Breast Cancer Survivors' Preferences for mHealth Physical Activity Interventions: Findings from a Mixed Methods Study

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Abstract

Purpose: Despite the benefits of physical activity for breast cancer survivors, the majority remain insufficiently active. Mobile health (mHealth) physical activity interventions may be a more scalable strategy to increase activity among survivors. However, little is known about their preferences for mHealth intervention features. This study explored survivors' preferences for these features.

Methods: Survivors [N=96; M_{age}= 55.8 (SD=10.2)] self-reported demographic and disease characteristics, physical activity. A subset (n=28) completed a semi-structured phone interview. Transcribed interviews were evaluated using a thematic content analysis approach and consensus review. Following interviews, the full sample self-reported interests and preferences for

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intervention features via online questionnaires. Quantitative data were analyzed using descriptive statistics.

Results: Five themes emerged from interview data: (1) importance of relevance to breast cancer survivors; (2) easy to use; (3) integration with wearable activity trackers; (4) provide sense of accomplishment and (5) variability in desired level of structure and personalization. The highest ranked intervention features were: daily and weekly progress feedback (87.5%), newsfeed (86.6%), activity challenges (81.3%) and scheduling tool (79.2%). Survivors were interested in receiving progress feedback (80.2%), motivational (78.1%) and reminder (75.0%) messages.

Conclusions: Breast cancer survivors are interested in mHealth physical activity promotion interventions but preferences varied around themes of relevance, ease of use, and enhancing personal motivation.

Implications for Cancer Survivors: Engaging survivors in developing and implementing remotely-delivered, mHealth activity promotion interventions may enhance their effectiveness.

Keywords

Physical activity; exercise; technology; breast cancer survivors; mHealth; mixed methods

INTRODUCTION

An estimated 3 million breast cancer survivors live in the U.S. and this number is expected to increase to 4 million over the next decade [1]. Breast cancer survivors are at an elevated risk of chronic conditions and compromised quality of life (QOL) [2, 3]. Higher levels of moderate to vigorous intensity physical activity (MVPA) are associated with fewer negative treatment-related side effects, better quality of life, and improved cancer outcomes including increased survival and reduced progression and mortality among breast cancer survivors [4, 5]. However, survivors demonstrate declines in MVPA that persist post-treatment [6]. Up to 70% do not meet public health and cancer survivor-specific recommendations of 150 minutes per week of MVPA [7–10].

Traditional MVPA interventions in breast cancer survivors incorporate intensive on-site, one-on-one or group training or coaching which is costly and limits their scalability [11–15]. Recent data suggest the majority of breast cancer survivors can perform home-based exercise programs safely and independently without need for supervision [16]. Interventions which use mobile health (mHealth) technology such as text messages, smartphone apps, or wearable activity trackers may be particularly useful for breast cancer survivors as they offer a more scalable alternative to traditional interventions and could have much broader reach given the increasing adoption of smartphones [17, 18]. Further, mHealth MVPA promotion interventions, especially those including wearables, offer a unique opportunity to continuously monitor survivors for adherence and safety which is an advance over traditional distance-based interventions. Emerging data indicate mHealth interventions demonstrate promising improvements in MVPA in other populations [19–22]. Recent data also suggest technology-supported interventions [23] and wearable activity trackers [24] may be of interest to breast cancer survivors and other survivor groups [25]. However, engagement and continued use of mHealth MVPA promotion interventions is mixed in the

general population [26] and only a few mHealth interventions have been conducted or are ongoing in cancer survivors [27–30]. Thus, the National Cancer Institute has identified developing and testing mHealth interventions in cancer survivors as a research priority [31]. Currently, little is known about the feasibility and acceptability of mHealth interventions to promote MVPA in cancer survivors. Prior to developing and testing interventions, it is essential to engage survivors to understand barriers and facilitators of mHealth technology and what types of technology-supported features are of most interest. Including survivors' perspectives increases the likelihood that mHealth interventions will be relevant, engaging and effective [32]. Therefore, the purpose of the present study was to explore the acceptability of various mHealth MVPA promotion intervention features among breast cancer survivors.

METHODS

Recruitment and Randomization

All study procedures were approved by the university institutional review board. Women were recruited through an "e-blast" sent to members of the Army of Women,© an on-line directory that connects researchers with survivors interested in participating in breast cancer-related research. Inclusionary criteria included: age ≥ 18 years, diagnosed with stage I-III breast cancer within the last 5 years, ≥ 3 months post-primary treatment (i.e. surgery, chemotherapy, radiation therapy), able to read, write and speak English, own a smartphone and have access to a computer with Internet. Women who expressed an interest in participation, were sent an e-mail further describing the study's purpose and eligibility criteria. This email also included a personalized link to the online screening tool. Women who self-reported meeting eligibility criteria were automatically redirected to an online informed consent. Study participation was limited to 100 participants for the questionnaire portion of the study. We randomly selected a subsample of 35 women using a pre-populated computer algorithm. Because of the qualitative and formative nature of the interview component, the interview sample size was chosen to sufficiently capture diversity of preferences but also achieve theme saturation.

