JCS Journal of Chest Surgery
https://doi.org/10.5090/jcs.21.138
pISSN: 2765-1606 eISSN: 2765-1614
J Chest Surg. 2022;55(2):108-117

Clinical Research

Evaluation of a Smart After-Care Program for Patients with Lung Cancer: A Prospective, Single-Arm Pilot Study

Hee Chul Yang, M.D., Ph.D.[1], Seung Hyun Chung, M.D., Ph.D.[2], Ji Sung Yoo, M.D., Ph.D.[2], Boram Park, Ph.D.[3], Moon Soo Kim, M.D.[1], Jong Mog Lee, M.D.[1]

[1]Center for Lung Cancer, [2]Department of Rehabilitation Medicine, and [3]Biometric Research Branch, Research Institute and Hospital, National Cancer Center, Goyang, Korea

ARTICLE INFO
Received November 11, 2021
Revised December 10, 2021
Accepted December 14, 2021

Corresponding author
Hee Chul Yang
Tel 82-31-920-1705
Fax 82-31-920-2798
E-mail yang@ncc.re.kr
ORCID
https://orcid.org/0000-0003-2605-5985

†This article was presented at the 48th Autumn Annual Conference of the Thoracic and Cardiovascular Surgery, Daegu, Korea, on October 20–22, 2016.

Background: The efficacy of telemedicine among cancer survivors is uncertain. The Smart After-Care Program (SAP), which is an interactive, smartphone-based remote health monitoring system, was developed to help patients manage their health after leaving the hospital. This study was designed to evaluate the efficacy of our remote health care program for lung cancer patients.
Methods: We enrolled 50 patients with lung cancer. Self-monitoring devices were supplied to all patients, who were instructed to enter their daily vital signs and subjective symptoms to the Smart After-Care app. The app also provided information about rehabilitation exercises and a healthy diet for lung cancer patients. All patients received health counseling via telephone once a week and visited an outpatient clinic during weeks 6 and 12 to assess satisfaction with the SAP and changes in quality of life and physical performance.
Results: Overall satisfaction with the SAP was very high (very good, 61.9%; good, 26.2%). In the multivariate analysis to identify factors affecting satisfaction, the distance between the patient's residence and the hospital was the only significant independent factor ($p=0.013$). Quality of life improved along all functional scales ($p<0.05$). Muscle strength significantly improved in the lower limbs ($p=0.012$). Two-minute walk distance also significantly improved ($p=0.028$).
Conclusion: This study demonstrated that the SAP was acceptable for and supportive of patients with reduced pulmonary function after lung cancer treatment. The SAP was found to be particularly useful for patients living far from the hospital.

Keywords: Smartphone, Telemedicine, Delivery of health care, Rehabilitation, Neoplasms

Introduction

Information and communication technology using wireless internet and smartphones has rapidly changed how we communicate. Geographical barriers are becoming less important [1]. Recently, information and communication technology has been combined with biosensors for remote medical services, and potential applications in the healthcare industry are being actively discussed [2-4]. However, many physicians have been hesitant to introduce remote vital sign monitoring devices into clinical situations due to unresolved concerns [5]. First, while these devices may provide greater convenience, legal issues related to the responsibility for medical care may arise in the absence of a direct physical examination. Second, while remote monitoring systems are expected to reach a certain level of efficacy, scientific evidence supporting this is currently insufficient. These concerns are especially worrisome in patients with serious conditions such as cancer.

The Smart After-Care Program (SAP) is a smartphone-based remote monitoring healthcare system designed to help patients manage their health after discharge from a hospital. Initially, similar programs have been shown to be effective in patients with chronic non-cancer diseases such as diabetes, hypertension, and arrhythmia [6-10].

Lung cancer is the leading cause of cancer death in the

world. In addition, lung cancer necessarily causes the deterioration of respiratory function [11,12]. Thus, lung cancer survivors may be more worried about their health than patients with other cancers. Providing these patients with health self-monitoring tools may help motivate them to adhere to respiratory rehabilitation programs by allowing them to recognize quantified improvements in function. Additionally, these tools may assist in the early detection of physical deterioration.

The primary purpose of this study was to investigate satisfaction with the SAP among lung cancer patients and to identify factors affecting satisfaction. The secondary purpose was to determine whether this program helped improve quality of life (QOL), cardiorespiratory endurance, and muscle strength.

Methods

This study was conducted among patients with lung cancer who were receiving outpatient chemotherapy or making regular outpatient visits after lung resection surgery. The study was approved by the National Cancer Center Institutional Review Board (NCC2015-0205). Written informed consent was obtained from each participant before registration.

Enrollment commenced in August 2015, and a total of 50 patients were recruited from a single institution over 3 months (Fig. 1). Subjects who owned an Android smartphone (version 4.3 or later) were eligible to participate if they: (1) were over 18 and under 85 years old, (2) consented to participate in the study, (3) had relatively stable comorbid conditions (if any), and (4) were willing to follow the study protocol. Subjects were excluded if: (1) giving feedback via a smartphone was deemed to be difficult for them, (2) they had a history of any serious illness other than lung cancer, or (3) they had difficulties performing rehabilitation exercises.

