F/u, follow-up; SD, standard deviation.

[a]Results by independent *t*-test were presented as *t* (*p*).

[b]Results by repeated measures ANOVA were presented as F (*p*).

TABLE 3 Comparison of post-test scores on outcome variables between younger and older adults in the intervention groups ($n = 50$).

Period	Age group	Self-care behaviours		Health literacy		eHealth literacy		Disease knowledge	
		Mean (SD)	t (p)	Mean (SD)	t (p)	Mean (SD)	t/F[a] (p)	Mean (SD)	t (p)
Baseline	<60 ($n=23$)	24.87 (7/34)	−0.56 (0.578)	9.57 (1.34)	−0.543 (0.590)	27.74 (6.74)	2.45 (0.015)	6.91 (2.19)	0.33 (0.747)
	≥60 ($n=27$)	26.11(8.28)		9.77 (1.42)		21.41 (10.69)		6.70 (2.33)	
F/u at 1 month	<60 ($n=23$)	32.61 (7.43)	−1.78 (0.081)	10.48 (0.79)	1.59 (0.117)	29.57 (7.84)	0.48[a] (0.494)	8.00 (1.78)	0.25 (0.802)
	≥60 ($n=27$)	35.81 (5.25)		10.07 (0.99)		23.22 (10.36)		7.89 (1.21)	
F/u at 3 months	<60 ($n=23$)	35.82 (5.25)	−2.03 (0.039)	10.22 (1.24)	−0.129 (0.898)	29.39 (7.99)	0.38[a] (0.543)	8.17 (1.99)	0.43 (0.668)
	≥60 ($n=27$)	39.19 (4.39)		10.25 (1.02)		23.56 (10.45)		7.96 (1.45)	
F/u at 6 months	<60 ($n=23$)	34.69 (6.90)	−2.981 (0.005)	10.17 (1.33)	0.555 (0.582)	31.69 (6.42)	1.78[a] (0.188)	8.52 (1.70)	0.99 (0.328)
	≥60 ($n=27$)	39.52 (3.84)		9.96 (1.34)		25.04 (10.10)		8.07 (1.49)	

Abbreviations: F/u = follow-up; SD, standard deviation.
[a]Results using analysis of covariance (ANCOVA) are reported after adjusting for the mean baseline eHealth literacy score.

between the two groups at follow-up. There was a statistically significant difference in self-care behaviours between the two groups at 1- ($p < 0.001$), 3- ($p < 0.001$) and 6-month ($p < 0.001$) follow-up. The level of disease knowledge in the intervention group was also significantly higher than that in the control group at 1-month ($p = 0.004$) and 6-month ($p = 0.032$) follow-up. However, no statistically significant differences in health literacy and eHealth literacy were found between the two groups during the follow-up period. Additionally, we performed a subgroup analysis of the intervention group by age (<60 vs. ≥60 years; Table 3).

The findings revealed that, among older adults, the mean scores of self-care behaviours after 3 and 6 months of the intervention were significantly higher than those of younger adults. There were no statistically significant differences in post-test scores (health literacy, eHealth literacy and disease knowledge) by age in the intervention group.

6 | DISCUSSION

Our study demonstrated that a 24-week interactive text messaging-based mHealth intervention for HF self-care resulted in enhanced long-term adherence to self-care behaviours and improved disease knowledge over 6 months when compared to the control group. These findings align with previous research that suggests mHealth interventions can lead to overall improvements in self-care maintenance, abilities and disease knowledge in HF patients (Hägglund et al., 2015; Seto et al., 2012). Importantly, the intervention group exhibited a substantial improvement in self-care behaviours and disease knowledge compared with the control group over the 6-month period, indicating that the 24-week outcome is clinically significant and warrants further exploration. In particular, our subgroup analysis revealed that older adults exhibited notably higher levels of self-care behaviours than younger adults following the intervention. This suggests that our interactive text message-based mHealth program is well-suited for HF self-care in older adults. However, our results diverge from two systematic reviews that found mHealth interventions with ≤6 months of follow-up did not improve self-care behaviours as assessed by self-reported questionnaires (Bezerra Giordan et al., 2022; Cajita et al., 2016). Therefore, multicentre randomized controlled trials are necessary to corroborate the long-term effects of the *WithUs* program by employing both objectively reliable wearable mobile devices for measuring self-care activities and validated self-report instruments.

In our study, we observed a statistically significant increase in both smooth and high static patterns of self-care behaviours as well as satisfactory disease knowledge between 1- and 6-month follow-up after a sharp rise at the 1-month follow-up in the intervention group. This is in line with a pilot study employing a one-group pretest–post-test design, which demonstrated a statistically significant improvement in self-care behaviours over a 3-month follow-up period following an mHealth intervention for HF self-care (Bakogiannis

et al., 2021). Conversely, a longitudinal study with a 3-month follow-up reported a declining trend in treatment adherence rates over time, with statistically significant decreases in diet and medication adherence (Riegel et al., 2019). However, our study did not evaluate the change in adherence rates for each specific self-care behaviour over time, indicating a need for further research to determine the influence of the *WithUs* program on self-care behaviour over time. Additionally, our findings diverge from a previous study conducted over a 12-month period that reported overall self-care behaviour adherence at approximately 74%, with average adherence rates declining by 1.4% per month within the context of a mobile phone-based HF telemonitoring program (Ware et al., 2019). This inconsistency may be ascribed to the diverse supportive and motivational strategies implemented by various mHealth programs. Specifically, the *WithUs* program focused on self-directed adherence to self-care behaviours through interactive text messages and weekly goal setting, which could potentially enhance self-care behaviours.