Data Collection

We used a sequential mixed methods approach. First, the subset of participants selected for a phone interview were emailed to schedule an interview appointment. After completion of interviews, the questionnaires were developed based on previous findings and findings from the interviews. All participants who consented to participate were e-mailed a secure, personalized link to the study questionnaire. Participants received up to three reminders to complete the questionnaires and/or schedule a phone interview.

Measures

Interviews—Interviews were conducted by an expert in physical activity and cancer survivorship. Interviews followed a semi-structured interview guide developed by the research team (see Supplementary Table 1). All interviews were audio recorded and professionally transcribed.

Online Questionnaire

Demographics and Health History.: Survivors provided demographic information including age, race/ethnicity, income, education, and height and body weight to calculate body mass index. They also reported date of cancer diagnosis, disease stage and treatment.

Physical Activity.: Participants indicated the number of times per week they engaged in MVPA on average in a given week over the previous 6 months and the average number of minutes of each session. These two questions were slightly adapted from the Health Information National Trends Survey to provide additional details on the definition of moderate to vigorous physical activity. The total times per week was multiplied by minutes per session to obtain total minutes of MVPA.

mHealth Intervention Feature Preferences.: Instructions for this portion of the survey explained that study findings would be used to inform the development of a completely remotely-delivered (i.e. no in-person contact), mHealth intervention that would use a smartphone application (app) and was designed to help breast cancer survivors make gradual progress towards meeting the public health recommendations of 150 minutes per week of MVPA each week. Participants were asked about their preference regarding a number of potential intervention features including educational content, specific app features (i.e. newsfeed, symptom tracker, scheduling tool), physical activity tracking and feedback, symptom tracking and text messages/app notifications (see Table 1). Survivors indicated whether they liked/disliked/were unsure (multiple choice) about most features and provided feedback on the potential content (i.e. type of messaging, topics to be covered) and structure of features such as delivery mode (i.e. text message, phone) or format (physical activity feedback), willingness to share data, and desire to have data shared. Survivors were provided with descriptions of the potential features and, when appropriate, images of what the feature might look like (i.e. feedback format). These questions were based on previous findings from a needs assessment in breast cancer survivors [23]. We also asked about preferences for social features. However, given the breadth of information obtained on this topic, we analyzed and reported on those data separately [33].

Data Analyses

Descriptive statistics including means and standard deviations (continuous variables) and frequencies (categorical variables) were calculated for all questionnaire data including demographic and disease characteristics, weekly minutes of MVPA, and beliefs about specific mHealth MVPA promotion intervention features. Logistic regression was used to determine whether participant characteristics including: race (White v. non-White); ethnicity (Hispanic/Latina v. Non-Hispanic/Latina); employment status (employed v. not employed); age (continuous); education (college degree v. <college degree); time since treatment (continuous); disease stage (continuous); treatments received (i.e. chemotherapy, radiation, endocrine/hormone therapy) (yes v. no), health status (continuous) or meeting MVPA guidelines (yes v. no) influenced preferences. Questions with three response items were recoded into two categories (Yes and No/Not sure) to create binary variables. All analyses were conducted in SPSS V.22 [34].

For interview data, an iterative, multi-step inductive approach was used to deduce underlying concepts [35]. Key themes were identified through thematic text analysis using an inductive approach [36–38]. First, two research team members independently read through interview transcripts and identified relevant content. Second, the two team members compared content codes and iteratively developed a coding scheme (i.e. code names and meanings) to describe and summarize relevant content. The coding scheme was reviewed by the larger research team to achieve consensus. Third, transcripts were read by two independent coders who assigned codes to relevant content. Discrepancies in coding were resolved through discussion with the larger research team. Then, the larger research team met to organize codes into larger thematic categories based on conceptual similarities and a priori research questions. Consensus was reached through discussion. Finally, two team members independently reviewed the narrative content within each thematic category, summarized findings and identified illustrative quotes. The pair reviewed any inconsistencies, and discrepancies were resolved through iterative consensus. NVivo 11.0 [39] was used to organize narrative content within thematic categories.

RESULTS

Participants

Initially, 259 women expressed interest in participating. As the study goal was originally set at 100, recruitment ceased after 104 eligible participants were consented. Of these, 96 completed the online questionnaire. Of the 35 women randomly selected as an interview subsample, 28 completed the interview. Demographics and disease characteristics for the full sample and interview subsample are presented in Table 2. In the full sample, women were on average 55.8 ±10.2 years of age. The majority of women were white (92.7%), had at least a college degree (83.7%), employed at least part-time (70.6%), and were 27.5 (± 15.1) months post-treatment on average. Survivors reported engaging in 140.8 ±123.6 minutes of MVPA per week. Participants who completed interviews had similar demographics to the full sample of participants

Interviews

Five main themes emerged about the preference for mHealth interventions from the interview data: (1) importance of relevance to breast cancer survivors; (2) easy to use; (3) integration with wearable activity trackers; (4) provide sense of accomplishment and (5) variability in desired level of structure and personalization. The desire to socially connect to other survivors also emerged as a theme. However, because there were so many subthemes under this topic area, we decided to analyze and present those data separately [33]. Interview questions are presented in Supplementary Table 1 and illustrative quotes related to each theme are provided in Table 3.

