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SurvivorCHESS to increase physical activity in colon cancer survivors: can we get them moving?

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Abstract

Purpose This randomized controlled trial evaluated the impact of SurvivorCHESS, an eHealth intervention, on physical activity in colon cancer survivors and to explore the impact of SurvivorCHESS on quality of life and distress.

Methods This was a two-arm single-blinded multi-site randomized controlled trial comparing a control group to an intervention group receiving a smartphone with the SurvivorCHESS program.

Results Participants using SurvivorCHESS ($n = 144$) increased their moderate to vigorous physical activities from 19.4 min at baseline to 50 min compared to the control group ($n = 140$) increasing from 15.5 to 40.3 min at 6 months ($p = .083$) but was not sustained 3 months after the study ended. No significant differences were found between groups over time for quality of life or distress items. Reports of physical symptoms were greater than other categories for distress items. Patients who had a higher body mass index and number of comorbid conditions were less likely to increase their physical activity. Self-determination theory including autonomous motivation and relatedness was not associated with the outcomes.

Conclusions Physical activity did increase over time in both groups and was not significantly different with the use of the eHealth intervention, SurvivorCHESS, compared to the control group. The amount of SurvivorCHESS use was not associated with physical activity.

Implications for cancer survivors Increasing physical activity in colon cancer survivors has the potential to improve quality of life and reduce recurrences. Using smartphone-tracking devices may be useful in helping to change this health behavior.

Keywords Colon cancer · Physical activity · Cancer survivorship · Surveillance · Survivorship care · Plans · eHealth

Introduction

Physical activity (PA) has been inversely associated with a number of cancers, including colorectal cancers [1–4]. Additionally, evidence suggests that increasing PA after diagnosis may decrease recurrences and improve survival, particularly in breast, colon, and prostate cancers [5–7]. The mechanisms of action for this effect are not known but may be related to changes in insulin pathways and inflammation [3, 8, 9]. Increased physical activity has many other benefits for cancer survivors including improved quality of life, physical functioning, and reduced fatigue [6, 10]. Physical activity recommendations for cancer survivors include engaging in regular physical activity, avoiding inactivity or sedentary behaviors, returning to normal daily activities as soon as possible following diagnosis, aiming to exercise at least 150 min/week, and including strength training exercises at least 2 days/week unless contraindicated [11].

The use of mobile eHealth interventions to influence health behaviors has increased with the adoption of smartphones over

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the last decade. Almost all (90%) Americans now use a cell phone with 64% of them being smartphones; adoption of smartphone use over 74% for seniors 65 years or older [12]. Many of the smartphone users seek health information and track health behaviors through health applications [13–15]. In a recent meta-analysis, Fanning and colleagues [16] evaluated 11 studies using mobile applications to increase physical activity. They found a significant overall effect size of 0.54 (95% confidence interval of 0.17–0.91) of increasing physical activity using mobile applications, but only four of the studies were of good quality.

CHESS (Comprehensive Health Enhancement Support System) is an umbrella name for several eHealth interventions (www.chess.wisc.edu). Content is aimed at a sixth-grade reading level and focused on specific needs identified in studies of the target population. Compared to the unrestricted Internet, the most important strength of CHESS may be its protected, guided universe of tailored information and support options provided in an integrated package with efficient navigation, thereby eliminating the need for complicated and frustrating online search and discovery. This approach has been tested in a number of previous randomized controlled trials that have shown benefit in different populations. We adapted CHESS for a mobile application to increase physical activity in colon cancer survivors (SurvivorCHESS) [17–23].

Self determination theory (SDT) provided a conceptual framework for the development and testing of SurvivorCHESS [24]. In SDT, to be successful in changing one's behavior requires (1) the development of *competence* in information gathering, decision-making, and behaviors that they are trying to change, (2) the *social support* systems to help them deal with the cancer experience, and (3) the *autonomy* that comes with regaining a sense of control over their lives. The individual's quality of life will improve, and they will adopt or maintain healthy lifestyle behaviors (e.g., physical activity) that are in their best interests. This conceptual framework (Fig. 1) has been used in a number of CHESS studies to explain possible mediation of the intervention on outcomes [25].

Our primary aim was to determine the impact of SurvivorCHESS on physical activity in colon cancer survivors, with the hypothesis that SurvivorCHESS users would significantly increase this outcome compared to the control group. The secondary aim was to explore the impact of SurvivorCHESS on quality of life and distress.

