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mHealth-Based Self-Management Program for Patients With Rheumatoid Arthritis: A Pilot Randomized Controlled Study

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ABSTRACT

Rheumatoid arthritis (RA) is a chronic autoimmune disease that gradually limits physical function and decreases quality of life (QOL). We evaluated an mHealth-based self-management program to help patients with RA improve their physical and psychological health, self-efficacy, physical activity, and QOL. The sample included 73 experimental and 69 control participants. A pilot randomized controlled design was employed to identify the effectiveness of an 8-week mHealth-based self-management program, which comprised educational modules regarding disease management and exercise, cognitive training, and motivational support through mobile messages and periodic phone calls. Knowledge of the health effects of RA, disease activity, perceived health, depression, self-efficacy for controlling symptoms, physical activity, and QOL were evaluated pre- and postintervention and after the 4-week follow-up period. This pilot study indicates that the mHealth-based program for people with RA is feasible. The mHealth self-management program improved patients' knowledge of RA, depression, self-efficacy for controlling symptoms, physical activity, and perceived health; however, disease activity and QOL did not significantly change. This pilot study demonstrates the potential of mHealth intervention as an effective program for strengthening self-management capacities in patients with RA.

Trial Registration: KCT0007523

1 | Introduction

Rheumatoid arthritis (RA) is a chronic autoimmune disease that gradually limits physical function and decreases quality of life (QOL). The QOL of people with RA is comparable to that of patients with end-stage renal disease, which is much lower than that of patients with osteoarthritis or diabetes (Ataoglu et al. 2018; Gong and Mao, 2016; Katchamart et al. 2019). Furthermore, a recent study demonstrated that Asians with RA reported poorer QOL than their Western counterparts (Suh et al. 2022). Clinical studies have indicated that early

antirheumatic medication and self-management increase the likelihood of RA remission (Zanetti et al. 2023). Moreover, recent studies have shown that effective treatment regimens can reduce severe impairment (Aletaha and Smolen 2018); however, the regimens do not appear to improve QOL for people with RA (Salaffi et al. 2019). Given its progressive nature and unpredictable course, initiatives to enhance QOL via self-management in this population should be emphasized.

Self-management refers to a person's ability to regulate the physical and psychological consequences of RA in a manner

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Summary

- mHealth self-management education enhances knowledge about the health effects of rheumatoid arthritis, depression, self-efficacy in controlling symptoms, physically active lifestyles, and perceived health.
- mHealth intervention shows promise as an effective tool for enhancing self-management skills in individuals with rheumatoid arthritis.
- mHealth program may help address unmet educational needs in patients with rheumatoid arthritis.

they deem most personally beneficial (Nikiphorou et al. 2021). The effects of self-management relate to higher levels of self-efficacy, adherence to treatment, and reduced pain and disease activity (Dixon and Michaud 2018); (Seppen et al. 2020; Shao, Yu, and Chen 2021). Therapeutic lifestyle change—a central self-management strategy—is important for improving QOL in people with RA. Levels of physical and psychological symptoms and self-efficacy for controlling symptoms are associated with QOL in Koreans with RA; self-efficacy is the key component affecting QOL (Suh et al. 2022). Those confident in their ability to regulate RA symptoms may actively participate in healthy lifestyles by accepting their illness, overcoming barriers, and trying to achieve treatment goals (Martinez-Calderon et al. 2020; Suh et al. 2019). Healthcare providers may benefit from incorporating cognitive-behavioral techniques into self-management education to improve individuals' confidence and behavioral skills in managing their disease (Dineen-Griffin et al. 2019; Washirasaksiri et al. 2024).

Notably, for these patients, the risk of developing cardiovascular disease (CVD) is 1.5–3 times greater than for the general population, and approximately one-third to half of their deaths are related to CVD (Løgstrup et al. 2021). However, substantial gaps exist between the perceived and actual risks of CVD among patients with RA; they lack knowledge about the health effects of an unhealthy lifestyle and how to maintain healthy lifestyles (Boo et al. 2017). Misperception of health risks may be a barrier to self-management, such as adopting a healthy lifestyle. Thus, self-management should also include understanding RA and its effects on one's health.

Patient education for better self-management is crucial in RA care because the disease courses are complex, and various symptoms, medication effects, and adverse events may occur (Damgaard et al. 2023; Nikiphorou et al. 2021; Wu et al. 2022). However, according to a prior report, only 24.2% of healthcare providers provide patient education for more than 5 min in their clinics; only 7% of patients with RA receive structured education (Park and Yoon 2016). In the same report, 42% of patients with RA answered that they “did not know” about its complications, and 90% of the participants expressed the need for self-management education. The reasons for the reduced implementation of patient education were mainly limited education time in clinical practices (Park and Yoon 2016). Therefore, there is a need to develop self-management educational programs regardless of time and place. Patients' greatest educational needs

(information most frequently requested) concerned disease process, medications, managing symptoms, and self-help (Hirsch et al. 2020). The literature also shows that behavioral or psycho-educational interventions are more effective than information- or education-only programs for behavioral changes (Prothero et al. 2018; Washirasaksiri et al. 2024).