Theme 1: Importance of relevance to breast cancer survivors—Women expressed a desire to have the program be relevant to their experiences as a breast cancer survivor. While they felt there was a lot of information available for the general public regarding MVPA, they were unsure whether this information applied to them as cancer survivors and liked the idea of having the intervention content be very specific to breast cancer survivors.

Women were also interested in having the program provide the latest evidence-based information and research studies on benefits and harms/risks of exercise for breast cancer survivors. They felt that making a clear linkage to their experience as a cancer survivor would serve as a reminder to them why being physically active is so important and encourage them to do more. Further, they wanted the program to take into account common side effects of treatment and provide modifications and recommendations for exercises to address these side effects. Women were also interested in knowing what other, similar survivors had done to become and stay active as well as hearing about "success" stories.

Theme 2: Easy to use—Survivors were very interested in the idea of having a smartphone app to monitor and promote MVPA for breast cancer survivors because they felt apps were easy to check and they almost always had their phone with them. However, they cautioned that a major barrier to using technology to promote MVPA could be survivors' level of tech savviness and the desire some people have to disconnect from technology. Survivors were clear that a technology supported intervention and specifically an app should be user-friendly and not overly complex. They wanted app features that were easy to read, engaging and visually appealing. They wanted to be able to navigate the app quickly and efficiently in terms of activity tracking and feedback. This included a desire for the technology to provide straightforward, clear, interpretable goals and feedback so they could easily see what they needed to do, evaluate their daily, weekly and monthly progress and identify what they need to improve upon.

Theme 3: Integration with Wearables—Survivors endorsed the use of wearable activity trackers to promote MVPA. Although wearables were not explicitly discussed as the only means to track activity throughout the interviews. Participants seemed to assume a wearable activity tracker would be used indicating this was like an essential feature. Participants indicated they were interested in a wearable that was easy to use, communicated seamlessly with an app and provided easy to access activity data. Because such wearables could be worn unobtrusively most of the time, many believed they would make it easier to track their progress and accomplishments, provide positive reinforcement, hold them accountable and serve as a reminder to be more active and accomplish their goals. They wanted a wearable to capture physical activity not only resulting from aerobic exercise, but also from other types of exercise (i.e. resistance training, yoga) and from activities of daily living (i.e. household chores and shopping). Many survivors were concerned about not receiving credit for all the activities they completed for both exercise and for their daily living. They also expressed frustrations they felt with perceived inaccuracies in commercially available wearable activity trackers. Regardless, survivors overwhelmingly indicated a strong preference for the use and integration of wearable activity trackers as the primary method for tracking, as opposed to other tracking options such as manual entry of activity, recording session timings or GPS tracking because they were easy to use and did not require them to carry their phone to have their activity count. However, most women also wanted the flexibility to manually enter physical activities in the event they forgot to wear the tracker, it malfunctioned or it did not capture the activity they were doing. Finally, women did not want to have to carry around their phone in order to participate in the intervention.

Theme 4: Encouraging and Provides Sense of Accomplishment—Most participants indicated a strong desire to have the program be positive and provide a sense of accomplishment. Women generally liked the idea of an app holding them accountable and keeping them oriented and working towards a goal. However, women suggested that repeatedly not being able to meet high activity goals would lead to frustration and disengagement. They thought it was important to have survivors start off slow and set goals that were realistic for each individual in terms of their fitness level and physical limitations so they could be successful which they felt would increase their motivation to do more activity. Survivors expressed a desire for the program to help them feel like they were "checking off" their goals. Survivors liked the idea of being congratulated or rewarded via positive feedback and encouraging messages multiple times throughout the week, including when they completed an exercise session or accomplished a goal, or some increment of that goal, because they felt these messages would motivate them to stay active. Women also felt it would be convenient and important to regularly remind them of their goals and what they needed to reach these goals and push them to do more. They saw it as an opportunity to feel positively connected to the study team in moments of low motivation. However, they consistently reiterated the need for all messages to be positive and encouraging and to not shame or make them feel guilty they did not reach their goals. Finally, survivors wanted to be able to easily look back at the progress they made and be recognized in the app or via messages for their progress.

