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ORIGINAL ARTICLE

Factors associated with physical activity of breast cancer patients participating in exercise intervention

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Abstract

Purpose Physical activity has been known to improve survival and quality of life of patients with breast cancer. To find factors associated with physical activity, we analyzed the dataset of the multicenter controlled trial of exercise intervention.

Methods Three hundred fifty-six participants were assigned to two groups: "Smart After-Care" (smartphone application and pedometer were provided) or exercise education only. Physical activity was measured by International Physical Activity Questionnaire–Short Form (IPAQ-SF) at baseline and after 12 weeks. The association between physical activity and other clinical characteristics was analyzed.

Results At baseline, physical activity amount was 2315.5 ± 3513.2 MET min/week: 33.0% inactive, 49.6% minimally active, and 17.4% health-enhancing physical activity (HEPA) active. Factors associated with HEPA include cancer stage and grip strength. A significantly lower proportion was HEPA active among those with advanced stage than among those with stage 0. After intervention, physical activity was increased to 3466.2 ± 4712.5 MET min/week: 15.3% inactive, 50.4% minimally active, and 34.2% HEPA active. Physical activity was increased in 63.4% of the participants. Factors associated with physical activity increase include cancer stage, diarrhea, and type of exercise intervention. Participants with advanced stage have a 3.3 times higher chance of increasing physical activity. Participants who received "Smart After-Care" have a 64% higher chance of increasing physical activity.

Conclusion Before the intervention, participants with advanced stage are less likely to be HEPA active. Exercise intervention was more beneficial for those with advanced stage or physical symptoms. "Smart After-Care" was more effective than education only in increasing physical activity.

Keywords Breast neoplasms · Exercise · Aftercare · Health behavior · Smartphone · Mobile applications

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Introduction

Breast cancer is the most frequently diagnosed malignant tumor and a leading cause of cancer-related mortalities among women worldwide. Moreover, the associated treatments result in numerous side effects, including pain, fatigue, nausea, weakness, lymphedema, and decreased range of motion, and these side effects affect a person's quality of life and overall functioning [1].

Physical activity has been known to improve survival as well as quality of life in the individuals with breast cancer. In a prospective observational study in which about 3000 individuals diagnosed with breast cancer were examined. Holmes et al. [2] found that the relative risk of death from breast cancer was significantly reduced among those who engaged in more physical activity and concluded that physical activity might improve their survival. Loprinzi et al. [3] reviewed literature regarding physical activity effect on breast cancer prognosis and reported that regular physical activity could help reduce recurrence and cancer-related mortality. The mechanism through which physical activity influences cancer prognosis was suggested to be related to hormones [2], and Patterson et al. [4] argued that obesity is related to higher mortality among patients with breast cancer. These studies indicate the possible relationship between metabolism and oncogenesis and importance of exercise in cancer management. Courneya and Friedenreich [5] suggested the incorporation of physical activity into the entire cancer control continuum.

To promote exercise for these individuals, it is important to consider factors that may influence physical activity behavior. We conducted a multicenter controlled trial of exercise intervention in which we utilized smartphone and mobile applications to encourage physical activity for breast cancer survivors. The main result of the trial was reported elsewhere [6]. The aim of this study is to find factors associated with physical activity among the participants of the trial so that a more efficient exercise intervention can be provided hereafter. From the dataset of the trial, we analyzed factors associated with baseline physical activity level and increase in physical activity after providing an exercise intervention.

Methods

Study participants

The prospective controlled multicenter trial was conducted to evaluate effects of an exercise intervention in patients with breast cancer. Three hundred fifty-six participants were enrolled between August 2015 and September 2015. This study was approved by the Institutional Review Board, and written informed consent was obtained from each participant. The inclusion criteria were, over the age of 20 years, histologically confirmed breast cancer. The exclusion criteria were history of treatment for accompanying severe disease within 1 month; severe cardiopulmonary disease that required exercise restriction; bone metastasis that caused extreme pain and pathologic fracture during exercise; inability to perform a 2-min walk test (2MWT); and ECOG performance status ≥ 3. All participants were assigned into two groups: one group for "Smart After-Care" and the other for exercise education only. The exercise intervention was conducted from August 2015 to December 2015.