Methods

Study design This was a two-arm, single-blinded multi-site randomized controlled trial. Participants were recruited from seven sites[1] across the USA between March 2010 and August 2012. Data collection ended in June 2013.

Eligibility criteria included the following: age of at least 21 years, pathologically confirmed stage I–III colon cancer, completed cancer treatment and at least 6 weeks postoperative to within 12 months of the diagnosis with no sign of recurrence, has any other cancers (except non-melanoma skin cancers), an activity level of less than 150 min/week as determined by the Godin leisure time physical activity questionnaire (GLTPAQ) score of ≤ 23 of moderate to vigorous activity [26–30], and no additional existing conditions that limits the ability to exercise.

Ethics and informed consent This study was approved by the relevant institutional review boards at all the centers. Participants provided written informed consent before starting the study.

Recruitment Potential subjects were identified through medical records or a tumor registry database. A standardized recruitment script was used by the recruitment coordinators in a clinic setting or over the phone. Eligible subjects were consented and given baseline measures to complete prior to randomization.

Randomization Upon completion of the baseline survey, subjects were randomized in a 1:1 ratio to the 6-month SurvivorCHESS intervention or usual care control group stratified by gender and treatment (whether or not they received adjuvant chemotherapy).

Intervention

Control group The control group received the National Cancer Institute's "Facing Forward: Life after Cancer Treatment" booklet,[2] the National Coalition for Cancer Survivorship's Cancer Survival Toolbox,[3] and a pedometer.

Intervention Participants randomized to the intervention group were given all materials provided to the control group, plus smartphones with the SurvivorCHESS application, along with voice and data services for the study period. After completing the 6-month study period, phone service was ended but subjects were permitted to keep the smartphones.

SurvivorCHESS is a smartphone CHESS application that included core services of skill building (promoting competence), support services (promoting relatedness), and information services and tools (promoting autonomy). It was designed and adapted from the CHESS application with input from

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[2] https://www.cancer.gov/publications/patient-education/facing-forward

[3] http://www.canceradvocacy.org/resources/cancer-survival-toolbox/

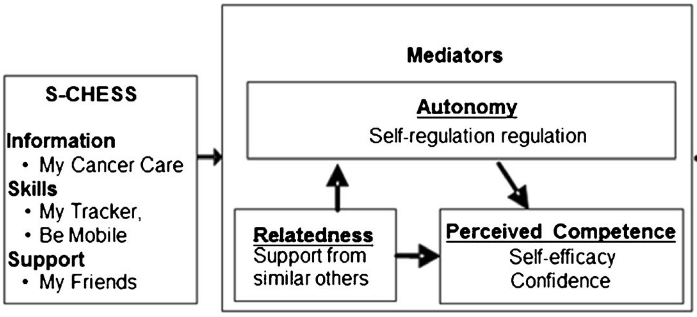

Fig. 1 Self determination theory applied to SurvivorCHESS

colon cancer survivors to provide information and support to help individuals increase their daily activity levels. A goal of 150 min/week was set, and various areas of services were provided: *My Tracker*, an area for physical activity logging and goal setting (to assure self-monitoring); *My Friends*, a social networking space consisting of other user profiles, individual messaging, and a discussion forum for participating colon cancer survivors to provide social support; *Be Mobile*, a section offering information modules on physical activity and health; and *My Cancer Care*, a colon cancer survivorship care plan section providing support tools and information on coping and adapting to life after cancer diagnosis along with the American Society of Clinical Oncology-recommended follow-up care plan (see Fig. 2).

The initial application was fairly static. Users were presented with the same options and display every log-in, and the application was entirely user-driven, with the study staff observing but not participating. Early in the study, we recognized that attrition was a concern while technology was evolving, so plans to enhance the application were developed. These changes consisted of establishing a staff facilitator and adding more dynamic content. After 6 months, in September 2010, a certified personal trainer, known to users as "Coach," was made available for users to ask questions about physical activity. The coach also began involvement and initiation in discussion group and individual, tailored private messaging to inactive users. Discussion posts varied by topic but often focused on encouraging users to share information about themselves or how they remained active. Aesthetic changes were also made: an icon on the home page let users know if they had new messages, and discussion group threads were ordered with the most recent post or comment on top, where it was most obvious. Beginning in June 2011, there was increased interaction by the coach and the addition of a new section of content called Coaching Corner. In this space, the coach could add content at any time for users. This included motivational messages, answers to common fitness questions, and exercise videos featuring the coach. This content was also featured in a rotating, random fashion on the home screen to inform users of what was available and help the home page remain dynamic. The coach continued to promote discussion in the group forum and sent individually tailored, biweekly

Fig. 2 SurvivorCHESS application homepage

My Tracker (tools): tracks activities and provides feedback to the user.