Theme 5: Level of Structure and Personalization—Women varied in the level of structure, instruction, feedback and reminders they wanted the intervention to provide. The majority highlighted clear goals as pivotal to increasing MVPA. Some women indicated a preference for a structured program in which goals were set for them while others desired a more flexible program to limit discouragement in cases where goals were not met. Women thought providing a list of physical activities they could choose from to participate in would help them to tailor the program goals to their specific needs. Videos and example exercises were viewed favorably, especially for resistance exercises, so they would know how and what to do. Additionally, they thought having some way to track other variables such as mood and treatment symptoms that may impact their activity and have this information incorporated into their goals would be useful for further tailoring the program to their needs.

While most survivors' thought receiving encouraging, motivational text messages would be helpful because they are unobtrusive, others indicated they would likely ignore messages if they receive too many. Many thought there should be an option to elect in or out of specific messages or indicate their desired frequency. Several women endorsed having a results page where they could easily view and interpret their own progress through the program in addition to, or in place of, messages. Ultimately, survivors valued the ability to personalize the program to their needs and desired the ability to choose various features and frequency of feedback based upon their own personal preferences.

Online Questionnaire

Intervention preferences elicited from the online questionnaire are presented in Table 4 and summarized below.

Educational Content—Survivors wanted to receive educational information via app alone (37.5%) or a combination of app and e-booklet (34.4%). Survivors' rated the following as the most important educational content to include: benefits of physical activity for breast cancer survivors (84.6%), effective goal setting and monitoring (81.7%), finding the activity that's right for them (76.9%), the importance of strength training (76.9%) and ways to incorporate activity into daily life (76.0%).

Specific App Features

Newsfeed.: Participants liked the idea of a newsfeed where study staff could post relevant content (86.6%). They were most interested in having newsfeed posts related to workout ideas (85.6%), information on new relevant studies published in physical activity and cancer survivorship (75.0%), and tips for proper nutrition (71.2%).

Scheduling Tool.: The majority of women (76.3%) thought an exercise scheduler would be helpful to keep them on track to meeting their activity goals. They liked the idea of having the option to record their own workouts or use workouts pre-populated by study staff (83.5%). In terms of scheduler features, they wanted the ability to change a scheduled exercise session (97.9%), "check off" workouts when completed (91.8%) and increase or decrease their exercise goals (79.2%). They also wanted the scheduler to sync with their phone calendars (76.0%).

Symptom Tracker.: About two-thirds (62.5%) of participants reported they would be interested in having a symptom tracker incorporated within the app to provide feedback on symptoms in relation to physical activity. Survivors' indicated they would be inclined to track their symptoms on a weekly basis (42.5%) and were most interested in tracking energy level (79.4%), how they feel, overall, (76.3%), and sleep quality (74.2%).

Others.: Survivors liked the idea of incorporating a Fit Tip of the Week (83.2%), Fit Challenges (81.3%), a Fit Study of the Week (74.7%), and Fit Survivor Spotlights (58.9%). Women's preferences were mixed about how they would like to receive these features; the most popular modality was via a newsfeed (Fit Tip of the Week 35.8%, Fit Study of the Week 36.8%), but similar proportions also indicated interest in receipt via text message, app notification or no preference.

MVPA Tracking and Feedback—When asked about preferences for tracking activity via manual entry, participants preferred the ability to select an activity from a preloaded activity list (51.0%) with the app remembering common activities they enter (97.9%). In terms of passive wearable tracking options, 46.3% of participants preferred wearing a wrist worn activity tracker, while 36.8% were interested in the option to wear it on their wrist, waist, or underneath their clothing. Survivors wanted feedback on their activity displayed on both an activity tracker and app (87.2%). Feedback metrics of interest included: steps taken (77.9%), total minutes of activity (72.1%), time spent in various intensities of activity (65.4%), and calories burned (63.5%). Survivors' indicated they would prefer to receive both daily and weekly physical activity feedback summaries (87.5%).

Text Messages/App Notifications—Overall, participants believed receiving text messages or app notifications including reminders to be active (75.0%), feedback on progress (80.2%) and motivational messages (78.1%) would be helpful. Survivors did not have a strong preference for whether these messages were delivered via text message or app notification. Survivors' were split on the frequency in which they were interested in receiving these messages (range: 25.5% to 38.9%) with the highest proportion indicating at least daily for each message category.

Preferences and Participant Characteristics—The relationship between preferences for specific features and demographic and disease characteristics are presented in Supplementary Table 2. Women with more advanced disease were less likely to indicate they liked the idea of a scheduler ($\beta= -1.16$; $p= 0.03$) than those with early stage disease. Those who had received chemotherapy ($\beta= 1.5$; $p= 0.04$) were more likely to endorse having a symptom tracker than those who had not. Compared to younger women, older women ($\beta= -0.07$; $p= 0.02$) were less likely to endorse a symptom tracker. Similarly, compared to those who had not, those who had who received radiation therapy ($\beta= -1.3$; $p= 0.04$) were less likely to endorse a symptom tracker. Women who had received chemotherapy were more likely than those who had not to indicate they liked the idea of reminder ($\beta= 1.8$; $p= 0.03$) and motivational messages ($\beta= 2.3$; $p= 0.01$). Those with better health status were less likely to indicate they liked the idea of reminder messages ($\beta= -1.1$; $p= 0.03$) than those with worse health status. Compared to women who had not received endocrine or hormone therapy, survivors who had were more likely to indicate they liked the idea of survivor spotlights ($\beta= 1.4$; $p= 0.03$) while older women ($\beta= -0.08$; $p= 0.01$) were less likely than younger women to endorse this idea. No other significant relationships were observed.