Among a total of 50 patients, 46 were undergoing outpatient observation after lung resection surgery for lung cancer, while the remaining 4 patients were undergoing chemotherapy±radiation treatment for advanced lung cancer without surgery. The average patient age was 58.3±11.7 years, with 28 men and 22 women, and the average body mass index (BMI) was 23.4±2.8 kg/m^2. Twenty-seven pa-

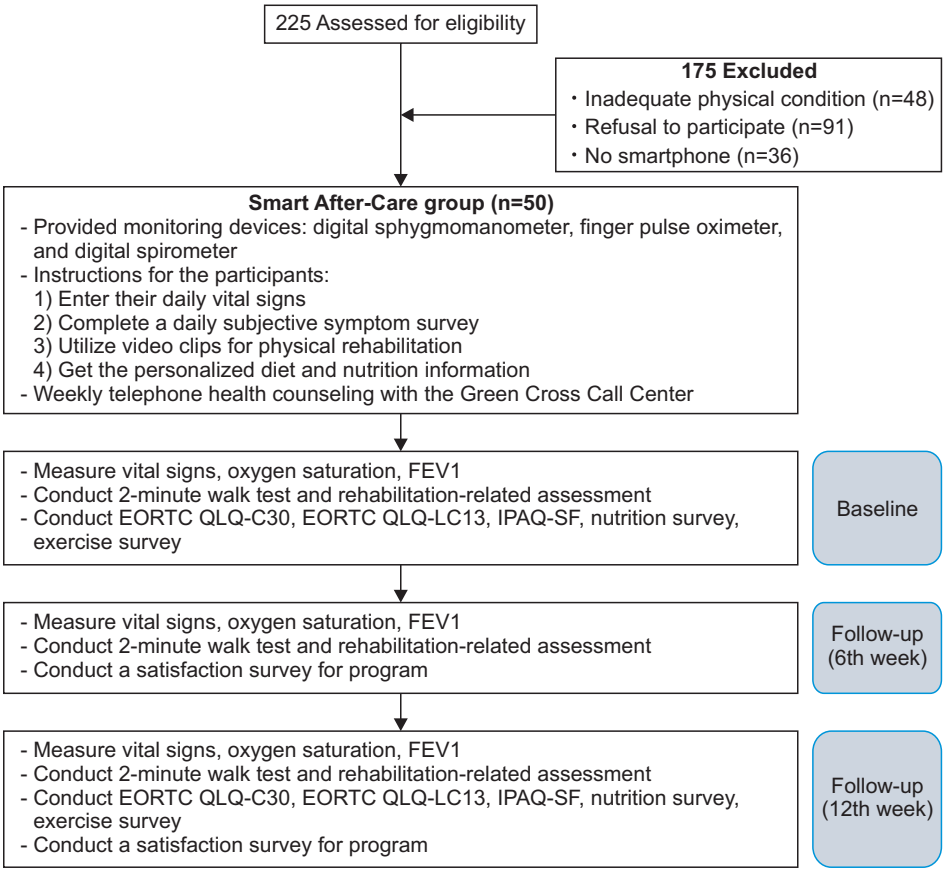

Fig. 1. Flow diagram and overview of timeline. FEV1, forced expiratory volume within 1 second; EORTC, European Organization for Research and Treatment of Cancer; EORTC QLQ-C30, EORTC Core Quality of Life Questionnaire; EORTC QLQ-L13, EORTC Quality of Life Questionnaire-Lung Cancer 13; IPAQ-SF, International Physical Activity Questionnaire-Short Form.

https://doi.org/10.5090/jcs.21.138

tients had stage I, 6 had stage II, 12 stage III, and 5 stage IV lung cancer. Of the 46 patients who underwent surgery, 35 underwent lobectomy, 8 underwent wedge resection, 2 underwent segmentectomy, and 1 underwent pneumonectomy (Table 1). During the study, 8 (16%) of the 50 patients dropped out. Among them were 5 patients (10%) who complained of the burden associated with taking measurements using the devices and inputting them into the app, 2 patients (4%) who were forced to drop out due to cancer progression, and 1 patient (2%) who did not feel a need for the program. Data analysis was conducted for the remaining 42 patients, who recorded their vital signs and completed a symptom checklist each day, participated in a weekly telephone health consultation, and completed an assessment of physical ability in the department of rehabilitation.

Of the remaining 38 patients who had undergone lung surgery, 12 patients were enrolled in the study less than 2 months after surgery, 6 patients were enrolled more than 2 months but less than 1 year after surgery, and 20 patients were enrolled more than 1 year after surgery.

Table 1. Patient characteristics: Smart After-Care participant data (n=50)

Characteristic	Value
Basic personal information	
Age (yr)	58.0±11.9
Sex	
Male	28 (56)
Female	22 (44)
Body mass index (kg/m^2)	23.4±2.8
Comorbidities	
Hypertension	9 (18)
Diabetes	5 (10)
Smoking status	
Current	17 (34)
Never	26 (52)
Ex-smoker	7 (14)
Lung cancer stage (AJCC eighth edition)	
IA	19 (38)
IB	8 (16)
IIA	3 (6)
IIB	3 (6)
IIIA	12 (24)
IIIB	0
IV	5 (10)
Treatment	
Lobectomy	35 (70)
Wedge resection	8 (16)
Pneumonectomy	1 (2)
Segmentectomy	2 (4)
Chemotherapy±RT (no surgery)	4 (8)

Values are presented as mean±standard deviation or number (%).
AJCC, American Joint Committee on Cancer; RT, radiotherapy.