Be Mobile (skill building): instructions on how to become physically active in a safe way.

My Friends (support services): discussion board among study participants.

My Cancer Care (information services): content about colon cancer and ASCO recommendations for follow-up care.

messages to all users based on use. A welcome message was also sent to all users within a week of being enrolled in the study introducing the participant to the coach. Additionally, phone notifications were added to remind users to track their exercise in SurvivorCHESS and to let them know when the coach posted in discussion group. All of these cumulative changes/additions were in effect until the end of data collection.

Outcomes and measures

Participants completed the study measures at baseline and at 3, 6, and 9 months. For participants randomized to SurvivorCHESS, use data was collected every time they accessed the application. The collected data for this analysis includes number of log-ins, pages viewed, and message content. We collected demographics and medical information about the cancer, body mass index, and comorbid conditions using OARS at baseline. We also measured comfort with Internet use with a five-point Likert scale from “not at all” (0) to “extremely” comfortable (4).

Physical activity, the primary outcome, was measured using the GLTPAQ on which participants are asked, “During a typical 7-Day period (a week), how many times on the average do you do the following kinds of exercise for more than 15 minutes during your free time?,” for each of three exercise categories: strenuous (“heart beats rapidly”), moderate (“not exhausting”), and mild (“minimal effort”). Examples are given for each category of exercise. The total minutes were then calculated from the weekly frequencies of moderate and vigorous physical activities (MVPAs) (excluding light activities) [26, 31].

Distress was measured using the NCCN distress tool [32]. This measure is self-administered and has a rating of 0 (lowest)–10 (highest) that measures overall distress and the four categories of distress (yes/no) experienced over the past week. The categories of distress included practical (6 items), family (4 items), and emotional (6 items) and physical (22 items) problems and spiritual/religious (1 item) concerns [33, 34]. This instrument was used at each of the assessments.

Quality of life was measured using the functional assessment of cancer therapy-colon (FACT-C, version 4) [35]. This is a 27-item compilation of general questions in four primary QOL domains: physical well-being, social/family well-being, emotional well-being, and functional well-being with 10 additional items that are colon cancer-specific. It is designed for self-administration, but can also be administered by interview format (person-to-person and over the telephone). Acceptable levels of reliability and validity have been established in adults with cancer. Responses are on a five-point Likert scale from “not at all” to “very much” over the last week. Total FACT-C scores could range from 0 to 136 with higher scores indicating better QOL.

Mediators Self-determination theory constructs of autonomy and relatedness with other cancer survivors were assessed with the treatment self-regulation questionnaire (TSRQ) autonomous motivation subscale [13] and the McTavish bonding scale [36], respectively. The TSRQ consists of 15 items on a 7-point Likert scale (not at all true to very true) used to assess the degree to which a person’s motivation is autonomous or self-determined. Previous tests found good reliability (Cronbach’s α = 0.88) and predicted change in health-related behavior ($p < .001$). The McTavish bonding scale is a five-item, single factor instrument developed to measure the extent to which survivors have bonded with or established relationships with other cancer patients through the intervention. Items are scored on a Likert-type scale (0 = never to 4 = nearly always). The bonding scale has demonstrated high internal consistency and reliability in a study of breast cancer patients at pretest and at 6 weeks (0.92 and 0.93, respectively).

We counted “use” of the intervention as entering the SurvivorCHESS program beyond the home page with “active” users defined as creating content or entering or revising data while all other views were considered passive.

Statistical analysis We estimated that a final sample size of 234 would be required to detect a moderately small-effect size of 0.33 with 0.80 power, a two-tailed α of 0.05, autocorrelations of 0.60, and targeted total recruitment of 294 patients to account for attrition and missing data.

Godin measures at all time points had a large portion of 0 s and, therefore, are not normal distributions. Mann-Whitney *U*, a non-parametric test, was used to test for the intervention effect. Analysis of covariance was used to assess the intervention effect for the primary outcome of physical activity and secondary outcomes of quality of life and distress. For all outcomes, gender (male, female) and treatment regimen (surgery only, surgery plus chemotherapy) were included as design variables and the baseline score of the given outcome was included as a covariate. The durability of the intervention effect was analyzed using the same model, but with the assessment of physical activity at 6 months rather than at baseline serving as the covariate. Mediation was examined using the test for joint significance [37], which requires a significant relationship between (1) the intervention and potential mediator (path a) and (2) the outcome and the potential mediator, controlling for intervention (path b). All analyses were conducted with SPSS version 21. No imputations were made for missing data.