Notably, the self-care behaviour levels and disease knowledge of patients in the control group also exhibited a gradual increase over time without the *WithUs* program, despite unsatisfactory mean scores for both variables. This observation could be due to the more integrative and intensive usual care provided at the two cardiac outpatient clinics compared with other centres in the country. Another contributing factor might be the COVID-19 pandemic and its potential confounding influence on health behaviours of patients in both the intervention and control groups during the study period. In particular, avoiding hospital visits due to fear of contracting COVID-19 might prompt patients to assume greater responsibility and develop a heightened self-awareness regarding the importance of self-care at home (Bakogiannis et al., 2021). This supposition aligns with our observation of a continuous increase in eHealth literacy levels during the follow-up period in both groups. eHealth literacy, defined as the ability to seek and evaluate health information from electronic sources (Norman & Skinner, 2006), may have rapidly expanded due to the COVID-19 pandemic, irrespective of *WithUs* program usage. However, no statistically significant differences in health literacy and eHealth literacy were observed between the two groups during the follow-up period, potentially related to most participants in this study exhibiting adequate health literacy and moderate eHealth literacy. Consequently, future studies employing the *WithUs* program should explore the intervention effects on patients with limited or inadequate eHealth literacy over time. Additionally, we did not assess which features of the *WithUs* program were most beneficial or impactful in improving each outcome variable, necessitating further investigation into the specific advantages of each application feature to optimize its effectiveness.

6.1 | Strengths and limitations of the study

The COVID-19 pandemic has highlighted the need for mHealth intervention strategies in providing remote care to patients with HF, allowing for the rapid adoption of mobile technologies as a complementary approach to bridge existing gaps in effective HF self-care (Safi et al., 2020). Moreover, with the global trend of shorter hospital stays, individuals' active participation in their healthcare after discharge has gained increased importance (Baek et al., 2018). In this context, our novel interactive text message-based mHealth intervention demonstrates the potential for an assistive communication strategy, in conjunction with traditional disease management, to facilitate and enhance communication between patients and healthcare professionals in support of HF self-care.

Despite its contributions, this study has some limitations. Firstly, the inclusion of only two cardiac outpatient clinics in urban areas of Korea may restrict the generalizability of the findings to wider populations, as healthcare systems, ethnicities and urban–rural residency differences may vary. Additionally, the majority of participants lived with a spouse or family, which could potentially influence study outcomes. Secondly, we employed a quasi-experimental design using convenience sampling due to challenges in recruitment and random assignment of participants, which arose from reduced follow-up visits in light of the COVID-19 pandemic. This nonprobability sampling approach could have introduced selection bias. Thirdly, the study could not ascertain the intervention's effects on hospital readmission and mortality rates, as these events did not occur during the follow-up periods. Furthermore, this investigation excluded physiological parameters such as blood pressure and heart rate as objective outcome variables. Future research should consider incorporating both self-reported responses and physiological parameters collected via mobile phones. Lastly, the app's rule-based chatbot design precluded patients from asking open-ended questions, as they would in a human conversation.

6.2 | Suggestions for further research

To substantiate the current findings, it is imperative to conduct multicentre randomized controlled trials that account for cultural diversity. Additionally, future investigations should evaluate the efficacy of the intervention concerning clinical outcomes, including medication adherence, hospital readmission and mortality rates, accompanied by long-term follow-up assessments. Moreover, the development of patient-centred or highly individualized mHealth interventions, utilizing artificial intelligence-powered chatbots, is strongly recommended.

7 | CONCLUSION

This study has shown that a 24-week interactive text message-based mHealth intervention, the *WithUs* program, significantly improved long-term adherence to self-care behaviours and disease knowledge in patients with HF. Further research is required to evaluate the long-term efficacy of this intervention in a larger, culturally diverse population and to assess its impact on clinical outcomes. There is also a need for increased efforts to develop artificial intelligence-based interactive mHealth programs to provide more tailored support and address patients' needs.

8 | RELEVANCE TO CLINICAL PRACTICE

In light of the global trend towards shorter hospital stays, active engagement in healthcare management after hospital discharge has become increasingly important. The *WithUs* program, as an interactive text messaging service, may offer a valuable strategy for preventing hospital readmission by enhancing long-term adherence to self-care behaviours. Nurses and other healthcare professionals have a crucial role in evaluating the efficacy of this intervention for patients with HF.

8.1 | What does this paper contribute to the wider global clinical community?

- The intervention group utilizing the novel interactive text message-based mHealth program exhibited superior self-care behaviours compared with the control group over the 6-month period.
- Interestingly, the self-care behaviour trajectory of patients in the intervention group exhibited a sharp increase between the first and third month of follow-up.
- The intervention group demonstrated significantly higher disease knowledge than the control group at both the first- and sixth-month follow-up assessments.
- The *WithUs* program can assist nurses and other healthcare professionals in monitoring patients' health indicators, such as symptom severity, diet and physical activity.

AUTHOR CONTRIBUTIONS

All authors have made a statistically significant contribution to the works described, sufficient to warrant being listed within the authorship list and have been involved in the drafting and development of this final manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

The institutional research board of Chung-Ang University, Seoul, Korea (IRB: 1041078-202,009-HRSB-289-01), approved the study protocol.

STATISTICS

There is a statistician on the author team and this is Youn-Jung Son.

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