All subjects visited the hospital 3 times over 3 months, at 6-week intervals. At initial registration, patients completed a baseline QOL survey (EORTC-QLQ C30 and LC13). The EORTC-QLQ C30 is the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire, which consists of a set of 30 validated core questions assessing QOL in cancer patients, and the EORTC-QLQ LC13 is a modular supplement containing 13 questions specific to patients with lung cancer [13]. Patients also completed a 2-minute walk test to measure cardiorespiratory endurance, a 30-second chair stand test to measure lower extremity muscle strength, a handgrip strength test to measure upper extremity muscle strength, and the International Physical Activity Questionnaire-Short Form [14]. Based on these results, patients received exercise instructions and training from rehabilitation specialists and returned to the rehabilitation department at weeks 6 and 12 of the study to receive additional exercise training and to re-assess exercise performance. The SAP satisfaction survey was conducted when patients visited the hospital during weeks 6 and 12, and QOL questionnaires given at the beginning and end of the study were compared.

Smart After-Care Program

Self-monitoring devices

We provided self-monitoring devices to all subjects and installed the Smart After-Care app on their smartphones. The self-monitoring devices included a Bluetooth electronic sphygmomanometer (UA-851PBT-C; A&D Electronics Co. Ltd., Shen Zhen, China), a finger pulse oximeter (Onyx Vantage 9590; Nonin Medical, Plymouth, MN, USA), and a digital spirometer (PF-200; Microlife Corp., Widnau, Switzerland). The devices were chosen based on the characteristics of lung cancer patients and enabled blood pressure, heart rate, oxygen saturation, and forced expiratory volume within 1 second (FEV1) to be obtained every morning. All participants were instructed to enter their daily vital signs into their smartphones. In addition, all participants were instructed to respond to a 13-question, lung cancer-specific checklist regarding their subjective physical state in the app (Fig. 2). If participants failed to properly input the information, the app was set to sound an alarm at 8 AM and 10 AM, and if a patient (1) failed to input the information for 3 consecutive days, (2) had an oxygen saturation of less than 95%, (3) had a heart rate above 120 beats/min or below 50 beats/min, (4) had systolic blood pressure

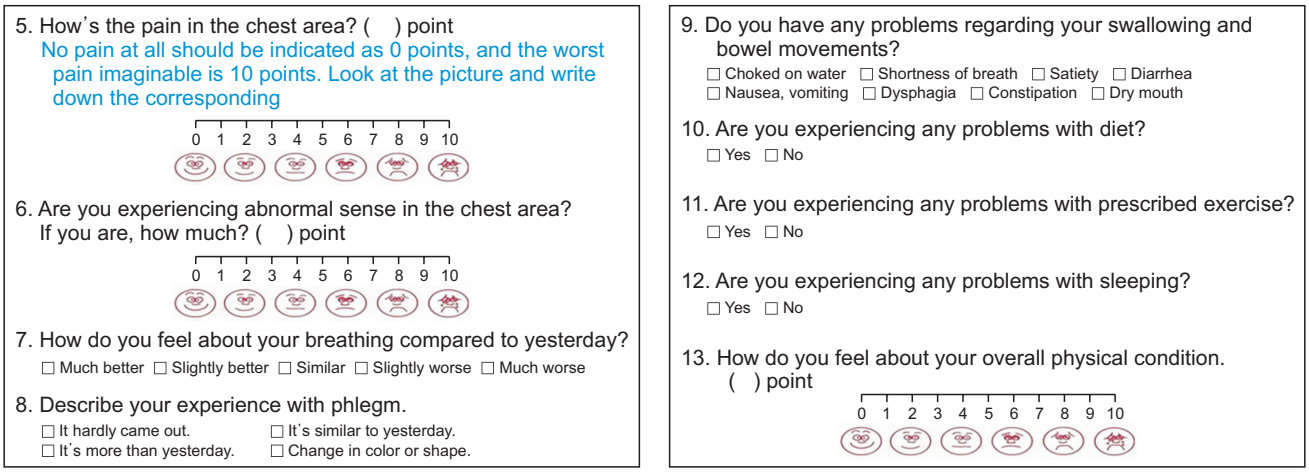

Fig. 2. Patients were instructed to complete a daily subjective condition survey in the Smart After-Care app.