Prior research has mostly focused on evaluating self-management programs for RA that were delivered either in-person or over calls (Wu et al. 2022). The field of mobile application (app) technology has experienced significant progress; patients and researchers prefer mobile clinical trials due to their convenient and accessible nature, independent of time or place (Perry et al. 2019). Mobile health apps are crucial for patients with RA given the chronic and progressive nature of the disease and the need for self-management (Seppen et al. 2020); mobile apps designed to improve self-management of RA are considered beneficial and optimal for disease management, particularly when the scope for in-person interventions is limited, such as during the COVID-19 pandemic (Seppen et al. 2022).

Prior research has shown that a self-management program lasting 6–8 weeks has had beneficial effects on physical function, self-efficacy, symptoms, and QOL in patients with RA (Anvar et al. 2018; Shao, Yu, and Chen 2020, 2021). Given the scarcity of evidence for technology-based self-management programs for Koreans with RA, this pilot study aimed to explore the feasibility and effectiveness of an 8-week nurse-led mHealth self-management education program. The pilot results included process indicators such as program recruitment, dropout, and completion rates. The effectiveness of an 8-week nurse-led mHealth self-management education program was evaluated in terms of knowledge about RA and its impact on physical and psychological health status (disease activity, perceived health status, and depressive mood), self-efficacy for controlling symptoms, self-management behaviors (levels of physical activity), and QOL. Our study hypothesized that the nurse-led mHealth self-management program would provide better outcomes in terms of knowledge about RA, physical and mental health, self-efficacy in symptom control, levels of physical activity, and QOL, compared to the one-time in-person instruction provided with a booklet.

2 | Methods

2.1 | Study Design

A pilot randomized controlled pretest, posttest, and follow-up test design was employed to identify the effectiveness of mHealth educational interventions in patients with RA. This study comprised an 8-week intervention and a 4-week follow-up period. Ethical approval was obtained from the institutional review board of Ajou University Medical Center (AJIRB- MED-SUR-19-400) before enrollment.

2.2 | Setting, Participants, and Procedure

The study samples were recruited from the rheumatology outpatient clinic of a university-affiliated hospital in South Korea from

December 2019 to January 2020. The eligibility criteria were as follows: (1) aged 20 years or older and (2) having been diagnosed with RA by a rheumatologist based on the American College of Rheumatology criteria. A rheumatologist screened the potential candidates for eligibility. While potential participants were waiting for routine follow-up appointments with their rheumatologists, a trained research assistant approached them and explained the study's objectives and its voluntary, anonymous nature. Written informed consent and initial assessments were obtained from all who agreed to participate, and the study was conducted in compliance with the Declaration of Helsinki.

Participants were randomly assigned to either the experimental or control group using a random number selection software. Serial numbers were assigned to the participants, and the experimental group participants were selected using the software, while the other participants were assigned to the control group. The rheumatologists in charge of their treatment were not informed of the participants' group assignments. With an effect size (d) of 0.45, an alpha value of 0.05, and a power of 0.80, an a priori power analysis using G*Power version 3.1 estimated that 62 participants per group were required. Considering the 25% dropout rate, we planned to recruit 166 patients with RA (83 patients per group).

2.3 | Intervention

The 8-week nurse-led mHealth intervention for the experimental group consisted of education for disease management, exercise, and cognitive training. The mHealth intervention programs comprised eight modules, each including videos and booklets. Participants could choose a module independently and go through it at their own pace and as often as they desired. To ensure the accuracy of self-reported physical activity levels, participants underwent a comprehensive training session at the beginning of the intervention. This session included detailed instructions and examples on how to accurately recall and document their physical activities. The training aimed to minimize recall bias and improve consistency in reporting.

The educational session focused on common RA symptoms, pharmacological treatments and their adverse effects, and self-management strategies. The strategies included healthy lifestyle choices to alleviate the physical and emotional effects of RA and techniques for supporting or protecting joints while performing regular tasks, such as opening jars or brushing teeth, without placing additional discomfort or load on joints. We also introduced self-help devices that help ease joint strain, such as long-handled shoehorns, and encouraged their use.

