PHYSICAL ACTIVITY, EXERCISE AND CANCER

ORIGINAL ARTICLE

Cancer exercise app design: Tailored exercise for people living with and beyond cancer

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ABSTRACT

Background: Exercise is important for the health of people living with and beyond cancer. Yet most cancer survivors do not receive advice or referral to exercise oncology rehabilitation programs. A smartphone delivered exercise oncology app could minimize many of the barriers to exercise that these individuals face. Objective: To develop an exercise oncology application that provides a tailored exercise program (based on exercise history, current physical function, etc.) and adapts to user's fatigue levels to minimize many of the barriers faced by clinicians, patients and people in underserved areas. Methods: The algorithms in the app were developed based on previous research. The individualized exercise prescription is based on the user's daily level of fatigue, and if the user is on treatment, type and duration of treatment, and current fitness level. Results: Developed an easy to navigate, read and use app with reminders to exercise and positive feedback for reaching one's goals. Conclusion: Cancer Exercise is a unique app that provides a tailored exercise oncology program for cancer survivors. Additional research is needed to see how the app may benefit people living in rural and underserved communities.

Keywords: Physical activity, Exercise oncology, mHealth, Mobile app, Individualized, Customized, Physical activity, Exercise and cancer survivors.

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INTRODUCTION

Exercise is critical for people living with and beyond cancer. Yet, for the 1.9 million Americans diagnosed annually with cancer, referral to an exercise oncology program seldom occurs (Gallicchio et al., 2022). Referral to exercise oncology programs is poor (9% by nurses and 23% by oncologists) and is associated with barriers related to: lack of awareness of programs, uncertainty regarding the suitability and safety of exercise, need for education to make appropriate referrals and the belief that referrals to exercise are not within scope of practice (Fong et al., 2018; Hardcastle et al., 2018; Nadler et al., 2017; Nyrop et al., 2016; Smaradottir et al., 2017; Webb et al., 2016). Cancer-related fatigue is the most common and distressing side effect of cancer and its treatment during and following treatment and there is a strong evidence base that supports the beneficial effects of exercise to reduce cancer-related fatigue (Campbell et al., 2019; Zhang et al., 2023). People living with and beyond cancer face varying frequency, intensity and distress from fatigue and other side effects from cancer and its treatment. Their side effects cause different levels of disability that often require care from specially trained therapists or exercise trainers who can develop personalized exercise oncology rehabilitation and recovery programs. People living in rural and underserved communities have limited access to these highly trained professionals and face the burdens and barriers of cost, transportation, travel and time away from work and home (Field et al., 2018; Maganty et al., 2023). Patients who are immune compromised or recovering from treatment may not be safe or feel comfortable exercising in a community facility even if it is with a certified American College of Sports Medicine certified Cancer Exercise Trainer. As many as 31% of cancer survivors are completely inactive and only 23% met the national recommendations (Webb et al., 2016). For cancer survivors, a sedentary lifestyle is linked to a 12-13% increased risk of cancer mortality (Biswas et al., 2015; Lynch, 2010). Inactivity increases risks for comorbid conditions, such as, declines in functional ability, obesity, hypertension, cardiovascular disease, type II diabetes and other cancer (Patel et al., 2019). A smartphone delivered exercise oncology application that tailors an exercise program for each user based on the most common side effect, cancer-related fatigue, would minimize many of the barriers faced by clinicians, patients and people in underserved areas.

We are aware of only three mobile health studies specifically related to exercise for cancer have been conducted – a survey and 2 clinical trials. In a survey of 279 breast cancer survivors' preference were noted for remotely delivered: exercise counseling (84.6%), exercise intervention (79.5%) and 68% reported they would prefer using an app (Phillips et al., 2017). Survey respondents reported that components of a mobile health intervention that would be important were an activity tracker (89.5%), personalized feedback 81.2% and feedback on how exercise influenced mood, fatigue etc. (73.6%). Less important features of an app were: social networking (31.2%), group competition 33.9%, and seeing others' progress 35.1%. The Restwise trial randomly assigned 60 heterogeneous cancer survivors to a 12-week exercise program or Restwise + exercise (Schwartz et al., 2015). Restwise is an online program developed for elite athletes to promote recovery. It requires users to complete daily objective physiologic and subjective psychologic measures and delivers an individualized exercise intensity recommendation. At posttest, the Restwise + exercise group demonstrated significant improvements in the 6-minute walk, 1-repetition maximum leg press and chest press ($p < .0001$). The Restwise + exercise group demonstrated an 18.5% greater increase in the 6-minute walk, 35.2% greater strength gain in the leg press and a 45% greater strength gain in the chest press than the exercise group. Another randomized controlled study, FatigueU/Cope, enrolled 279 heterogeneous cancer patients actively receiving cancer treatment (Wilkie et al., 2022). Patients received a table-based exercise program that was tailored to the patient's fatigue level (Schwartz Cancer Fatigue Scale scores >15 higher dose of exercise or scores <14 lower dose of exercise). The determination of exercise dose was based on previous research (Schwartz, 1999, 2000; Schwartz et al., 2001; Schwartz et al., 2002). While the exercise intervention was only 4-weeks in duration, mean fatigue decreased significantly for the FatigueU/Cope group