Intervention

All participants in both groups were educated with the same exercise rehabilitation program, which consisted of aerobic and resistance exercise. The amount of weekly aerobic exercise and intensity of resistance exercise were prescribed individually based on the results of the baseline evaluation. For the participants in the "Smart After-Care" group, a newly developed smartphone application (Smart After-Care, BIT Computer Co., Ltd., Seoul, Korea) and an InBody Band pedometer (InBody Co., Ltd., Seoul, Korea) were provided in addition to exercise education (Fig. 1). They were instructed to wear the pedometer throughout the waking hours. Minutes of physical activity as measured by the pedometer were recorded weekly via the application, and the weekly goal of the activity in minutes and achievement rate were displayed on the smartphone. The smartphone application also provided video clips of prescribed exercises, and the participants were instructed to enter the number of exercise sets they performed. The participants' activity and exercise during the intervention period were reported automatically to the website developed for the clinicians. The detailed intervention protocol was reported elsewhere [6].

Outcome assessment

Demographic characteristics were collected using self-report measures at baseline. Medical and treatment characteristics were reviewed from records. Physical activity was measured by self-report using the International Physical Activity Questionnaire–Short Form (IPAQ-SF) [7, 8]. Participants were asked to report frequency and duration of walking, moderate activity, and vigorous activity performed for at least 10-min duration per session during the past 7 days. The data from the questionnaire were transformed into energy expenditure estimates as metabolic equivalent of task (MET) according to the IPAQ scoring protocol [9]. Moreover, this data was used to categorize physical activity into three levels according to the IPAQ manual: inactive, minimally active, and health-enhancing physical activity (HEPA) active [9]. For physical function assessment, the 2MWT, 30-s chair stand test, and hand grip strength measure were performed. The 2MWT