DISCUSSION

Technology usage is rapidly increasing and emerging as a potentially useful tool for promoting MVPA. However, there is very little evidence about the acceptability and preference for using technology among cancer survivors. Thus, the present study used a mixed-methods approach to evaluate breast cancer survivors' interest and preferences for mHealth MVPA promotion interventions. Overall, survivors believed mHealth interventions could be helpful for MVPA promotion and were interested in a variety of mHealth intervention features. Survivors wanted intervention features that were easy to use, specifically designed and tailored to breast cancer survivors, positive and encouraging, seamlessly integrated wearable activity trackers and personalized. Preferences varied regarding which specific features should be implemented and how. Our findings indicated that unique preferences survivor preferences for mHealth physical activity interventions should be taken into consideration when designing strategies to enhance their uptake and efficacy.

Findings from the present study are consistent with other studies that have explored breast survivors' preferences for technology-supported MVPA interventions and wearable activity trackers [23, 24] providing further evidence to support the acceptability of these types of interventions among breast cancer survivors. Integration of a wearable activity tracker with other intervention components and technologies emerged as a desired feature. Although

commercially available activity trackers (e.g. Fitbit) are popular, little is known about their effectiveness for increasing MVPA, alone, or in combination with other intervention components in breast cancer survivors. Studies in the general population and other chronic diseases indicate activity trackers may be effective tools in the context of multicomponent interventions [27], but in isolation may not be effective, alone, at creating meaningful *long-term* changes in MVPA [38–40]. Future research should examine their effectiveness, alone, and in combination with other intervention tools, among breast cancer survivors. Finally, because survivors' preferences for wearables in terms of measurement capabilities extends beyond their current capacity, it may be important to understand survivors' expectations of the functionality of technology used in interventions. If there is a mismatch between their expectations and the capabilities, it may be necessary to educate them to ensure they are not disappointed or become discouraged because the technology does not function as they had hoped or expected.

The variability in preferences for intervention features in conjunction with the desire for technology that is easy to use, visually appealing and intuitive serves to highlight the importance of engaging survivors throughout the entire process of developing and testing mHealth MVPA activity interventions to enhance intervention uptake. Survivors should be involved in the initial development phase to ensure variability in preferences is taken into consideration to make sureintervention features are thoroughly vetted prior to making decisions on what features to include. To ensure ease of use, research teams should strongly consider engaging experts alongside survivors in usability testing and human computer interaction to thoroughly test mHealth interventions before deployment in the field. Survivors should also be included in message development to ensure messages are relevant and meet their criteria for being encouraging, providing a sense of accomplishment and avoiding guilt. Finally, because data from the general population indicate that simply providing individuals with an app or text messages may not be sufficient to elicit significant changes in MVPA [19–21]., the engagement process should not stop with intervention deployment because keeping survivors engaged in using the mHealth technology is likely critical to intervention success [40–42]. Future work is needed to better understand not only mHealth intervention uptake, but continued usage and engagement with the intervention [41]. This includes developing a better understanding of how to define and measure engagement, systematically test engagement strategies, and delineate engagement strategies from intervention delivery so as not to compromise intervention rigor. Finally, because treatment received, disease stage, health status, and age were significantly related to some preferences, participant characteristics should also be considered in the engagement process to ensure the right intervention features are being used to engage the population of interest.

The variability in survivors' preferences for intervention features and levels of support also indicates there is not a "one-size-fits-all" mHealth intervention to promote MVPA in breast cancer survivors. Future work should explore which intervention features are most effective for whom, under what conditions [43, 44] and at what cost. Multiple intervention components and decision rules can be tested systematically using methodologies such as Multiphase Optimization Strategy Trials (MOST; [45, 46]), Sequential Multiple Assignment Trials (SMART; [45]) or Micro-randomized trials [47]. These rigorous trial designs allow for rapid studies to identify and adapt the most effective technology-supported exercise

intervention components, or component sequence(s), to answer the questions of what works for whom, in what contexts, and for what outcomes [44]. Additionally, mHealth interventions provide a unique opportunity to create highly tailored interventions which can take into account personal preferences (i.e. message frequency, contact modality) and other contextual factors (weather, symptoms, time of day, motivation, activity level) in real time, which has not been possible in traditional on-site and home-based MVPA interventions. Future work should explore how best to tailor intervention components for diverse groups of breast cancer survivors and should also consider testing the feasibility and efficacy of a patient-centered tailoring approaches whereby survivors are provided with a "menu" of features to choose from to customize the intervention to their preferences.