Results

Study population Five hundred twenty-two potential subjects were identified for participation (see the consort diagram in Fig. 3); 181 declined participation due to lack of interest, being too busy, not providing consent or returning baseline measures, or for other reasons. Another 57 were not eligible

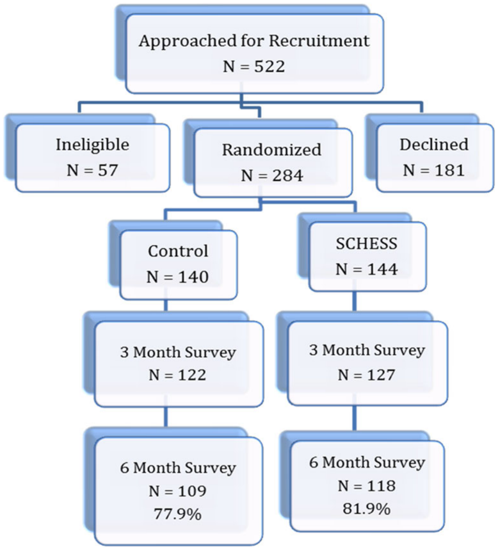

Fig. 3 Consort diagram

because they exercised more than 150 min/week, had medical issues that prevented participation, or other reasons. Informed consent and a baseline survey were obtained from the remaining 284 individuals, and each was then randomized to either the intervention group ($n = 144$) or control ($n = 140$). Attrition was 28.1% for the control group and 18.2% for the intervention group at 6 months for a total evaluable sample for 227 of the 234 identified in our power analysis.

Participant description Demographics are presented by group in Table 1. There were no significant differences between the intervention and control groups ($p = .87$), but there was by disease stage ($p = .036$) as there were more stage III patients in the intervention arm.

Intent to treat analysis For the primary outcome of physical activity (at 6 months) that only counted the MVPA (or strenuous) data, the intervention effect was not significant [$F(1, 221) = 2.404$, $p = .122$]. The intervention effect for the same outcome at 9 months controlling for the 6-month outcome is also not statistically significant [$F(1, 202) = 0.722$, $p = .396$]. SurvivorCHESS participants reported greater physical activity at 6 months (mean = 49.98 min, SD 45.28) than those in the control group (mean = 40.27 min, SD 42.22) ($p = 0.083$). However, no significant differences between groups were observed for the durability of the intervention effect at 9 months (see Fig. 4). Both groups were classified as insufficiently active at baseline and moved to moderately active at 6 and 9 months. At 6 months, 27% ($n = 30/111$) in the control group and 38.8% ($n = 45/116$) in the SurvivorCHESS group had MVPA scores that were ≥ 150 min/week with similar findings at 9 months (27.7 and 35.8% respectively).

Quality of life Quality of life was not significantly different between the intervention and control groups over time. The overall baseline FACT-C scores were 103.3 in the control group and 105 in the SurvivorCHESS (SCHESS) group and increased to 106.5 and 109.1, respectively; between-group differences of the total score, controlling for gender and treatment, were not significantly different ($p = 0.39$). Subscales of physical, social, emotional, and functional well-being were also not significantly different ($p > 0.24$ for all) between the intervention and control groups over time (Fig. 5).

Distress Distress was not significantly different between the intervention and control groups over time (Fig. 6). The overall baseline distress scores were 3.36 in the control group and 2.98 in the SCHESS group and decreased to 2.96, respectively; between-group differences of the score, controlling for gender and treatment, were not significantly different ($p > 0.17$ over time). The number of endorsed categories was not significantly different between the groups over time. Physical problems were greater than the other categories followed by emotional problems. The number of items endorsed declined slightly in both groups over the 6-month study but was not significant.

Effect of use on outcomes A SurvivorCHESS user was defined as someone who accessed the system beyond the log-in page at least once during the study. Of the 144 participants randomized to SurvivorCHESS, 135 (93.8%) were identified as users. Of the nine participants identified as non-users, five never accessed the system and four accessed the system but never proceeded beyond the log-in page. In a sensitivity analysis, we compared the control group to just SurvivorCHESS *users* (rather than to those randomized to SurvivorCHESS); because of the small sample size, SurvivorCHESS non-users were omitted from the analysis rather than be included as a distinct third comparison group. There were no substantive differences in results when the control group was compared to the full intervention group or when it was compared to the intervention group who used the system.