compared to usual care (p = .02). This study indicates the efficacy of a low cost, unsupervised exercise intervention to reduce fatigue and the potential for a well-designed individually tailored mobile health solution to reduce fatigue and potentially improve functional outcomes.

Objective

The goal was to develop an exercise oncology application that could provide a tailored exercise program for each user. The following describes the design of the Cancer Exercise app. Cancer Exercise is an individually tailored exercise program delivered through an application for people living with and beyond cancer and their support person(s). The app meets the preferences identified by cancer survivors while integrating a well-tested intervention that follows the American College of Sports Medicine (ACSM) Exercise Guidelines for Cancer Survivors (Campbell et al., 2019; Phillips et al., 2017; Schwartz, 1999, 2000; Schwartz et al., 2015; Schwartz et al., 2001; Schwartz et al., 2002; Schwartz & Winters-Stone, 2009).

METHODS

Cancer exercise app decision tree structure

Cancer Exercise was developed from many years of exercise oncology intervention research. The protocols that were tested and revised over many years of research were refined into an algorithm that adapts to an individual's cancer treatment schedule and level of fatigue. The exercise dose determination begins when the user begins the onboarding process and it asks if a person exercises, how much they currently exercise and if they are ready to start an exercise program. The decision tree is then divided again by whether they are on treatment, and if yes, the type (chemotherapy, immunotherapy, radiation therapy, etc.) and duration of treatment. If the user is a support person, the app skips the treatment step and goes directly to the exercise section. The next decision is determined by results on a 6-minute walk and 30-second sit-to-stand test. The 6-minutes is timed by the app and distance walked is measured and recorded by the app. The user needs to count and record the number of sit-to-stands completed and record the number. This combination of information is used to produce an individualized exercise program that will have the user engage in 3 days of aerobic, 2 days of resistance and flexibility exercises. At 3-week intervals, the program asks the user if the workout is too hard, too easy or just right and at 6-week intervals the 6-minute walk and sit-to-stand tests are re-administered so the user can see their progress and current status. The program does not focus on weight change but there is a place to record weight, blood pressure and waist circumference with the fitness test data.

Algorithms

The algorithms in Cancer Exercise were developed using data amassed in the Authors's 20+ years of exercise oncology intervention studies. The exercise algorithms are tailored based on previous exercise status, type and timing of treatment and daily fatigue level and were tested and refined in studies with diverse populations of cancer survivors (Bea et al., 2022; Bea et al., 2023; de Heer et al., 2019; Schwartz et al., 2015)

Prior to each exercise session the user is asked to rate their fatigue. The fatigue algorithm adjusts daily based on fatigue that is rated on a visual analogue scale (Figure 1) and is calibrated to decrease the exercise dose based on the level of fatigue. If fatigue is rated 9-10 exercise is reduced to simple stretching or completely cancelled and a rest day is declared. When the dose of exercise is attenuated the intensity (based on rating of perceived exertion) and volume of aerobic exercise are decreased and the weight or resistance and number of repetitions of resistance exercises are decreased.