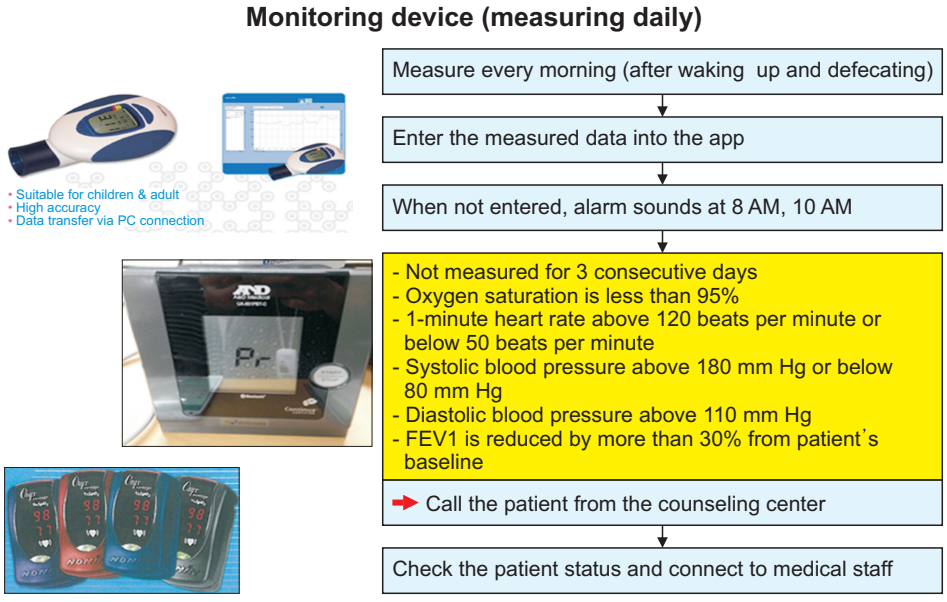

Fig. 3. A digital spirometer, Bluetooth sphygmomanometer, and pulse oximeter were provided to patients as self-monitoring devices. Data inputted into the app were sent to a central control server with an alarm set to sound if predetermined criteria were met. FEV1, forced expiratory volume within 1 second.

above 180 mm Hg or below 80 mm Hg, (5) had diastolic blood pressure above 110 mm Hg, or (6) had an FEV1 that was more than 30% lower than that patient's baseline level, the counseling center was notified and called the patient (Fig. 3).

Smart After-Care application

The Smart After-Care application was built specifically for this study, ran on the Android operating system, and included a personalized exercise and diet program for lung cancer patients in addition to recording vital signs. To encourage compliance with the prescribed exercise program, each movement was designed to be easy to follow, with a video clip for demonstration. The exercises consisted of muscle strength exercises using elastic bands, stretching exercises to increase flexibility, and breathing exercises to strengthen respiratory muscles.

Good nutrition plays an important role in improving health as well as in the treatment of disease [15]. Particularly among cancer survivors, nutritional problems such as lack of appetite are frequent. To address these problems, in this study, the BMI values of patients were calculated and classified into 6 grades according to the BMI classification criteria of the Korean Society of Obesity. Based on BMI grade, individual nutritional requirements were calculated using the Mifflin-St. Jeror formula [16]. These individual nutritional requirements were divided into 8 groups, and 12 personalized diets were provided for each group through

https://doi.org/10.5090/jcs.21.138

the app. Patients were able to check menu-specific nutrients, dietary calories, and special recipe videos at any time (Fig. 4).

Survey information

Survey of SAP satisfaction

The satisfaction survey consisted of 4 main categories, as follows: (1) overall satisfaction with the SAP and willingness to use it after this study (4 questions), (2) satisfaction with the equipment and programs used in the SAP (6 questions), (3) service usability (7 questions), and (4) satisfaction with the telephone health counseling conducted by the counseling center (5 questions). Each question had 5 response choices, as follows: (1) very good (absolutely yes), (2) good (yes), (3) fair (average), (4) poor (no), and (5) very poor (absolutely no).

The answers were standardized for statistical analysis. We investigated the independent associations between satisfaction level and relevant clinical factors via the Kruskal-Wallis test.

Survey of QOL

The EORTC QLQ-30 assessment consists of a functional scale and a symptom scale. The functional scale is divided into 6 categories: global health status, physical functioning, role functioning, emotional functioning, cognitive functioning, and social functioning. The symptom scale consists of 8 symptoms: nausea/vomiting, pain, dyspnea, insomnia, appetite, constipation, and diarrhea. In addition, this study incorporated the EORTC QLQ-LC13, developed as a QOL survey for lung cancer patients. The survey consists of 13 questions about cough, hemoptysis, dyspnea, sore mouth, dysphagia, peripheral neuropathy, alopecia, pain in the chest, pain in the arm/shoulder, and other pain. Scores were calculated according to the EORTC QLQ-C30 version 3.0 scoring manual [17]. The QOL score changes for each area were compared using the Wilcoxon signed-rank test (1-sided, H1: before<after).

Statistical analysis

STATA ver. 13.0 software (Stata Corp., College Station, TX, USA) was used for statistical analysis and data processing. Continuous variables are represented by means±standard deviations, and categorical variables are presented as median values. For continuous variables, within-group post-hoc comparisons were performed using the Wilcoxon

