Original Study

Efficacy of Mobile Health Care Application and Wearable Device in Improvement of Physical Performance in Colorectal Cancer Patients Undergoing Chemotherapy

In Yae Cheong,[1] So Yeon An,[2] Won Chul Cha,[3] Mi Yong Rha,[4] Seung Tae Kim,[5] Dong Kyung Chang,[6] Ji Hye Hwang[1]

Abstract

The use of mobile health care applications is a method increasing in use in the cancer care continuum from cancer prevention to cancer diagnosis, cancer treatment, and cancer survivorship. However, no clinical study has yet investigated the effects and feasibility of a smartphone application-based personalized exercise intervention for colorectal cancer patients undergoing chemotherapy. In 75 colorectal cancer patients undergoing active chemotherapy, a rehabilitation program using a mobile health care application on a wearable device was effective in improving physical function and relieving cancer- and cancer treatment-related toxicities, regardless of the chemotherapy duration.

Background: The use of a mobile health care application, the delivery of health care or health care-related services through the use of portable devices, to manage functional loss, treatment-related toxicities, and impaired quality of life in cancer patients during chemotherapy through supervised self-management has been increasing. The aim of the present study was to evaluate the efficacy and feasibility of comprehensive mobile health care using a tailored rehabilitation program for colorectal cancer patients undergoing active chemotherapy. **Patients and Methods:** A total of 102 colorectal cancer patients undergoing chemotherapy underwent 12 weeks of smartphone aftercare through provision of a mobile application and wearable device that included a rehabilitation exercise program and information on their disease and treatment. The grip strength test, 30-second chair stand test, 2-minute walk test, amount of physical activity (International Physical Activity Questionnaire short-form), quality of life (European Organization for Research and Treatment of Cancer Quality of Life Questionnaire C30), and nutritional status (Patient-generated Subjective Global Assessment) were assessed and measured at baseline, at mid-intervention (6 weeks), and at completion of the intervention (12 weeks). The rehabilitation exercise intensity was adjusted by the test results at every assessment and through real-time communication between the patients and clinicians. **Results:** Of the 102 patients, 75 completed all 12 weeks of the smartphone aftercare rehabilitation program. The lower extremity strength ($P < .001$) and cardiorespiratory endurance ($P < .001$) was significantly improved. Fatigue ($P < .007$) and nausea/vomiting ($P < .040$) symptoms were significantly relieved after the program. **Conclusion:** A tailored rehabilitation exercise program provided through a comprehensive mobile health care application was effective in improving patients' physical capacity and treatment-related symptoms even during active chemotherapy.

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[1]Department of Physical and Rehabilitation Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, South Korea
[2]Center for Clinical Medicine, Samsung Biomedical Research Institute, Seoul, South Korea
[3]Department of Emergency Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, South Korea
[4]Department of Dietetics, Samsung Medical Center, Seoul, South Korea
[5]Division of Hematology-Oncology, Department of Medicine
[6]Division of Gastroenterology, Department of Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, South Korea

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Address for correspondence: Ji Hye Hwang, MD, PhD, Department of Physical and Rehabilitation Medicine, Samsung Medical Center, Sungkyunkwan University School of Medicine, 81 Irwon-ro, Gangnam-gu, Seoul 06351, South Korea
E-mail contact: hwanglee@skku.edu

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Introduction

Colorectal cancer is the third most common cancer in men and the second most common cancer in women worldwide.[1] The prognosis of colorectal cancer has improved owing to early detection and improved cancer-directed therapies and management strategies. The reported 5-year survival rate of colorectal cancer is as great as 63% to 65%.[2,3] However, despite successful prolongation of life of colorectal cancer patients, treatment toxicities often result in long-term functional loss and impaired quality of life in many cancer patients.

Colorectal cancer patients often experience cancer-related symptoms, a reduction in physical performance, and resultant deterioration in quality of life during chemotherapy.[4] Among patients undergoing treatment for colorectal carcinoma, 46% reported moderate to severe fatigue, which typically increased during chemotherapy.[5] Therefore, not only management of the primary disease, but also management of functional loss, treatment-related toxicity, and quality of life is necessary in the cancer care continuum of colorectal cancer patients.