The exercise session consisted of stretching and resistance exercises (15 min), aerobic movements (10 min), and hand exercises (10 min) to enhance the range of motion, muscle strength, and hand function. Stretching and resistance exercises included range-of-motion and stretching exercises with elastic TheraBands to maintain or increase large joint function. The aerobic portion included stepping into a standing position or sitting in a chair, standing up, and sitting in a chair again. The therapeutic putty hand training program comprised squeezing putty in a full fist, hook fist, and between fingers; pinching

putty; extending the fingers out against putty; and rolling putty. All exercise sessions were guided by videos and instructions, allowing participants to follow along. The resistance bands and putty used were determined according to individual functional abilities.

Cognitive training included strategies to balance activity and rest, stress management, and encouraging requests for help and social support from family, colleagues, and healthcare providers. Videos of two women's success stories in overcoming RA with healthy lifestyles were provided as surrogate experiences to motivate the participants and enhance their confidence in overcoming RA. An e-diary was provided to assist participants in setting their own goals during the program and tracking their pain, fatigue, physical function, and overall well-being daily. This allowed them to objectively examine their symptoms and feelings in relation to their goals and make the appropriate behavioral changes. Engaging in this process helped participants increase their confidence in their abilities to control symptoms and enhance their self-management skills. Moreover, it enabled the researcher to empathize with and understand the participants' experience with RA, as well as provide personalized education. Based on the e-diary records of each participant, weekly individual counseling sessions lasting 10–15 min were conducted over the phone, and tailored informative and persuasive text messages were sent to the participants in the experimental group twice per month. We tracked whether participants completed all the modules. Participants in the control group were given elastic TheraBands, therapeutic putty, and booklets for the educational and exercise sessions through an in-person short education session (10 min). Following the completion of all data collection processes, the control group was given the opportunity to access the online modules.

2.4 | Measures

The pilot results included process measures such as the total number of recruited participants, the number of participants who withdrew along with the reasons for their withdrawal, and the number of participants who successfully completed the intervention. These data were diligently monitored by the research team. The trial outcome variables—knowledge of the health effects of RA, disease activity, perceived health, depression, self-efficacy for controlling symptoms, levels of physical activity, and QOL—were surveyed before and after the intervention, as well as after the 4-week follow-up period. The preintervention survey was conducted on paper, while the follow-up assessments following the intervention were performed over the telephone. The research assistant who collected the data was blinded for the group assignment.

2.4.1 | Disease Features

The Korean version of the Multidimensional Health Assessment Questionnaire (MDHAQ) measures RA-related disease features (Lee et al. 2006). The scale consists of questions related to the participants' physical function and severity of RA symptoms, such as pain and fatigue. Higher scores

indicate poorer physical function and higher overall pain and fatigue. Disease activity was assessed using the rheumatoid arthritis disease activity index (RADAI). The RADAI provides self-reported joint evaluation rates for the intensity of pain in 16 joint groups (both shoulders, elbows, wrists, fingers, hips, knees, ankles, and toes) on a scale of 0 (*no pain*) to 3 (*extreme/severe pain*). The total score ranged from 0 to 48 and was converted to 0–10 based on scoring guidelines (Pincus, Swearingen, and Wolfe 1999), with higher scores indicating higher levels of perceived disease activity. In this study, Cronbach's α for the RADAI was 0.92.

2.4.2 | Knowledge of the Health Effects of RA

The health effects of RA on CVD were measured using the 13-item Heart Disease Fact Questionnaire-Rheumatoid Arthritis (John et al. 2009). The English questionnaire was translated into Korean by two translators and any discrepancies were resolved. An independent, multilingual translator translated the resolved version back into English. The revised English version was compared to the previous English version to ascertain any potential loss of semantic significance. Content authenticity was verified by a rheumatologist and two registered nurses with Ph.D. degrees, who specialized in providing care for patients with RA. Participants were asked to answer “yes” or “no” to each question. One point was awarded for each correct answer; the total scores ranged from 0 to 13, with higher scores indicating higher levels of knowledge of CVD related to RA. The KR-20 was 0.74 in this study.

2.4.3 | Perceived Health Status

Perceived health status was assessed using the following question: “How is your health in general? Is it very good, good, fair, poor, or very poor?” The responses were dichotomized so that 0 = *good or fair* and 1 = *poor*.

2.4.4 | Depression

The Korean version of the 20-item Center for Epidemiologic Studies-Depression Scale (CES-D) was used to evaluate levels of depressive mood (Shin et al. 1991). The scale rates the frequency of mood states on a 4-point scale from 0 (*rarely*) to 3 (*most or all the time*) to determine the mood states encountered in the previous week. The total scores were calculated by summing the item scores. Possible scores ranged from 0 to 60, with higher scores indicating higher levels of depressive mood. Internal reliability for the CES-D was found to be 0.85 for the general population, including Koreans (Shin et al. 1991). In this study, it was 0.91.