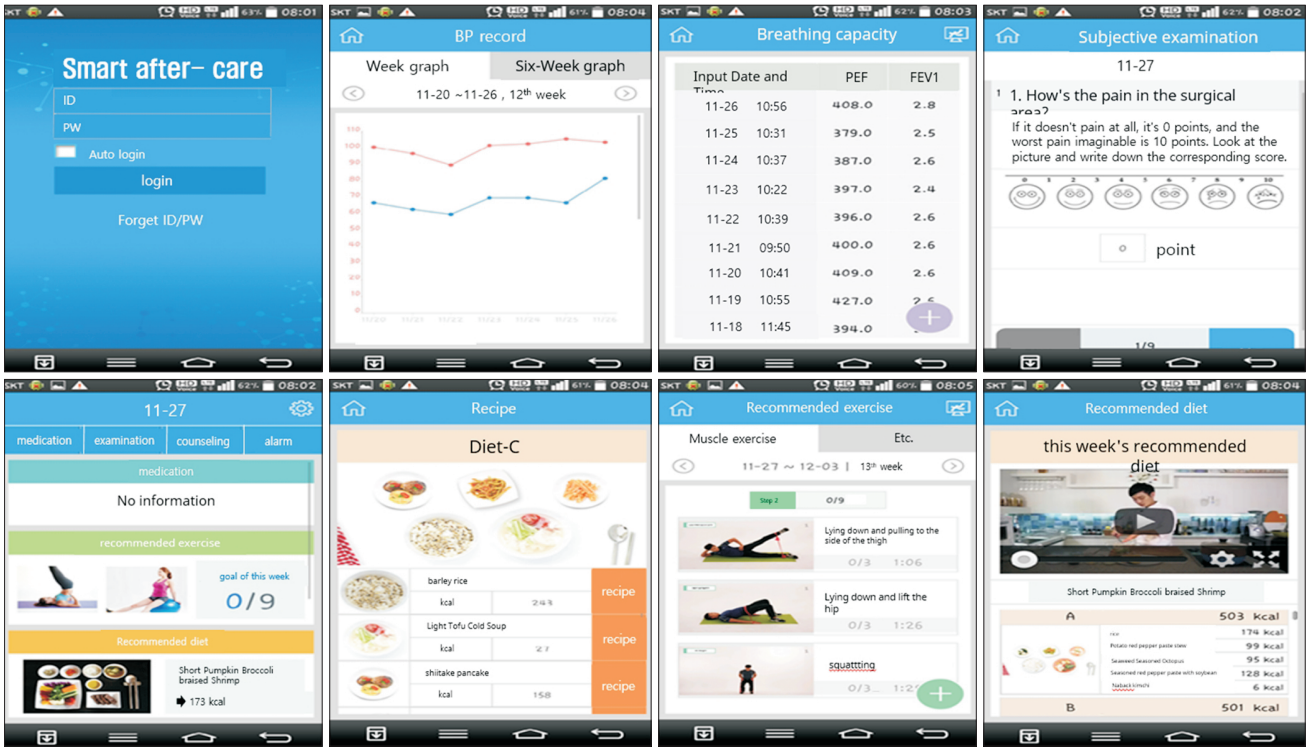

Fig. 4. The Smart After-Care application contained personalized exercise and diet information as well as a screen to input vital signs and a subjective condition survey. A variety of video clips were included to assist with lung cancer patients' rehabilitation.

rank-sum test (1-sided). A p-value of less than 0.05 was considered to indicate statistical significance.

Results

For internal validation of the SAP satisfaction survey, item internal consistency was calculated to determine whether each of the 4 categories was consistently organized, and item discriminant validity [18,19] was calculated to determine whether each of the categories was adequately separated from the others. The Cronbach α value was 0.94, showing very high survey reliability (Table 2).

In the final satisfaction survey, 88% of patients reported "very good" or "good" overall satisfaction (question 1). When asked, "Do you have any plans to use the SAP after this study?", 86% of patients responded, "absolutely yes" or "yes." Regarding the convenience of using the equipment, 97.6% of patients answered, "very good" or "good" (question 6). When asked, "Did the SAP improve your trust in your medical care?", 97% of patients responded "absolutely yes" or "yes." When asked, "Do you think the SAP is a good way to manage serious diseases?" (question 17), 97% of patients responded "absolutely yes" or "yes." Regarding overall satisfaction with telephone health counseling (question 22), 76% of patients responded "very good."

The SAP satisfaction survey responses were standardized to determine which factors influenced satisfaction level, with a lower total score indicating higher satisfaction. The correlations between satisfaction and age, sex, distance from hospital to residence, smoking history, lung cancer

Table 2. Characteristics and internal validation of the Smart After-Care Program satisfaction questionnaire

	No. of items	IIC (min–max)	IDV (min–max)	IDV (%)	Median scale score (min–max)	Cronbach α (n=42)
Total						0.94
Domain 1[a]	4	0.60–0.79	0.22–0.74	100.0	15 (10–20)	0.88
Domain 2[b]	6	0.51–0.82	0.23–0.67	83.3	11.7 (10–16.7)	0.85
Domain 3[c]	7	0.39–0.67	0.22–0.69	80.9	13.6 (10–18.6)	0.85
Domain 4[d]	5	0.67–0.90	0.34–0.82	93.3	10 (10–15.5)	0.91

Each domain consists of satisfaction questionnaire items related the subject. Higher IIC and IDV values indicate better domain classification of the questionnaire.
IIC, item internal consistency; IDV, item discriminant validity.
[a]Domain 1: general satisfaction. [b]Domain 2: ease of use. [c]Domain 3: service usefulness. [d]Domain 4: telephone counseling center.