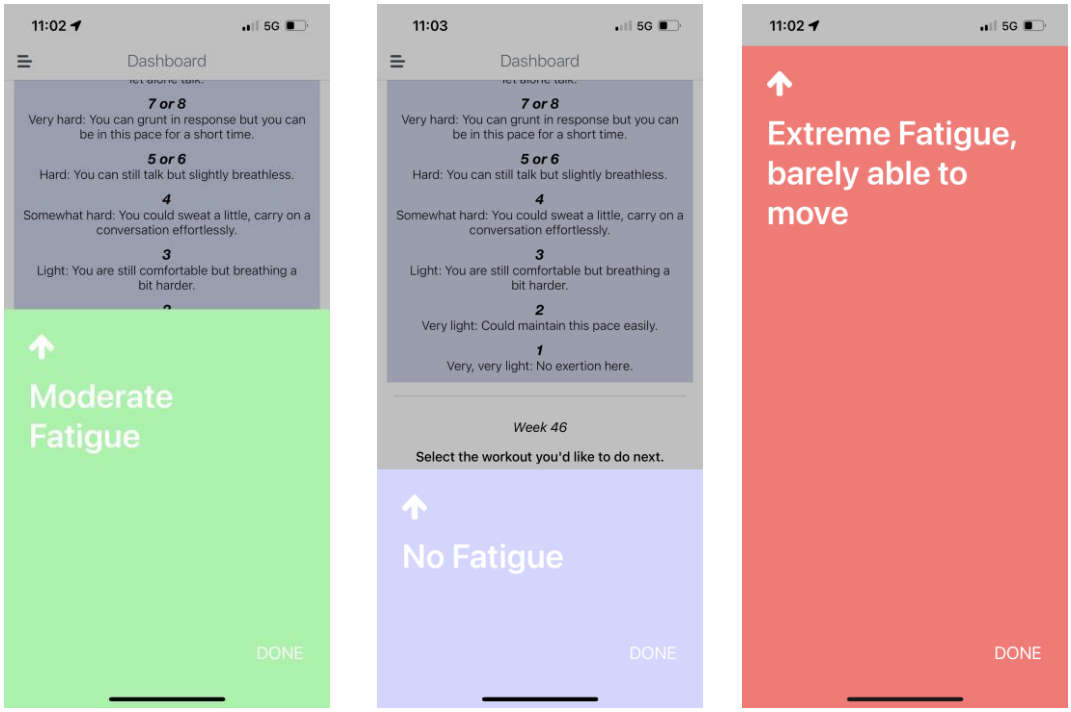

Figure 1. Example screenshots of ratings of fatigue.

On treatment days/weeks the dose of exercise is also attenuated depending on type of treatment (e.g. radition therapy, chemotherapy, immunotherapy). For example, for people living with cancer receiving radiation therapy, exercise may not be attenuated depending on the protocol because side effects accumulate slowly. In contrast, many chemotherapies and immunotherapies cause acute side effects, consequently the exercise dose is decreased, for several days after treatment. Currently, there are no specific exercise attenuations for blood and bone marrow transplant due to lack of data with this treatment. However, the app will provide an exercise program based on receiving chemotherapy and the individual's level of fatigue.

The exercise prescriptions provided, even when attenuated for treatment, adhere to the ACSM Exercise Guidelines for Cancer Survivors (Campbell et al., 2019) and provide a minimum of 90 minutes of aerobic exercise and 2 days of resistance exercise per week for most users. If a user is too fatigued or debilitated to exercise this much at the start of the program, the exercise dose gradually and systematically increases to meet the ACSM Exercise Guidelines for Cancer Survivors. As the user gets fitter and stronger, the exercise dose progressively increases over time so the user will meet the USPHS Physical Activity Guidelines for Adults (Piercy et al., 2018).

APP FEATURES

App features include reminders to exercise, re-enforcing encouragement for meeting daily exercise goals, and notifications to bring users back if they miss a few exercise days or weeks. The "*Resource Section*" provides detailed information about exercise, the ACSM Exercise Guidelines, "*Benefits of Exercise*", and "*How to Exercise Safely*". There is a dedicated section on "*Special Considerations*" for exercising with lymphedema, during chemotherapy, with bone metastasis, etc. The "*Resources Section*" also includes a library of all the workout exercises with illustrations and explanations, a stretch library and breathing exercises. The social cognitive theory forms the basis of the framework, and as such, the app has reminders

that re-enforce engagement and self-monitoring to allow users to track their progress. There are also encouraging comments for successfully completing exercises and weekly sessions. These approaches help people integrate physical activity into their lifestyle and personal identity (Duncan et al., 2010).

USE OF THE APP

During the user onboarding process information is entered on age, weight, type and stage of cancer, type(s) of treatment and dates of ongoing treatment, if applicable. At this point in the onboarding process, there is an option for the user to select that the user is a support person (e.g., partner, spouse, friend, etc.) and not a cancer survivor. Exercise history questions then ask the user how many days in the past week the user engaged in both aerobic and resistance. The next slide frame asks if the user feels they can exercise on their own with a custom program that shows them how to exercise (Figure 2. Caption A). If they answer "*Yes*" they get a "*Congratulations*" screen and continue to receive instructions on rating their fatigue and perceived exertion, what their weekly plan will look like and how it will change. Then the user begins the baseline testing (6-minute walk and 30-second sit-to-stand) which is recorded in the Results section. The initial fatigue measure is used to generate the exercise program. Figure 2. Caption B illustrates an aerobic exercise prescription for a user on chemotherapy with moderately severe fatigue (rating #7). The Warm-up begins at a low intensity and then s/he will begin a set of 4 aerobic intervals (walking, cycling or jogging or other aerobic activity of choice) for 30 seconds (or other appropriate time) and an RPE of 4-6 of equivalent recovery time at an RPE of 2-3, followed by a low intensity cool down. The intensity is set in RPE, and in this case the total exercise dose is reduced because the user is on chemotherapy and rated her fatigue 7 on a 10-point scale. Users can select the exercise type they prefer from the weekly exercise assignment of 3 days of aerobic exercise and 2 days of resistance exercise. The program will let the user do both aerobic and resistance exercise in one day but does not allow the user to progress to do more exercise without a rest day in between.