2.4.5 | Self-Efficacy for Controlling Symptoms

The 8-item short version of the Arthritis Self-Efficacy Scale was used to measure each participant's confidence in dealing with symptoms of RA (Lorig et al. 1989). An example item is, “How certain are you that you can decrease your pain?” Participants

were asked to rate their confidence on a 10-point scale ranging from 1 (*very uncertain*) to 10 (*very certain*). The questionnaire was translated into Korean, back translated, and linguistically validated. The total scores were calculated by averaging the item scores, ranging from 1 to 10, with higher scores indicating greater self-efficacy. Cronbach's α was reported as 0.92 when the measure was developed. In this study, Cronbach's α for this test was 0.94.

2.4.6 | Physical Activity Level

The Korean version of the International Physical Activity Questionnaire (IPAQ; Craig et al. 2003) was used to measure physical activity. Participants were asked to recall the frequency and duration of three intensity levels (vigorous, moderate, and walking) of physical activity they had engaged in for at least 10 min in the past 7 days. Examples of vigorous and moderate physical activity were provided to help them assess their physical activity levels more accurately. Data collected with the IPAQ were scored as metabolic equivalent task scores (MET, min/week) by multiplying the number of minutes of each intensity level by its corresponding metabolic value. One MET was defined as the amount of oxygen consumed per minute while resting. A minimum of 150 min of moderate activity per week is suggested to be beneficial for health promotion in the general population (Piercy et al. 2018) and in populations with chronic diseases, such as RA (Nelson et al. 2007). This amount of physical activity is equivalent to approximately 600 MET-min/week. Participants with more than 600 MET-min/week of physical activity and moderate activity or walking at least three times per week were considered physically active. The Korean version of the IPAQ has shown acceptable reliability and validity.

2.4.7 | Quality of Life

The Quality-of-Life RA Scale was used to assess QOL (Danao, Padilla, and Johnson 2001). This 8-item scale evaluates various RA-specific QOL aspects, including physical, psychological, and social factors. Participants were asked to rate their perceived QOL from 0 (*very poor*) to 10 (*excellent*). Total scores were calculated by averaging the item scores, with higher scores indicating better RA-specific QOL. The scale's original developer reported Cronbach's α of 0.87 to 0.90 for the English and Spanish versions (Scott, Smith, and Kingsley 2005). In this study, Cronbach's α for this scale was 0.94.

2.5 | Data Analysis

Data were analyzed using IBM SPSS software (version 23.0; IBM Corp., Armonk, NY, USA). The variables were screened for potential errors, missing data, and outliers. We used the Shapiro–Wilk normality test to verify the normality of the dependent variables, and descriptive statistics were calculated for all the variables. *T*-tests and chi-square tests were conducted to examine homogeneity between the intervention and control groups. We used *t*-tests to evaluate the effect of the intervention over time. Differences were considered statistically significant at $p < 0.05$.

3 | Results

3.1 | Process Measures

Of the 184 patients with RA assessed, 18 declined to participate due to a lack of interest in the study, insufficient time to engage or a lack of internet connection. Consequently, a total of 166 agreed to participate in this study and successfully completed the informed consent and initial assessment process. They were randomly assigned to either the experimental ($n=83$) or control ($n=83$) groups (Figure 1). The randomization process was adequate and evenly distributed throughout the groups. Ten participants in the experimental group withdrew during the intervention ($n=3$) or were lost to follow-up ($n=7$). These 10 were excluded from the analysis, yielding a dropout rate of 12.0%. The reason for withdrawal in the experimental group were a lack of time ($n=1$), hospitalization for an unrelated reason ($n=1$), and concerns over the potential danger to confidentiality associated with mHealth intervention ($n=1$). In the control group, 14 either withdrew ($n=2$) or were lost to follow-up ($n=12$), resulting in a dropout rate of 16.9%. Therefore, 142 participants (73 in the experimental group and 69 in the control group) completed the study (Figure 1). We monitored the progress of the experimental group in completing the intervention modules and e-diary. A total of 73 individuals in the experimental group successfully completed the mHealth Modules.

3.2 | Baseline Demographic and Study Variables

Demographic characteristics of participants are reported in Table 1. Participants' mean age was 54.15 (SD 9.61) years, and 86.6% ($n=123$) of the participants were women. The average duration of the disease was 10.50 (SD 8.26) years, and 76.1% ($n=108$) of the participants had positive RA factors. The mean score for physical function, as evaluated by the MDHAQ, was 0.97 out of 10. The mean scores for overall pain and fatigue related to RA were 3.04 (SD 2.32) and 3.85 (SD 2.53) of 10,

respectively. Participants were randomly assigned into either the experimental or control group, and the general and disease-related characteristics were not substantially different between the groups.