Table 3. Factors affecting the satisfaction level

Variable	Category	Total satisfaction score	p-value
Age (yr)	<30	35.65 (33.04–38.26)	0.398
	30–39	24.34 (24.34–24.34)	
	40–49	22.39 (21.73–23.04)	
	50–59	20.00 (18.26–40.43)	
	≥60	24.13 (18.26–40.00)	
Sex	Male	25.21 (18.26–40.00)	0.410
	Female	23.04 (18.26–40.43)	
Distance from hospital to residence (km)	<20	23.04 (18.26–40.43)	0.013
	20–80	28.26 (18.26–40.00)	
	>80	18.26 (18.26–23.91)	
Smoking status	None	23.91 (18.26–40.43)	0.599
	Ex-smoker	21.73 (18.26–26.08)	
	Current	25.65 (18.26–40.00)	
Stage	1	23.04 (18.26–38.69)	0.214
	2	21.73 (18.26–33.91)	
	3	20.00 (18.26–40.43)	
	4	21.95 (20.00–23.91)	
Comorbidities	None	24.78 (18.26–40.43)	0.126
	Hypertension	22.17 (18.26–40.00)	
	Diabetes	18.26 (18.26–20.43)	

Values are presented as median (min–max). Lower scores reflect higher satisfaction.

https://doi.org/10.5090/jcs.21.138

stage, and comorbidities were investigated. Only distance from the hospital to the patient's residence was found to be significantly correlated with satisfaction level (p=0.013) (Table 3).

In the EORTC QLQ-C30 survey, for the functional scale, significant improvements were observed in all subsections (p<0.05). However, no significant improvement was seen in the symptom scale. Similarly, no significant differences were observed in the EORTC QLQ-LC13 survey results (Table 4).

No significant difference was observed in upper extremity muscle strength, but significant improvements in lower extremity muscle strength were observed, with repetitions increasing from 18 to 22 for the 30-second chair stand test (p=0.012). A significant improvement was also noted in walking distance in the 2-minute walk test (from 185.7 to 195.0 m; p=0.028) (Table 5).

Discussion

In this study, we found that the SAP can be useful in lung cancer patients. The participants had a high level of overall satisfaction with the SAP, and these results were reflected in their intentions of future use. Five participants (10%) dropped out due to the stress of adhering to the protocol of the SAP. However, 97% of those who completed the study were satisfied with the convenient use of the equipment. This suggests that patients were more adaptable to smartphones and electronic devices than expected, potentially for 3 reasons. First, only patients with smartphones were selected for the study. Second, the average age of the patients in the study was 58 years, indicating that relatively young patients participated in the study. Third, the research team collaborated extensively to manage the patients. The counseling center provided weekly telephone

Table 4. Changes in quality of life before and after the Smart After-Care Program

Variable	Before	After	p-value
EORTC QLQ-C30			
Global health status	66.7 (16.7–100.0)	83.3 (33.3–100.0)	<0.001
Physical functioning	80.0 (20.0–100.0)	86.7 (60.0–100.0)	0.017
Role functioning	83.3 (0–100.0)	83.3 (33.3–100.0)	0.030
Emotional functioning	75.0 (16.7–100.0)	91.7 (41.7–100.0)	<0.001
Cognitive functioning	83.3 (33.3–100.0)	83.3 (33.3–100.0)	<0.001
Social functioning	83.3 (0–100.0)	100.0 (33.3–100.0)	0.022
Fatigue	33.3 (0–100.0)	22.2 (0–66.7)	1.000
Nausea/vomiting	0 (0–66.7)	0 (0–50.0)	0.626
Pain	16.7 (0–100.0)	0 (0–83.3)	0.998
Dyspnea	33.3 (0–100.0)	0 (0–66.7)	1.000
Insomnia	33.3 (0–100.0)	0 (0–100.0)	0.916
Appetite	0 (0–100.0)	0 (0–100.0)	0.989
Constipation	0 (0–100.0)	0 (0–66.7)	1.000
Diarrhea	0 (0–100.0)	0 (0–66.7)	0.926
Financial problem	0 (0–100.0)	0 (0–66.7)	0.994
Total score	633.2 (538.3–838.6)	620.1 (521.0–785.5)	0.995
EORTC QLQ-L13			
Cough	33.3 (0–100.0)	33.3 (0–66.7)	0.926
Hemoptysis	0 (0–33.3)	0 (0–0)	1.000
Dyspnea	22.2 (0–77.8)	11.1 (0–66.7)	0.989
Mouth	0 (0–66.7)	0 (0–66.7)	0.650
Dysphagia	0 (0–66.7)	0 (0–33.3)	0.938
Neuropathy	0 (0–66.7)	0 (0–100.0)	0.930
Alopecia	0 (0–66.7)	0 (0–100.0)	0.612
Pain, chest	0 (0–100)	0 (0–66.7)	0.983
Pain, arm	33.3 (0–100.0)	33.3 (0–100.0)	0.995
Pain, other	16.65 (0–100.0)	0 (0–66.7)	0.933
Total score	177.7 (0–466.9)	111.0 (0–600.2)	1.000

Values are presented as median (min–max). Higher scores reflect higher quality of life. p-values for differences were determined using the Wilcoxon signed-rank test (1-sided, H1: before<after).
EORTC, European Organization for Research and Treatment of Cancer; EORTC QLQ-C30, EORTC Core Quality of Life Questionnaire; EORTC QLQ-L13, EORTC Quality of Life Questionnaire-Lung Cancer 13.