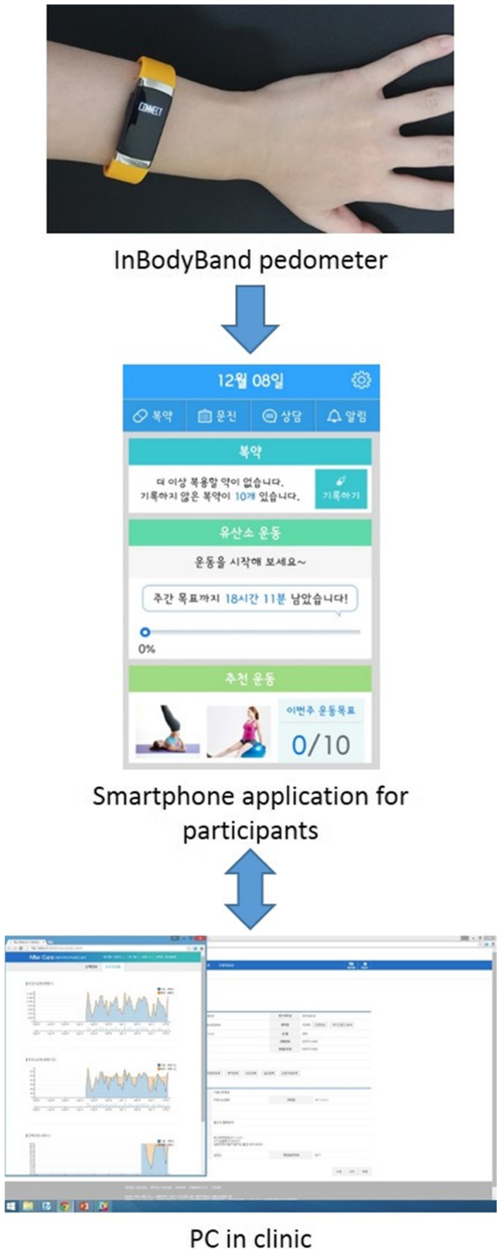

Fig. 1 Schematic diagram of Smart After-Care

was used to measure cardiorespiratory endurance. Timed walking tests are validated submaximal endurance measures of fitness in all age groups [10]. Participants were asked to walk back and forth along a 15.2-m stretch of hallway as fast as they could over a period of 2 min. The distance walked was recorded in meters. Lower body strength was measured with the 30-s chair stand test which is predictive of lower extremity function and disability [11, 12]. Participants were seated in the middle of a chair, and their arms were crossed and held against the chest. Then, they were asked to stand up and sit down repetitively as many times as possible in 30 s, and the number of full stands from the initial sitting position and the return to seated position after standing was recorded. The hand grip strength was used to assess upper body muscular strength using an electronic handgrip dynamometer (FT-7110, China) on both hands [13]. The hand grip strength test was measured two times in each hand, and the better value of the two performances was used for the analysis. Health-related quality of life was assessed by the Korean version of European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30 (EORTC QLQ-30) and Quality of Life Questionnaire Breast Cancer Module 23 (EORTC QLQ-BR23). EORTC QLQ-30 is an instrument for measuring the quality of life in patients with general cancer and includes 30 items that measure five functional scales, three symptom scales, and a scale of global quality of life. EORTC QLQ-BR23 is a specific questionnaire containing 23 items composed of four functional scales and four symptom scales related to breast cancer. The reliability and validity of the Korean version of EORTC QLQ-C30 and EORTC QLQ-BR23 have been confirmed in various studies [14, 15]. Participants completed the EORTC QLQ-C30 and EORTC QLQ-BR23. According to the guidelines provided by the EORTC, raw scores of the EORTC QLQ-C30 and EORTC BR23 were transformed linearly from 0 to 100 scales [16]. All assessments were done at baseline and after 12 weeks.

Statistical analysis

The association between physical activity and other clinical characteristics was analyzed. To find factors associated with baseline physical activity, HEPA defined by baseline IPAQ-SF was used as dependent variable, and other clinical characteristics at baseline were examined by univariate logistic regression analysis. Then, multivariate logistic analysis was performed including all significant variables identified by the univariate analysis. To find factors associated with physical activity change after the exercise intervention, physical activity increase defined as increase in the amount of physical activity measured by IPAQ-SF at 12 weeks compared to baseline was used as dependent variable, and other clinical characteristics at 12 weeks were examined by univariate and multivariate logistic regression analysis consecutively. Statistical significance level was set at p value < 0.05. IBM SPSS version 22.0 was used for all statistical analyses.

Results

Of the 356 participants, 17 subjects were dropped out, and a total of 339 participants were included in the analysis. General characteristics of the participants are summarized in Table 1.

Table 1 Baseline characteristics of the participants

Baseline characteristics	No. of participants (%)/ mean ± SD
Age	50.4 ± 9.5
< 40	33 (9.7)
40–49	109 (32.2)
50–59	155 (45.7)
60 ≤	42 (12.4)
Gender (female)	339 (100.0)
Cancer stage	
0	21 (6.2)
I	119 (35.1)
II	109 (32.2)
III or higher	46 (13.6)
Treatment	
Surgery	335 (98.8)
Time after surgery (days)	24.3 ± 25.46
Chemotherapy	218 (64.3)
Radiotherapy	232 (68.4)
Comorbidity	
Diabetes	25 (7.4)
Hypertension	41 (12.1)
Type of intervention	
"Smart After-Care"	167 (49.3)
Exercise education only	172 (50.7)

Baseline physical activity

At baseline, physical activity of the participants measured by IPAQ-SF was 2315.5 ± 3513.2 MET min/week. Exercise time in a week was 555.7 ± 721.8 min. According to the categories of physical activity levels, 33.0% of the participants were inactive, 49.6% were minimally active, and 17.4% were HEPA active.

The results of all other measures were reported elsewhere [6].

Factors associated with baseline physical activity

Factors associated with baseline HEPA identified by the univariate analysis include cancer stage, hand grip strength, global health status, physical functioning, fatigue, and appetite loss. Age, cancer treatment, and medical comorbidities such as diabetes or hypertension did not show significant association. The multivariate logistic regression analysis revealed cancer stage and grip strength to be significantly associated with baseline HEPA (Table 2), and no interaction terms between variables were significant. Only 4.3% of those with advanced stage (3 or higher) were found to be HEPA active, whereas about 6 times higher proportion (23.8%) of those with stage 0 were HEPA active (OR = 0.14, $p < 0.05$). A significantly higher proportion of subjects who had good grip strength were HEPA active than those who did not (28.1% vs. 15.5%, OR = 2.19, $p < 0.05$).

Physical activity after 12 weeks

After 12 weeks of exercise intervention, physical activity was increased to 3466.2 ± 4712.5 MET-min/week, and exercise time in a week increased to 779.1 ± 946.4 min. The proportion of active participants according to categories of physical activity levels was also increased: 15.3% were inactive, 50.4% were minimally active, and 34.2% were HEPA active. Compared to baseline, the amount of physical activity (MET-min/week) was increased in 63.4% of the participants. The category of physical activity level was increased in 42.1% and decreased in 13.3%, and 44.5% remained in the same level.