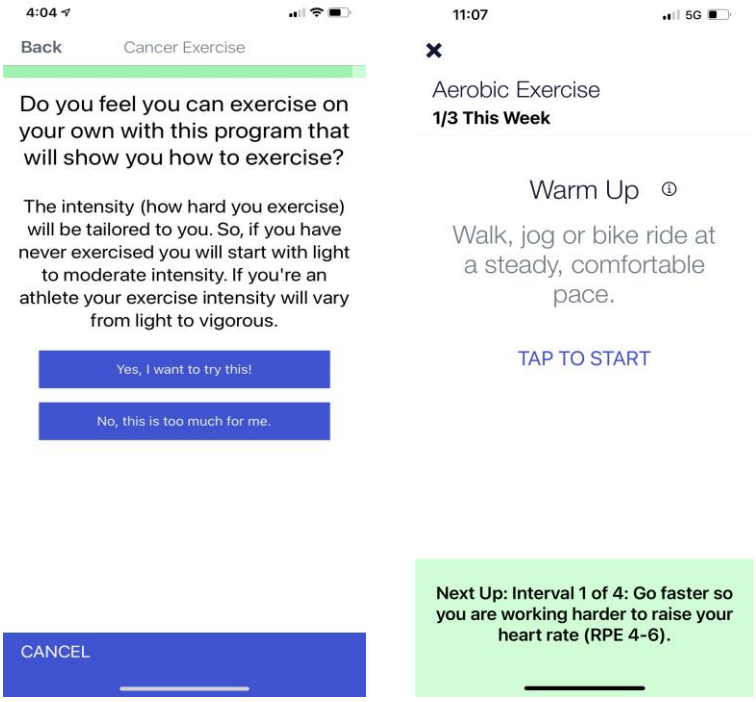

Figure 2. Example screenshots of Cancer Exercise app. (A) Are you ready to exercise with a program that shows you how? (B) Example: aerobic exercise warm-up with instruction for the next part of the exercise.

Design of the cancer exercise app

Knowing that many people living with and beyond cancer are over older, the app was designed for simplicity, readability, ease of navigation and use. To aid in usability, each exercise screen has an information button which takes the user to the library with a picture of the exercise and explanation of how to perform it. During aerobic exercises the screen color gradually changes as the time to completion of each exercise nears. Cancer Exercise is available for iOS and Android devices and can be used on a tablet or smartphone. The design and functionality were revised based on initial testing by cancer survivors. The app has been in the general domain since 2021for iOS devices and was published for android devices in 2023. It has been revised based on users' comments and suggestions to – provide more feedback after each session and the 6-week testing, add a place to record weight and blood pressure. The suggestions regarding feedback were integrated into the first version and subsequent updates were used to add a place for users to record their weight and blood pressure in the Progress tab.

Research use

There are opportunities for researchers to use the app too. For research, each participant user will be given a unique identification number that is tied to the specific study they are participating in. Data is stored securely and can be download for analysis. Researchers can download user data via a HIPAA compliant server, which allows for more extensive, formal app testing.

CONCLUSION

Cancer Exercise is a uniquely tailored mobile application for people living with and beyond cancer and their caregivers. It provides individualized exercise prescriptions based on whether the individual is currently receiving treatment, the type and timing of treatment and their level of fatigue when they begin the day's exercise. The caregiver can also use the application. The algorithms within the application are highly individualized and were derived from years of testing in randomized trials. Future research will focus on the effect of the Cancer Exercise app to benefit the lives of people living with and beyond cancer to maintain and regain their strength for life. The Cancer Exercise app received awards from Ava Digital Awards (Gold medals for apps in medicine and information). It was also nominated Best Mobile App 2020.

ABBREVIATIONS

ACSM, American College of Sports Medicine; RPE, Rating of Perceived Exertion.

AUTHOR CONTRIBUTIONS

A. L. Schwartz: app development and leader. W. Helling: programmer. S. Griffin: project manager. S. Mike's: graphic design. B. Weber overall direction of app development.

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DISCLOSURE STATEMENT

ALS is the developer of the app and President of Coleman Health LLC. BW is president of Inspiring Apps. SG, WH, SM and BW receive a salary from Inspiring Apps.

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