The differences in the levels of knowledge regarding the health effects of RA, RADAI, perceived health status, depressive mood, self-efficacy for control symptoms, levels of physical activity, and QOL between the two groups are presented in Table 2. The mean RADAI was 2.11 of 10, and the overall self-efficacy score was 45.3 of 80 on average. Approximately 56% ($n=80$) perceived their health as good, and 55.6% ($n=79$) of the participants were classified as physically active. The mean for depressive mood was 12.86 of 60, and the mean for RA-specific QOL was 5.81 of 10. There were no statistically meaningful differences in the study variables between the groups before the intervention.

3.3 | Trial Outcomes

Table 3 and Figure 2 display the trial outcomes for evaluating the effects of the mHealth-based self-management program. Posttest results revealed that the knowledge of the health effects of RA was significantly higher ($p=0.023$) in the experimental group (mean 9.82) than in the control group (mean 8.86). Levels of self-efficacy for control symptoms were significantly higher in the experimental group than in the control group at the end of the intervention (46.73 vs. 41.07, $p=0.032$) and in the follow-up phase (48.58 vs. 40.91, $p=0.004$). The levels of depression decreased in the experimental group gradually while increasing in the control group, and the depression level in the experimental group was statistically significantly lower than that in the control group in the follow-up phase (10.07 vs. 14.04, $p=0.022$). QOL in the experimental group increased over time, while it remained relatively stable in the control group; however, the differences were not statistically significant ($p=0.054$) at the end of the intervention (6.10 vs. 5.69, $p=0.193$) and in the follow-up phase (6.23 vs. 5.60, $p=0.054$). The proportion of physically active lifestyles was higher after the intervention in the experimental group compared to the control group (78.1% vs. 60.3%, $p=0.022$) but not in the follow-up phase (Figure 2). The proportion of those perceiving their health to be good was significantly higher in the experimental group than the control during the postintervention (64.4% vs. 42%, $p=0.008$) and follow-up phases (76.7% vs. 59.4%, $p=0.027$).

4 | Discussion

Effective self-management is crucial for chronic illnesses such as RA. Unfortunately, rheumatologists and/or physicians who care for these patients often do not have the time to offer comprehensive psychological support and self-management education as part of their regular practice. Given the internet's promise in these domains, we conducted a pilot trial of a nurse-led mHealth self-management education program designed specifically to address the gap in healthcare service provision to people with RA.

Our pilot study indicates that the mHealth-based program for people with RA is feasible: the recruitment rate was high; the randomization procedure was suitable; the overall attrition

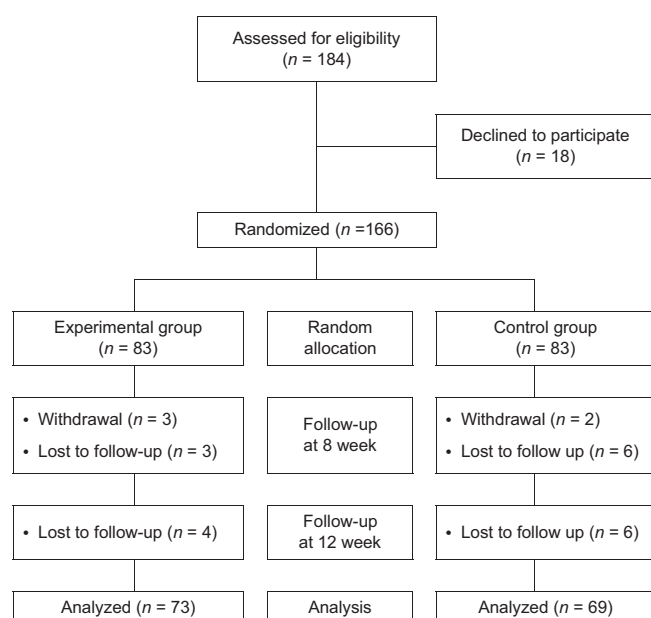


FIGURE 1 | CONSORT flow diagram.

TABLE 1 | Homogeneity of general characteristics (N=142).