Table 5. Changes in muscle strength and cardiorespiratory endurance before and after the Smart After-Care Program

Variable	Before	After	p-value
Upper arm, left[a] (kg)	25.5 (15.9–50.3)	25.0 (15.7–48.7)	0.461
Upper arm, right[b] (kg)	27.8 (11.0–52.4)	26.0 (7.4–50.5)	0.227
Lower extremity[c] (repetitions)	18.0 (8.0–35.0)	22.0 (8.0–116.0)	0.012
2-minute walk test (m)	185.7 (90.0–255.0)	195.0 (99.0–231.5)	0.028

Values are presented as median (min–max). p-values for differences were determined using the Wilcoxon signed-rank test (1-sided, H1: before<after).
[a]Muscle strength of the left upper arm. [b]Muscle strength of the right upper arm. [c]Muscle strength of lower extremity, measured as repetitions of chair stand up/sit down within 30 seconds.

health counseling and offered retraining of patients on the use of the equipment at any time during the 12-week study period. Devices could be exchanged without delay if necessary.

In lung cancer patients, aerobic exercise reduces postoperative complications and helps patients recover quickly [20,21]. Furthermore, enhanced physical activity is related to increased cancer survival and decreased cancer recurrence rate [22]. Therefore, we emphasized personalized exercise and respiratory rehabilitation in this study. As a result, significant improvements in lower extremity muscle strength and 2-minute walking distance were observed. As a cardiorespiratory endurance assessment for lung resection surgery, a 6-minute walk test has been cited the most frequently [23]. However, several previous studies have reported that a 2-minute walk test may be safer and more useful for measuring cardiorespiratory endurance in patients with impaired bodily function, such as those with Parkinson disease or older adults [24]. Considering the disease characteristics and lung function of the participants, we adopted a 2-minute walk test. No adverse events were noted during the 2-minute walk tests, and significant improvement was demonstrated by the test. Meanwhile, no significant change occurred in upper extremity muscle strength. We attribute this result to the difficulty in completing upper body exercises because of pain in the chest wound area or limited shoulder joint movement among the patients who had undergone thoracic surgery. In the future, given these characteristics of patients after lung cancer surgery, a program focusing on improving flexibility would be preferable to one focused on muscle strength.

After lung cancer treatment, many survivors have poor QOL. Yun et al. [25] analyzed the correlation between QOL and mortality in patients with complete recovery after lung cancer surgery. They found that more severe decreases in QOL had greater impacts on mortality; thus, they argued that a systematic care program should exist to evaluate and manage QOL. According to these authors, this program should include exercise and diet management, along with monitoring of disease recurrence after lung cancer treatment. From this perspective, SAP is a potential option. Conventionally, management of patients with lung cancer surgery involves only outpatient follow-up through chest computed tomography every 3–6 months. Our aim was to improve the QOL of lung cancer patients more actively through the SAP and, if successful, to determine how it helps improve QOL. Among the QOL indicators, all functional scales improved significantly, potentially due to the systematic management of the SAP. However, the symptom scales did not change significantly, presumably due to the relatively small proportion of patients who had undergone surgery within 2 months of study initiation (n=12) or who were undergoing chemotherapy (n=4). In other words, we believe that 26 patients (62%) were enrolled in the study at a stage when acute symptoms had already abated. In the future, if a randomized controlled study is conducted among patients with acute symptoms, the ability of the SAP to contribute to reducing symptoms can be determined more clearly.

The distance from hospital to the patient's residence was the only independent factor significantly correlated with satisfaction. For the statistical analysis, we divided the distance into 3 categories (less than 20 km, between 20 km and 80 km, and more than 80 km). Distances less than 20 km were considered to indicate good access to the hospital, while distances greater than 80 km indicated a high level of burden in traveling back and forth in a day. Satisfaction was significantly higher among patients who resided more than 80 km from the hospital than among those who lived closer (p=0.013). While telemedicine like SAP does not involve in-person visits or examinations, participating patients can communicate with the medical team more frequently than with conventional services. When a patient's condition is unstable, the SAP is thought to assist in taking appropriate first-aid measures and is expected to reduce unnecessary hospital visits due to simple anxiety.

This study has some limitations. As a pilot study, the number of participants was small, and the study was de-

signed for a single arm. A large-scale, prospective randomized controlled study with more homogeneous lung cancer patients will be needed to confirm whether the SAP actually helped improve the QOL and physical ability. Additionally, caution is required in interpreting the results because the effectiveness of the SAP may have varied depending on the treatment modality, the extent of pulmonary resection, stage of cancer, or the timing of study participation.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Acknowledgments

The authors thank Seongjin Eo for the preparation of all documents.

Funding

The authors disclosed receipt of the following financial support for the research, authorship and/or publication of this article: This work was supported by the National Information Society Agency (grant no., 1531180-1).