Factors associated with physical activity increase

Factors associated with physical activity increase identified by the univariate analysis include cancer stage, role functioning, diarrhea, and type of exercise intervention. Age, cancer treatment, comorbidities, baseline physical activity, and physical function did not show significant association. The multivariate logistic regression analysis revealed cancer stage, diarrhea, and type of exercise intervention to be significantly associated with physical activity increase (Table 3), and no interaction terms between variables were significant. Participants with advanced stage (3 or higher) have 3.3 times higher chance of increasing physical activity by exercise intervention of either type than those with stage 0 (67.4% vs. 38.1%, OR = 3.33, $p < 0.05$). Higher diarrhea score from EORTC-QLQ30 was associated with higher chance of increasing physical activity (OR = 1.02, $p < 0.05$). Diarrhea seems to be one of the treatment-related symptoms. Among the participants in the "Smart After-Care" group, 68.9% increased their physical activity after the intervention, whereas 58.1% of those in the exercise education only group did. Participants who received "Smart After-Care" have 64% higher chance of increasing physical activity than those with exercise education only (OR = 1.64, $p < 0.05$).

Discussion

The American Cancer Society guidelines [17] recommend engaging in regular physical activity of at least 150 min of moderate intensity or 75 min of vigorous intensity each week. It has been claimed that physical activity is recommended for not only primary cancer prevention but also prevention of cancer recurrence, thus improving cancer survival. Besides, physical activity has been shown to be related to higher

Table 2 Factors associated with baseline health-enhancing physical activity measured by IPAQ

	B	Standard Error	Wald	*p* value	Odds ratio estimates	95% confidence interval	
Stages			7.071	.070			
Stage ≥ III vs. stage 0	− 1.996	.893	4.997	.025	.136	.024	.782
Stage II vs. stage 0	− .558	.586	.906	.341	.572	.181	1.806
Stage I vs. stage 0	− .137	.566	.059	.808	.872	.288	2.643
Good grip strength	.782	.339	5.328	.021	2.186	1.125	4.248
Intercept	− 1.377	.529	6.781	.009	.252		

IPAQ International Physical Activity Questionnaire

quality of life and lower fatigue symptom [18]. In this respect, it is desirable for all clinicians who take care of patients with cancer to be concern of their patients' healthy behavior including physical activity. Most patients with cancer have worries about their health, and behavioral recommendation is as important as medical treatment.

Despite the importance of physical activity for health, patients with breast cancer tend to decrease physical activity after the diagnosis and treatment of cancer. In a survey of 287 patients with breast cancer followed up to 18 months post-diagnosis, Harrison et al. [19] reported more than 50% were insufficiently active. Irwin et al. [20] investigated 856 women with breast cancer and reported that their total physical activity was decreased by 11%. With respect to cancer stage, they found 52%, 58%, and 62% of patients with carcinoma in situ, stage I, and stages II–IIIa, respectively, decreased their physical activity. These findings are in line with our study results. Our study participants showed lower MET-minutes value at baseline than the general population [7], but it became higher than that in the general population after intervention. One finding worthy of note in this study is that participants with advanced stage (3 or higher) responded better to the exercise intervention. They showed less engagement in HEPA initially. However, after the intervention, they were 3.3 times more likely to increase their physical activity than those with stage 0. This suggests that more attention should be paid to those who are weak, less active, and with advanced disease. It is desirable for clinicians who take care of patients with advanced cancer to provide education to encourage physical activity.

Interventions to encourage physical activity for patients with breast cancer have been attempted. Lahart et al. [21] investigated the effectiveness of home-based physical activity intervention for patients with invasive breast cancer post-adjuvant therapy. The intervention consists of face-to-face counseling and monthly support telephone call for 3 months.

Table 3 Factors associated with physical activity increase measured by IPAQ (MET-minute/week) after 12 weeks intervention

	β	Standard error	Wald	*p* value	Odds ratio estimates	95% confidence interval	
Type of intervention (Smart vs. control)	.496	.248	4.005	.045	1.641	1.010	2.667
Stages			5.716	.126			
Stage ≥ III vs. stage 0	1.201	.554	4.700	.030	3.325	1.122	9.850
Stage II vs. stage 0	.789	.495	2.543	.111	2.202	.835	5.811
Stage I vs. stage 0	1.048	.494	4.502	.034	2.853	1.083	7.514
Diarrhea (EORTC-QLQ30)	.021	.010	4.741	.029	1.021	1.002	1.040
Intercept	− .772	.469	2.714	.099	.462		

IPAQ International Physical Activity Questionnaire, *MET* metabolic equivalent, *EORTC-QLQ30* European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30