Characteristics	Total	Experimental group (n = 73)	Control group (n = 69)	X ² or t	p
		n (%) or mean ± SD			
Female	123 (86.6)	62 (84.9)	61 (88.4)	0.369	0.543
Age (years)	54.15 ± 9.61	52.85 ± 9.75	55.54 ± 9.33	-1.676	0.096
Married and live together	113 (79.6)	60 (82.2)	53 (76.8)	0.632	0.427
Education (college or above)	71 (50.0)	38 (52.1)	33 (47.8)	0.254	0.614
Employment (employed)	70 (49.3)	35 (47.9)	35 (50.7)	0.110	0.741
Household income (≥ 4 000 000 KRW)	75 (52.8)	43 (58.9)	32 (46.4)	2.234	0.135
Disease duration (years)	10.50 ± 8.26	9.79 (7.37)	11.26 (9.12)	-1.049	0.296
Seropositivity (positive RF factor)	108 (76.1)	55 (75.3)	53 (76.8)	0.042	0.838
RA treatment, n (%)					
Being treated with DMARDs, n (%)	133 (93.7)	70 (95.9)	63 (91.3)	1.257	0.262
Being treated with steroid, n (%)	66 (46.5)	30 (41.1)	36 (52.2)	1.750	0.186
Being treated with NSAIDs, n (%)	99 (69.7)	49 (67.1)	50 (72.5)	0.479	0.489
Being treated with biologics, n (%)	17 (12.0)	8 (11.0)	9 (13.0)	0.146	0.702
Function (0~10)	0.97 ± 1.32	0.92 ± 1.37	1.01 ± 1.27	-0.406	0.685
Pain (0~10)	3.04 ± 2.32	2.78 ± 1.98	3.31 ± 2.62	-1.356	0.178
Fatigue (0~10)	3.85 ± 2.53	3.53 ± 2.39	4.18 ± 2.64	-1.549	0.124
Hypertension, n (%)	64 (45.1)	37 (50.7)	27 (39.1)	1.913	0.167
Diabetes, n (%)	12 (8.5)	5 (6.8)	7 (10.1)	0.498	0.480
BMI (kg/m ²)	23.41 ± 3.39	23.82 ± 3.68	22.98 ± 3.03	1.475	0.142

Abbreviations: BMI, body mass index; DMARD, disease-modifying antirheumatic drugs; NSAIDs, nonsteroidal anti-inflammatory drugs; RA, rheumatoid arthritis; RADAI, RA disease activity index.

rate was approximately 15%; and participants in the experimental group successfully completed the program. Our hypothesis was that participants with RA who are randomly assigned to the nurse-led mHealth self-management program would experience significant improvements in their knowledge of illnesses, self-efficacy in controlling symptoms, health status, and QOL, compared to the control group receiving only one education session. Our findings partially support the hypothesis by demonstrating that the mHealth self-management intervention group had better outcomes in terms of knowledge of the health effects of RA, depression, self-efficacy in controlling symptoms, physically active lifestyles, and perceived health.

The most significant improvement was observed in patients' self-efficacy in controlling symptoms, which is consistent with previous findings (Shao, Yu, and Chen 2021). In patients with RA, self-confidence in controlling symptoms is an important component of care that extends beyond medication therapy and helps the patients manage the physical and psychological

effects of the condition. Our program specifically focused on educating participants about the skills necessary to manage their symptoms effectively. Self-monitoring using a daily e-diary as part of self-management was promoted throughout the program. Shao, Yu, and Chen (2021) also affirmed that diaries are useful for self-monitoring for patients with RA, particularly for changes in symptoms and functional status. This pilot study found a substantial increase in self-efficacy levels in the experimental group at the end of the intervention and during the follow-up phase, aligning with findings from previous studies (Damgaard et al. 2023; Lorig et al. 2008; Short et al. 2018).

Another advantage of the strategy implemented in this pilot study was the provision of targeted motivational support through weekly phone calls and personalized mobile texts. Phone calls were used to motivate participants to set achievable goals and to discuss their challenges, encouraging them to practice self-management solutions and improve their cognitive control over healthy lifestyle choices. This approach

TABLE 2 | Homogeneity of study variables ($N=142$).

Characteristics	Total	Experimental group ($n=73$)	Control group ($n=69$)	X^2 or t	p
		n (%) or mean \pm SD			
Knowledge of the health effects of RA	8.34 \pm 2.79	8.32 \pm 2.71	8.36 \pm 2.90	-0.101	0.920
RADAI (1~10)	2.11 \pm 1.75	2.06 \pm 1.74	2.16 \pm 1.77	-0.341	0.734
Perceived health (fair or above), n (%)	80 (56.3)	46 (63.0)	34 (49.3)	2.722	0.099
Depressive mood (0~60)	12.86 \pm 9.77	12.44 \pm 9.29	13.30 \pm 10.30	-0.527	0.599
Self-efficacy for control symptoms (0~80)	45.30 \pm 16.56	45.52 \pm 16.26	45.06 \pm 16.98	0.166	0.869
Physically active lifestyle (MET \geq 600), n (%)	79 (55.6)	41 (56.2)	38 (55.1)	0.017	0.896
Quality of life (0~10)	5.81 \pm 1.95	5.95 \pm 1.89	5.66 \pm 2.01	0.889	0.375

Abbreviations: MET, metabolic equivalent task scores; RA, rheumatoid arthritis; RADAI, RA disease activity index.

TABLE 3 | Effects of mHealth intervention.