ORCID

Hee Chul Yang: https://orcid.org/0000-0003-2605-5985
Seung Hyun Chung: https://orcid.org/0000-0002-8900-810X
Ji Sung Yoo: https://orcid.org/0000-0003-3559-8412
Boram Park: https://orcid.org/0000-0003-2683-8795
Moon Soo Kim: https://orcid.org/0000-0001-8228-9036
Jong Mog Lee: https://orcid.org/0000-0001-7691-6072

References

1. Schneider MP, Gertsch A, Bugnon O. *Cyberhealth serving to support individual intake of medication*. Swiss Med Wkly 2013;143:w13827.
2. Glynn LG, Hayes PS, Casey M, et al. *Effectiveness of a smartphone application to promote physical activity in primary care: the SMART MOVE randomised controlled trial*. Br J Gen Pract 2014;64:e384-91.
3. Hirst JE, Mackillop L, Loerup L, et al. *Acceptability and user satisfaction of a smartphone-based, interactive blood glucose management system in women with gestational diabetes mellitus*. J Diabetes Sci Technol 2015;9:111-5.
4. Varnfield M, Karunanithi M, Lee CK, et al. *Smartphone-based home care model improved use of cardiac rehabilitation in postmyocardial infarction patients: results from a randomised controlled trial*. Heart 2014;100:1770-9.
5. Silverman RD. *Current legal and ethical concerns in telemedicine and e-medicine*. J Telemed Telecare 2003;9 Suppl 1:S67-9.
6. Chung YS, Kim Y, Lee CH. *Effectiveness of the smart care service for diabetes management*. Healthc Inform Res 2014;20:288-94.
7. Kim HS, Choi W, Baek EK, et al. *Efficacy of the smartphone-based glucose management application stratified by user satisfaction*. Diabetes Metab J 2014;38:204-10.
8. Kim YJ, Rhee SY, Byun JK, et al. *A smartphone application significantly improved diabetes self-care activities with high user satisfaction*. Diabetes Metab J 2015;39:207-17.
9. Kumar N, Khunger M, Gupta A, Garg N. *A content analysis of smartphone-based applications for hypertension management*. J Am Soc Hypertens 2015;9:130-6.
10. Oresko JJ, Duschl H, Cheng AC. *A wearable smartphone-based platform for real-time cardiovascular disease detection via electrocardiogram processing*. IEEE Trans Inf Technol Biomed 2010;14:734-40.
11. Jemal A, Siegel R, Ward E, et al. *Cancer statistics, 2008*. CA Cancer J Clin 2008;58:71-96.
12. Park SY, Park IK, Byun CS, et al. *Cause-specific analysis of risk factors in completely resected pathologic stage Ia non-small cell lung cancer*. Korean J Thorac Cardiovasc Surg 2009;42:725-31.
13. Bergman B, Aaronson NK, Ahmedzai S, Kaasa S, Sullivan M. *The EORTC QLQ-LC13: a modular supplement to the EORTC Core Quality of Life Questionnaire (QLQ-C30) for use in lung cancer clinical trials. EORTC Study Group on Quality of Life*. Eur J Cancer 1994;30A:635-42.
14. Lee PH, Macfarlane DJ, Lam TH, Stewart SM. *Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review*. Int J Behav Nutr Phys Act 2011;8:115.
15. Kim C, Moon HW, Kim YH, Park SI. *Quality of life after esophageal surgery for esophageal surgery*. Korean J Thorac Cardiovasc Surg 2006;39:310-6.
16. Mifflin MD, St Jeor ST, Hill LA, Scott BJ, Daugherty SA, Koh YO. *A new predictive equation for resting energy expenditure in healthy individuals*. Am J Clin Nutr 1990;51:241-7.
17. Fayers P, Aaronson NK, Bjordal K, Groenvold M, Curran D, Bottomley A. *EORTC QLQ-C30 scoring manual*. 3rd ed. Brussels: European Organisation for Research and Treatment of Cancer; 2001.
18. Lee Y, Lim MC, Son Y, et al. *Development and evaluation of Korean version of Quality of Sexual Function (QSF-K) in healthy Korean women*. J Korean Med Sci 2014;29:758-63.
19. Lim MC, Lee JS, Joo J, et al. *Development and evaluation of the Korean version of the Gynecologic Cancer Lymphedema Questionnaire in gynecologic cancer survivors*. Gynecol Oncol 2014;133:111-6.
20. Benzo R, Wigle D, Novotny P, et al. *Preoperative pulmonary rehabilitation before lung cancer resection: results from two randomized studies*. Lung Cancer 2011;74:441-5.

21. Cesario A, Dall'Armi V, Cusumano G, et al. *Post-operative pulmonary rehabilitation after lung resection for NSCLC: a follow up study*. Lung Cancer 2009;66:268-9.
22. Jones LW, Eves ND, Waner E, Joy AA. *Exercise therapy across the lung cancer continuum*. Curr Oncol Rep 2009;11:255-62.
23. Arbane G, Tropman D, Jackson D, Garrod R. *Evaluation of an early exercise intervention after thoracotomy for non-small cell lung cancer (NSCLC), effects on quality of life, muscle strength and exercise tolerance: randomised controlled trial*. Lung Cancer 2011;71:229-34.
24. Leung AS, Chan KK, Sykes K, Chan KS. *Reliability, validity, and responsiveness of a 2-min walk test to assess exercise capacity of COPD patients*. Chest 2006;130:119-25.
25. Yun YH, Kim YA, Sim JA, et al. *Prognostic value of quality of life score in disease-free survivors of surgically-treated lung cancer*. BMC Cancer 2016;16:505.