Appropriate exercise interventions during cancer treatment, even during chemotherapy, have had positive effects on known cancer treatment-related symptoms such as fatigue and improving physical function and quality of life.[6] van Vulpen et al[2] investigated the effects of a supervised exercise intervention in colorectal cancer patients during chemotherapy in randomized controlled trials in 2016. The exercise group showed less fatigue and greater physical functioning compared with the usual care group. Despite the beneficial effects of rehabilitation on alleviating functional impairments in cancer survivors, rehabilitation services remain underused in cancer care.[7,8]

Mobile health (mHealth) is the delivery of health care or health care-related services through the use of portable devices, especially smartphones.[9] mHealth in the medical arena is a promising mechanism for improving education for patients and could be an effective method for overcoming the "health care gap" by providing new opportunities to reach underserved populations.[10] It could also be an effective tool for improving patient adherence to self-management programs. Accordingly, mHealth is a method increasing in use in the cancer care continuum from cancer prevention to cancer diagnosis, cancer treatment, and cancer survivorship.[11]

At present, most chemotherapy regimens for many primary cancers, including colorectal cancer, are administered on an outpatient basis. Thus, patients are required to engage in appropriate self-management of side effects and other treatment-related problems at home. mHealth might lessen the patients' burden and provide comprehensive management to cancer patients by providing a large amount of health care information and supervised self-management. A study by Kearney et al[12] found that a mobile telephone-based, advanced symptom management system (ASyMS) was effective in the management of chemotherapy-related toxicity in patients with cancer.

To date, despite these beneficial aspects of mHealth in medical health, no study has yet investigated the effect and validation of a smartphone application-based exercise intervention for colorectal cancer patients undergoing chemotherapy. The aim of the present study was to evaluate the efficacy and feasibility of comprehensive mobile health care on quality of life and physical performance of colorectal cancer patients during active chemotherapy using a smartphone application and wearable device.

Patients and Methods

Participants

Colorectal cancer patients who visited the colorectal cancer clinic in a tertiary hospital from September to December 2016 were enrolled in the present study. The inclusion criteria were colorectal cancer patients aged $>$ 20 years undergoing chemotherapy with a Karnofsky performance status of $\geq$ 60, who owned and were able to use a smartphone. Patients were excluded if they required exercise restrictions owing to severe cardiovascular, pulmonary, or renal disease, had cognitive impairment that prevented smartphone use, and/or were unable to give verbal consent.

Application Development

A comprehensive mobile health management application was developed. The aim was to develop a comprehensive mobile health care system that would allow for patient self-monitoring, provide health information, and facilitate communication. In addition to the application engineers, 13 health care professionals from a multidisciplinary team were recruited to advice on the system using clinical evidence and expert experience. The application included a to-do list, health information, and in-app-chat service (Figure 1). The to-do list provides daily tasks such as taking medication, achievement of rehabilitation exercise, checking present side effects of chemotherapy, and scheduling for hospital visits. The application provides daily personalized tasks based on clinical evidence. The health information includes general health information on the drugs, side effects, and management of chemotherapy. The in-app-chat service provides real-time communication with experts. The wearable devices interlock with the mobile application and gather real-time patient information, enabling regular monitoring of the patient's health status. Through a mobile health application with multiple functions, a clinical evidence-based health care system was developed.

Intervention

Smartphone Aftercare Program. All participants were provided with a 12-week smartphone aftercare program using the mobile application and wearable device. The patients were instructed to download the application in their smartphones. The smartphone aftercare mobile application included information on chemotherapy-related symptom care, nutritional care, appointment schedule management, and a real-time communication system through messaging with the study coordinator. Patients were also provided with an Internet of Things (IoT) wearable device (Urban S; Partron Co, Seoul, Korea) to record daily activity, including the number of steps, walking distance, and a vital sign such as the heart rate. An individualized rehabilitation exercise program was prescribed to each patient and was adjusted after every time point according to the results of the assessment.