Variables	Mean \pm SD			Difference, mean \pm SD	
	Pretest	Posttest	F/u	Pre-post	Pre-f/u
Knowledge of the health effects of RA					
Experimental group	8.32 \pm 2.71	9.82 \pm 2.32	9.63 \pm 2.37	-1.50 \pm 2.78	-1.32 \pm 2.62
Control group	8.36 \pm 2.90	8.86 \pm 2.66	8.88 \pm 3.27	-0.49 \pm 2.35	-0.52 \pm 2.70
t (p)	-0.101 (0.920)	2.303 (0.023)	1.563 (0.120)	-2.334 (0.021)	-1.776 (0.078)
RADAI					
Experimental group	2.06 \pm 1.74	2.16 \pm 1.60	2.03 \pm 1.43	-0.10 \pm 1.25	0.03 \pm 1.31
Control group	2.16 \pm 1.77	2.11 \pm 1.59	2.24 \pm 1.61	0.06 \pm 1.29	-0.08 \pm 1.24
t (p)	-0.341 (0.734)	0.198 (0.843)	-0.833 (0.406)	-0.722 (0.471)	0.527 (0.599)
Depressive mood					
Experimental group	12.44 \pm 9.29	11.15 \pm 8.49	10.07 \pm 9.53	1.29 \pm 7.83	2.37 \pm 7.50
Control group	13.30 \pm 10.30	13.87 \pm 11.32	14.04 \pm 10.85	-0.57 \pm 6.90	-0.74 \pm 7.60
t (p)	-0.527 (0.599)	-1.612 (0.110)	-2.323 (0.022)	1.493 (0.138)	2.452 (0.015)
Self-efficacy for control symptoms					
Experimental group	45.52 \pm 16.26	46.73 \pm 15.14	48.58 \pm 14.49	-1.21 \pm 13.58	-2.11 \pm 12.81
Control group	45.06 \pm 16.98	41.07 \pm 15.94	40.91 \pm 16.73	3.99 \pm 15.61	4.14 \pm 15.61
t (p)	0.166 (0.869)	2.164 (0.032)	2.922 (0.004)	-2.117 (0.036)	-2.616 (0.010)
Quality of life					
Experimental group	5.95 \pm 1.89	6.10 \pm 1.81	6.23 \pm 1.90	-0.15 \pm 1.24	-0.28 \pm 1.67
Control group	5.66 \pm 2.01	5.69 \pm 1.90	5.60 \pm 1.99	-0.03 \pm 1.56	0.06 \pm 1.61
t (p)	0.888 (0.375)	1.309 (0.193)	1.945 (0.054)	-0.495 (0.622)	-1.249 (0.214)

Abbreviations: f/u, follow-up; RA, rheumatoid arthritis; RADAI, RA disease activity index.

successfully boosted the number of participants who embraced a physically active lifestyle right after the intervention in this study. Research indicates that mHealth for patients can effectively promote healthier lifestyles, including increasing physical activity and improving medication adherence (Seppen et al. 2020).

However, this pilot study was unable to confirm any meaningful effect on increasing physical activity throughout the follow-up period. This can be attributed in part to a reduction in extrinsic motivators, such as the phone calls or text messages sent during the intervention. The nature of the mHealth program, not involving face-to-face interaction, makes it difficult

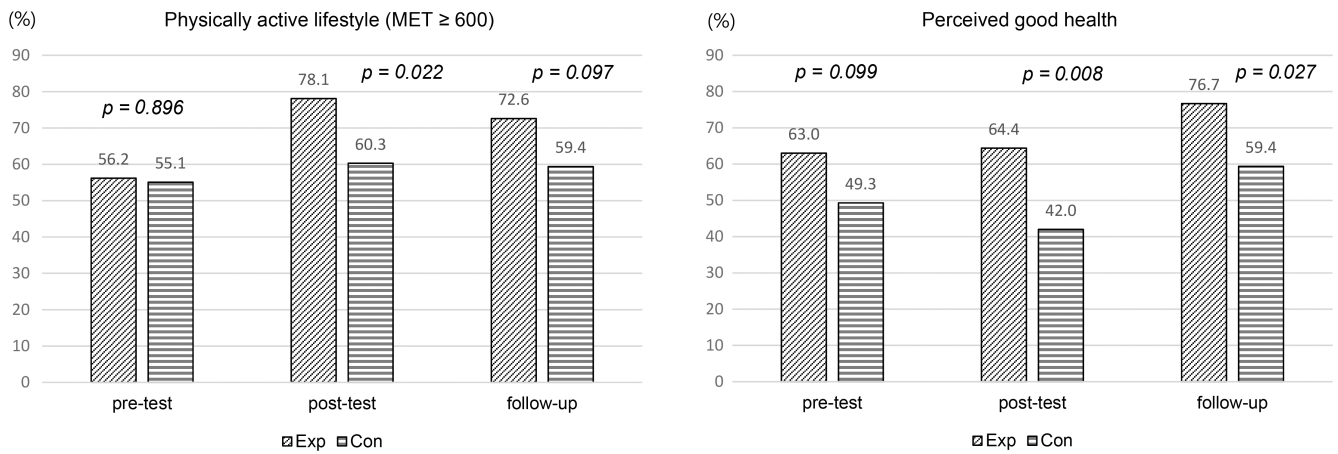


FIGURE 2 | Effects of mHealth intervention on physically active lifestyles and perceived health. Abbreviations: con, control group; exp., experimental group; MET, metabolic equivalent task scores.