They reported improvement in physical activity, BMI, health-related quality of life, and serum total cholesterol level compared to the usual care group. Courneya et al. [22] provided exercise training intervention to patients with breast cancer receiving chemotherapy. They examined factors associated with exercise training response and found the chemotherapy type and cancer stage as the medical moderators of exercise training effects. Patients receiving nontaxane-based chemotherapy, which has less side effects than taxane-based therapy, and with more advanced stage showed better outcomes. It is evident that exercise interventions to encourage healthy behavior for patients with breast cancer need to be developed to maximize their participation. In our study, we employed smartphone and mobile technology for this purpose, and it seems to be somewhat helpful. The results of our study agree that medical variables should be considered when implementing such interventions.

Many other researchers reported a relationship between medical treatment and physical activity. In a focus group study, Husebo et al. [23] identified treatment side effects as a barrier to exercise. Huy et al. [24] assessed 1067 patients with breast cancer about their physical activity behavior before diagnosis, during treatment, and 1 year after surgery. What they found was that physical activity decreased during chemo- and radiotherapy, and participation in rehabilitation increased their physical activity. Kwan et al. [25] also found that chemotherapy was associated with decrease in physical activity, and Harrison et al. [19] identified treatment-related complication as a predictor of physical activity decline. All these study findings support the notion that attention should be paid to those receiving cancer treatment and experiencing treatment-related symptoms, and a relevant exercise intervention should be provided. In our study, we found the association between physical activity increase and diarrhea symptom. It is hard to explain why no other physical symptoms that can be considered treatment-related, except diarrhea were identified to be significantly associated with physical activity change. However, we assume that diarrhea was one of the treatment-related side effects because there was a positive correlation between diarrhea score and side effect score in the EORTC questionnaire. It can be inferred that exercise intervention is more helpful to those experiencing treatment-related side effects.

Physical activity behavior change is a challenging issue to healthcare providers [26]. Many theoretical models for behavior change has been suggested [27]. Rogers et al. [28, 29] introduced a behavior change intervention program based on the social cognitive theory and reported better outcome in physical activity, fitness, quality of life, and laboratory markers than the usual care. Their behavior change intervention consisted of supervised exercise sessions tapered to home-based exercise, face-to-face counseling sessions, and group discussion sessions. Our intervention did not include supervised exercise or group discussion sessions but utilized mobile technology to provide the study participants with feedback and education. Our approach would be more effective in expanding the boundary of participants than direct exercise intervention. Supposing that the population using smartphone is increasing and more and more freely downloadable health applications are available, more behavior change interventions utilizing mobile technology need to be developed. Comparison of efficacy of interventions needs to be done in the future studies, yet our approach may be better applicable in urban life. A supervised exercise program can be an efficient intervention for those who are in need of more attention or willing to follow exercise recommendations, such as patients with breast cancer with advanced stage or physical symptoms as those found in this study. To increase adherence to physical activity, interventions should be tailored to the participants' needs [30].

This study is a secondary data analysis of a clinical trial and has several limitations. First, the outcome measure of physical activity, IPAQ, is dependent on the participants' subjective report. Though it is widely used in many researches, objective assessment of physical activity is requested to ensure effectiveness of the exercise intervention. Besides, in our study, we did not define how much increase in physical activity is meaningful. Increase in physical activity after the intervention does not necessarily mean that the amount of physical activity is increased to the sufficient level. Another limitation is that we did not include psychological variables adequately, though many previous studies indicated their importance in exercise compliance. Future studies should be designed precisely to overcome these limitations.

The findings of this study can be summarized as follows: Before the exercise intervention, patients with advanced-stage breast cancer are less likely to be HEPA active. After the exercise intervention of either "Smart After-Care" or exercise education only, physical activity of the participants was significantly increased. Exercise intervention of either type was more beneficial in increasing physical activity for patients with breast cancer who are at the advanced stage or experiencing treatment-related side effects than those who are not. "Smart After-Care" that utilized mobile technology to promote exercise was more effective than exercise education only in increasing physical activity of patients with breast cancer. More attention should be paid to patients with breast cancer who are at the advanced stage or receiving chemotherapy. Further exercise interventions to maximize participation of patients with breast cancer need to be developed and implemented in the clinical practice.

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Compliance with ethical standards

This study was approved by the Institutional Review Board, and written informed consent was obtained from each participant.

Conflict of interest The authors declare that they have no conflict of interest.

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