Results of this study should be interpreted within the context of its limitations. First, our sample may be more engaged and technologically savvy than the typical breast cancer survivor because they were members of the Army of Women© and were recruited via the Internet. Additionally, the majority of participants were White, non-Hispanic, high income, early stage survivors. Future research should examine whether this study's findings generalize to more diverse breast cancer survivors (i.e. Hispanic, more advanced disease) at different times since diagnosis and with varying experiences with technology. Additionally, we examined a limited number of participant characteristics that may influence preferences within our relatively homogenous sample and all characteristics were self-reported and used a crude measures of physical activity. Future work should explore how additional factors (i.e. psychosocial, motivational, personality) may influence preferences in larger more diverse samples using objective measures when available. Finally, this study involved a cross-sectional assessment of preferences for mHealth intervention features. As many factors may influence mHealth intervention usage across time, future work should explore the dynamics of individual intervention preferences and how to accommodate them to ensure intervention success.

Despite these limitations, to the best of our knowledge, this is the first study to use a mixed methods approach to examine breast cancer survivors' preferences for a variety of mHealth intervention features. Our rigorous mixed methods approach yields greater insight into survivors' preferences than quantitative or qualitative data alone. In addition, our sample was geographically diverse and included both active and inactive survivors allowing us to understand preferences for features based on a broad range of geographic locations and physical activity levels. Finally, engaging survivors to understand their preferences may increase the success of future mHealth physical activity promotion interventions in this population.

In conclusion, our study indicates breast cancer survivors are interested in mHealth physical activity promotion interventions. Findings highlight the need to develop easy to use, encouraging, tailored mHeath interventions specific to breast cancer survivors. The observed variability in survivors' preferences for specific features indicates engaging survivors in designing, testing and implementing mHealth interventions is needed to enhance their relevancy and efficacy. Future work is warranted to determine which mHealth intervention features, sequence of features or combination of features is most feasible, acceptable,

engaging, efficacious and cost-effective for increasing and maintaining physical activity in breast cancer survivors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

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Table 1.

Potential Intervention Features Assessed Definitions Provided to Participants

Feature	Description
Educational Content	Basic educational content about physical activity, safety and effectively changing behavior
Specific App Features	
Newsfeed	Place where study staff could post workout ideas, interesting photos, links, videos, etc.
Scheduling Tool	Allows participants to specify when and how they will meet their activity goal for that week.
Symptom Tracker	Allows participant to track symptoms or mood within the app and provides feedback on these data in relation to physical activity
Fit Survivor Spotlight	Highlights the story of a breast cancer survivor who had become successfully active
Fit Tip of the Week	Provides simple tip for increasing physical activity. (Ex: Every minute of activity counts! If you can't set aside 30 minutes to go for a walk, try to take three 10 minute walks throughout the day.)
Fit Study of the Week	Provides simple information on studies related to physical activity and cancer survivorship. (Ex: "A study by Dr. Jones found that walking at a moderate intensity three times per week for 40 minutes improves memory.")
Fit Challenge	Individual challenge could enroll in for a given amount of time either in conjunction with your weekly goal or as an additional way to engage in more physical activity (Ex: "5 minutes brisk walk a day weekly challenge")
Activity Tracking	Wearable monitor worn on the body 24/7 to automatically track physical activity
Activity Feedback	Information on metrics related to physical activity engaged in (i.e. steps, minutes, heart rate, etc.)
Text Messages/App Notifications	Reminders to be active, motivational messages or progress messages delivered via text message or app notification

Table 2.

Sample Demographic and Disease Characteristics

Factor	Full Sample (n=96)	Interview Subsample (n=28)
Age *(M, SD)*	55.8 (10.2)	53.39 (10.1)
Race, white (%)	92.7	92.9
Education		
< College degree (%)	16.3	10.7
College degree (%)	33.7	39.3
Graduate or professional degree (%)	50.0	50.0
Employment status		
Not working (%)	29.4	25.0
Working part-time (%)	29.3	32.1
Working full-time (%)	41.3	42.9
Disease Stage		
Stage I (%)	53.3	67.9
Stage II (%)	34.8	21.4
Stage III (%)	12.0	10.7
Treatment Type		
Chemotherapy (%)	56.3	50.0
Radiation (%)	615	57.1
Surgery (%)	95.8	100
Hormone Therapy (%)	66.7	57.1
Currently Receiving Hormone Therapy (%)	76.9	59.3
Months Since Treatment *(M, SD)*	27.5 (15.7)	21.8 (15.1)
Reported physical activity, min/week *(M, SD)*	140.8 (123.6)	172.6 (129.2)

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Table 3.