to quantify the intensity and degree of involvement in the intervention. Although we tracked the completion of the intervention modules, the true amount of engagement and how it affected the results is unknown. Future research should prioritize the development of innovative approaches for evaluating participant engagement, aiming to directly enhance behavior and QOL. Our proposal involves creating and executing an mHealth program that utilizes artificial intelligence and has an extended intervention duration. The goal would be to pinpoint the precise time-frame in which individuals with RA willingly adopt positive habits in the future.

The results of our pilot study revealed statistically significant changes in subjective measures of self-efficacy, depressive symptoms, and physical activity levels. However, our study found that QOL improved progressively but not considerably when compared to the control group. There was no substantial enhancement in disease activity as measured by the RADAI, which aligns with findings from previous studies (Shao, Yu, and Chen 2021). One possible explanation is that the effectiveness of medication therapy has a stronger correlation with disease activity than subjective assessments such as self-efficacy (Chaleshgar-Kordasiabi et al. 2018). This suggests that although mHealth programs, which include online learning modules and weekly one-on-one consultations, can improve cognitive self-efficacy related to symptom control, they may not directly enhance the skills needed to reduce disease activity. Nevertheless, since the mHealth education program implemented in this pilot study did not adversely impact the disease activity of any of the participants and may be utilized without any concerns about safety, time and location, larger studies are necessary to investigate the long-term effects on disease activity.

This pilot study underscores the potential of mHealth programs to support self-management among patients with RA, especially when social distancing is required, such as during the early phases of the COVID-19 pandemic. The improvement in self-efficacy and depression management suggests that mHealth has the potential to fulfill an important unmet need in the care of people with RA. However, for more effective disease activity management, this pilot study suggests that mHealth programs need to be integrated with strategies that ensure sustained

engagement and adherence to the prescribed interventions. The limitations of this study include its inability to assess long-term compliance with the mHealth app and the limited generalizability of the findings due to the specific conditions under which the intervention was carried out. Furthermore, the assessment of changes in health behavior relied on self-reported levels of physical activity, with a single question defining perceived health status. The absence of substantial changes in QOL and disease activity suggests the need for enhanced program content that directly addresses these issues.

5 | Conclusions

Our pilot study indicates that a nurse-led mHealth intervention as feasible, acceptable and effective for increasing self-management of chronic diseases in community-dwelling patients with RA. This study is among the few pilot randomized controlled studies to evaluate a clinically applicable cognitive-behavioral education intervention via an mHealth app accompanied by motivational support. Participants demonstrated substantial improvements in some, but not all, outcome variables. Nevertheless, the outcome trends for all variables revealed favorable changes in the experimental group. A large and long-term trial would be required to achieve sufficient statistical power to detect improvements in clinical outcomes such as disease activity or QOL in this population.

5.1 | Relevance for Clinical Practice

Given the progressive and unpredictable nature of RA, it is important to prioritize programs that improve QOL through self-management in individuals with the condition. Effective patient education is essential in managing RA because of the complex nature of the condition, which involves several symptoms, treatment impacts, and potential side effects. However, prioritizing patient education for self-care can be difficult in busy professional environments. Thus, there is a need for the development of self-management educational programs that can be used without any concerns about safety, and that are independent of time and place.

This pilot trial demonstrated the feasibility of a nurse-led mHealth program for people with RA and measured short-term favorable benefits. Nurses can have a crucial impact on improving patient adherence to mobile health self-management programs, which are essential for patients to properly manage their condition. Nurses need to provide novel views on nursing, enhance digital health literacy to assess and apply digital health information, and acquire skills to access suitable health information.

Author Contributions

Hyunjin Oh: conceptualization, methodology, writing – original draft. **Chang-Hee Suh:** conceptualization, methodology, investigation, resources, formal analysis, writing – review and editing. **Ji-Won Kim:** conceptualization, methodology, writing – review and editing. **Sunjoon Boo:** conceptualization, methodology, investigation, funding acquisition, formal analysis, resources, writing – original draft, project administration, writing – review and editing.

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Ethics Statement

Ethical approval was obtained for the study from the institutional review board of Ajou University Medical Center (AJIRB- MED-SUR-19-400).

Consent

Written informed consent was obtained from the participants.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy and ethical restrictions.

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