Selected Quotes to Support Themes Identified

Theme	Illustrative Quote
Importance of Relevance to Breast Cancer Survivors	I think that it needs to be aimed toward survivors. That would be the first component. There's a lot on the Internet that gives you a lot of exercises but it's not aimed towards survivors. [P#174]
	I think for people finding the right fitness for them and maybe suggestions on, "Here's what you can do, here's what other cancer survivors have found helpful. [P#42]
	It's kind of upsetting me about this is I think if there was something geared towards cancer survivors I think that would make a big difference because we do have different needs.[P#86]
Easy to Use	I think the hardest thing with apps is not making it complicated because then most people turn them off and they don't come back to them. I got a ton of apps on my phone that I don't use because they're a pain in the neck to use. If it's easy to use, I think that that's where people will come back to, but if it's really complicated I think that's where it gets turned off. [P#238]
	If things are too difficult to interact with, I think people don't use them. [P#199]
	I think simplicity will be the key in pulling things into concise, easy to use. [P#125]
	I would say the most important thing is the ease of use, the simplicity of it because if it's cumbersome I won't use it. [P#213]
Integration with Wearables	If I could be tracking myself on my phone or tracking my progress I think that would really be a motivator to me. [P#136]
	I would want it to track everything and also easily convert all the different kinds of activities into some kind of common measure, so that you could have a total idea of what you did. [P#167]
	I would love for it to interface with Fitbit, because I've used that for walking for a couple of years now. [P#39]
	I wish there was something… that would take into account all different forms of activity, so you do get the credit [ID#213]
	I always like to be better than I was but also to encourage me to keep on going because it is tough right now. [P#136]
	I'd be more likely to use aspects of the machine helping me, you know like giving me good feedback. "Good Job, you got seven thousand steps in today." [P#118]
Encouraging and Provides Sense of accomplishment	Seeing your progress, I think is very important. Seeing measurable progress, whether its in calories burned, or minutes, or meeting a percentage of your goal. [P#199]
	Something that just keeps, for me, shows that I'm still improving and not to let go and not give up on it, but I am improving. [P#238]
	I like the idea of positive feedback wherever the source. I think that's super huge for anyone and especially for survivors because after you have cancer you're always a little bit like how is everything in there? [P#220]
Level of Structure and Personalization	[A symptom tracker] could be [motivating]. I think that would be very individual. I think that would be people who participated in that and people who didn't because you're just reluctant to talk about that side of things. Having the option open is always good I think. [P#170]
	I think it has to have different levels. Some people have no idea about how much exercise they should do or what's useful but then some people. need more information because [they already]… know that. If it's there and it has different levels available depending on what you need then I would be interested in using it. [P#213]
	I think for people finding the right fitness for them and maybe suggestions on, "Here's what you can do, here's what other cancer survivors have found helpful. If you've had a mastectomy and you limited range of motion, here are some good things you can do." [P#42]

Theme	Illustrative Quote
	I would say… text messages can be good. I think having a logical limit on them and having people being able to opt in, "Well I want something 3 times a day," or "I want something once every other day," or any kind of time frame so that you don't get people opting out because they can't deal with so many messages. [ID#125]

Table 4.

Findings from Online Survey of Breast Cancer Survivors' Preferences for Technology-Supported Intervention Features (N=96)

Question	Frequency (%)
Educational Content	
How would you like to receive education information?	
App Only	37.5
App and e-Book	34.4
No preference	20.8
e-Book Only	5.2
Other	2.1
What type of educational content do you think would be important to have?[*]	
Benefits of MVPA for breast cancer survivors	84.6
Effective goal setting and monitoring	81.7
Finding the right activity for you	76.9
Importance of strength training	76.9
IncorporatingMVPA into your life	76.0
Ways to monitor intensity	70.2
Proper nutrition	67.3
Proper hydration	59.6
Overcoming barriers	55.8
Facilitating MVPA participation	48.1
Public Health recommendations for MVPA	43.3
Safety	36.5
Newsfeed	
What are your thoughts on a newsfeed where study staff could post workout ideas, interesting photos, links, videos, etc.?	
I like this idea	86.6
Not sure	11.3
I don't like this idea	2.1
If there were a study newsfeed, what types of information would you like posted?[*]	
Work-out ideas	85.6
Information on new relevant studies in MVPA and cancer survivorship	75.0
Tips on proper nutrition	71.2
Content on how to keep motivated	67.3
Common questions and answers about activity and cancer	64.4
Stories about other breast cancer survivors who successfully became active	61.5
Information related to other aspects of a healthy lifestyle	58.7
Relevant articles and information from the popular press regarding MVPA	32.7
Exercise Scheduler	
Do you think an exercise scheduler would be helpful for keeping you on track?	
Yes	76.3
Not sure	18.6

Question	Frequency (%)
No	5.2
Do you think it would be helpful to be able to increase or decrease the weekly goal provided by the program?	
Yes, both increase and decrease	79.2
No, goal should stay static	11.5
Yes, but only increase goal	9.4
Would you want to select from specific workouts designed by the study team or enter your own?	
Option to use workouts designed by study staff or enter my own	83.5
Enter my own workouts	10.3
Use workouts designed by study team	3.1
Which of the following would you want to schedule in a scheduler?	
Day only (i.e. 30 min walk on Wednesday)	41.1
Day and specific time (i.e. 30 min walk on Wed at 6:30am)	36.8
No preference	22.1
Would you like this scheduler to sync with the calendar on your phone?	
Yes	76.0
Not sure	18.8
No	5.2
Do you want the ability to move scheduled exercise sessions to different days/times?	
Yes	97.9
Not sure	2.1
No	0.0
Would you want the ability to check off workouts you complete?	
Yes	91.8
No	4.1
Not sure	4.1
Symptom Tracker	
What are your thoughts on incorporating a symptom or mood tracker within the app and providing feedback on these data in relation to physical activity?	
I like this idea	62.5
Not sure	25.0
I don't like this idea	12.5
How frequently would you want feedback on your symptoms/mood in relation to physical activity?	
Weekly	42.5
Daily	27.6
Every 2–4 days	21.8
Monthly	8.0
If you were provided with a symptom/mood tracker, what would you be interested in tracking?[*]	
How you feel, overall	76.3
Energy level	79.4
Pain	46.4
Sleep quality	74.2
Anxiety	48.5

Question	Frequency (%)
Other	2.1
Prefer not to answer	6.7
Other Features: Fit Survivor Spotlight, Fit Studies, and Fit Challenges	
What are your thoughts on a Weekly Fit Survivor Spotlight?	
I like this idea	58.9
Not sure	35.8
I don't like this idea	5.3
Who would you want to be featured in a Weekly Fit Survivor Spotlight?	
Combination	38.0
Someone who is currently enrolled in the intervention	33.7
No preference	28.3
Do you think a Fit Tip of the Week that message would be helpful for keeping you on track?	
Yes	83.2
Not sure	12.6
No	4.2
How would you like to receive Fit Tip of the Week messages?	
In-app study newsfeed	35.8
App notification	23.2
Text message	22.1
No preference	18.9
Do you think a Fit Study of the Week message would be helpful for keeping you on track?	
Yes	74.7
Not sure	18.9
No	6.3
How would you like to receive Fit Study of the Week messages?	
In-app study newsfeed	36.8
App notification	27.4
Text message	17.9
No preference	17.9
What are your thoughts on weekly Fit Challenges you could enroll in?	
I like this idea	81.3
Not sure	12.5
I don't like this idea	6.3
Physical Activity Tracking and Feedback	
Which of the following would you prefer as a way to enter the physical activity you performed?	
Select from list of activities	51.0
Free-entry of activity	37.5
No preference	11.5
Would you like the app to remember your common activities?	
Yes	97.9
No	1.0
Not sure	1.0

Question	Frequency (%)
Where on your body would you most prefer to wear an activity tracker?	
Wrist	46.3
Option to wear it all ways	36.8
Attached to clothing at hip/waist	9.5
No preference	6.3
Attached to undergarments	1.1
Where would you prefer to get feedback on your activity?	
Both activity tracker display and app	87.20
App	5.3
Activity tracker display	4.3
Doesn't matter	3.2
What feedback would you like the app to provide to you on your activity?[*]	
Steps taken	77.9
Total minutes of activity	72.1
Time spent in various intensities of activities	65.4
Calories burned	63.5
Distance traveled	60.6
Minutes of exercise	58.7
Time spent in various types of activities	53.8
Physical activity enjoyment	17.3
Would you want both daily and weekly feedback displayed when you opened the app?	
Yes	87.5
Not sure	9.4
No	3.1
Text Messaging/App Notifications	
Do you think push notification or text message reminders to be active would be helpful?	
Yes	75.0
No	15.6
Not sure	9.4
How would you like to receive reminder messages?	
Text message	46.2
App notification	35.5
No preference	18.3
What would you like the frequency of reminder messages to be?	
At least daily	38.9
1–2 times per week	21.1
3–4 times per week	20.0
5–6 times per week	10.0
Less than 1 time per week	8.9
Other	1.1
Do you think push notification or text message motivational messages would be helpful?	
Yes	78.1

Question	Frequency (%)
Not sure	11.5
No	10.4
How would you like to receive motivational messages?	
Text message	50.0
App notification	36.2
No preference	13.8
What would you like the frequency of motivational messages to be?	
At least daily	25.5
1–2 times per week	24.5
3–4 times per week	23.4
5–6 times per week	12.8
Less than 1 time per week	12.8
Do you think push notification or text message progress feedback messages would be helpful?	
Yes	80.2
Not sure	10.4
No	9.4
How would you like to receive feedback messages?	
Text message	44.7
App notification	37.2
No preference	18.1
What would you like the frequency of feedback messages to be?	
At least daily	30.9
3–4 times per week	22.3
1–2 times per week	22.3
5–6 times per week	12.8
Less than 1 time per week	11.7

*
Indicates more than one response could be selected.