SurvivorCHESS use For the intervention group, use was greatest in the first week and declined over the 6 months of the study, though the mean number of pages viewed per week stayed relatively consistent from week 5 to the end of the study period (Fig. 7). Of the possible 180 days of use, the mean number of use was 55.3 (SD 50.0, median 34, range 1–178); of the possible 24 weeks of use, the mean number of system use was 15.7 (SD 9.1, median 16, range 1–27). *My Tracker* was the most accessed SurvivorCHESS service, with a mean of 713.0 (SD 831.7, median 376, and range 1–4221) followed by *My Friends* with a mean of 287.0 (SD 509.9, median 117, and range 1–3983); *My Cancer Care* was

Table 1 SurvivorCHESS demographics at baseline (*n* = 284)

	Internet (*n* = 140)		SCHESS (*n* = 144)	
	N	%	*N*	%
Gender				
Male	67	48	70	49
Female	73	52	74	51
Race				
Caucasian	124	89	128	89
Other	16	11	16	11
Employment				
Retired	46	33	43	30
Full-time	57	41	60	42
Part-time	14	10	19	13
Medical leave	7	5	10	7
Other	15	11	12	8
Education				
No high school degree	7	5	7	5
High school degree	22	16	23	16
Some college courses	33	24	29	20
Associate or technical degree	21	15	13	9
Bachelor’s degree	33	24	35	24
Graduate degree	24	17	37	26
Health insurance				
Have	137	99	139	97
Do not have	2	1	5	3
Living situation				
Not alone	114	81	125	87
Alone	26	19	19	13
Colon cancer stage				
I	27	20	39	27
II	82	59	63	44
III	29	21	41	29
Treatment regimen				
Surgery only	69	49	78	55
Surgery + chemotherapy	71	51	65	45
Previous exerciser?				
No	46	33	48	33
Yes	83	59	86	60
BMI				
Underweight (< 18.5)	3	3	1	1
Normal weight (18.5 to 24.9)	31	30	25	27
Overweight (25 to 29.9)	35	34	29	31
Obese (> 30.0)	34	33	39	41
ECOG performance status				
0 (fully active)	44	54	41	66
1 (restricted but ambulatory and able to carry out light work)	15	18	10	16
2 (ambulatory but unable to carry out any work activities)	23	28	11	18
Have ostomy appliance				
No	126	95	135	96
Yes	7	5	5	4
	N	*M* (SD)	*N*	*M* (SD)

Table 1 (continued)

	Internet (n = 140)		SCHESS (n = 144)	
	N	%	*N*	%
Age	104	57.84 (14.5)	115	59.34 (13.7)
Internet comfort[a]	137	2.75 (1.3)	141	2.73 (1.2)
Godin physical activity[b]	139	15.49 (27.6)	144	19.43 (27.07)
OARS comorbidity[c]	139	2.24 (1.7)	144	2.01 (1.8)
OARS physical health rating scale[d]	137	2.49 (0.8)	143	2.41 (0.9)
Self-determination theory constructs[e]				
TSRQ-autonomous	138	4.6 (1.26)	143	4.9 (1.08)
TSRQ-controlled	138	1.82 (1.38)	141	2.04 (1.27)
TSRQ-amotivation	135	1.26 (1.17)	135	1.18 (1.18)
Perceived competence scale	138	3.95 (1.62)	142	4.38 (1.57)
Family care climate measure	107	3.09 (1.85)	103	3.49 (1.61)
Health care climate questionnaire	134	2.65 (2.08)	136	2.72 (1.91)
Bonding	137	1.44 (1.09)	137	1.61 (0.97)

[a] Internet comfort was measured on a scale from 0 (“not comfortable at all”) to 4 (“extremely comfortable”)

[b] Godin moderate and vigorous physical activity in minutes per week

[c] Number of comorbid conditions

[d] Self-reported physical health rating from 1 (excellent physical health) to 6 (totally physically impaired)

[e] TSRQ has 15 items on a seven-point Likert scale (not at all true to very true) used to assess the degree to which a person’s motivation is autonomous or self-determined. The bonding scale is a five-item, single-factor instrument developed to measure the extent to which survivors have bonded with (established relationships with) other cancer patients scored on a five-point Likert-type scale (0 never to 4 nearly always)

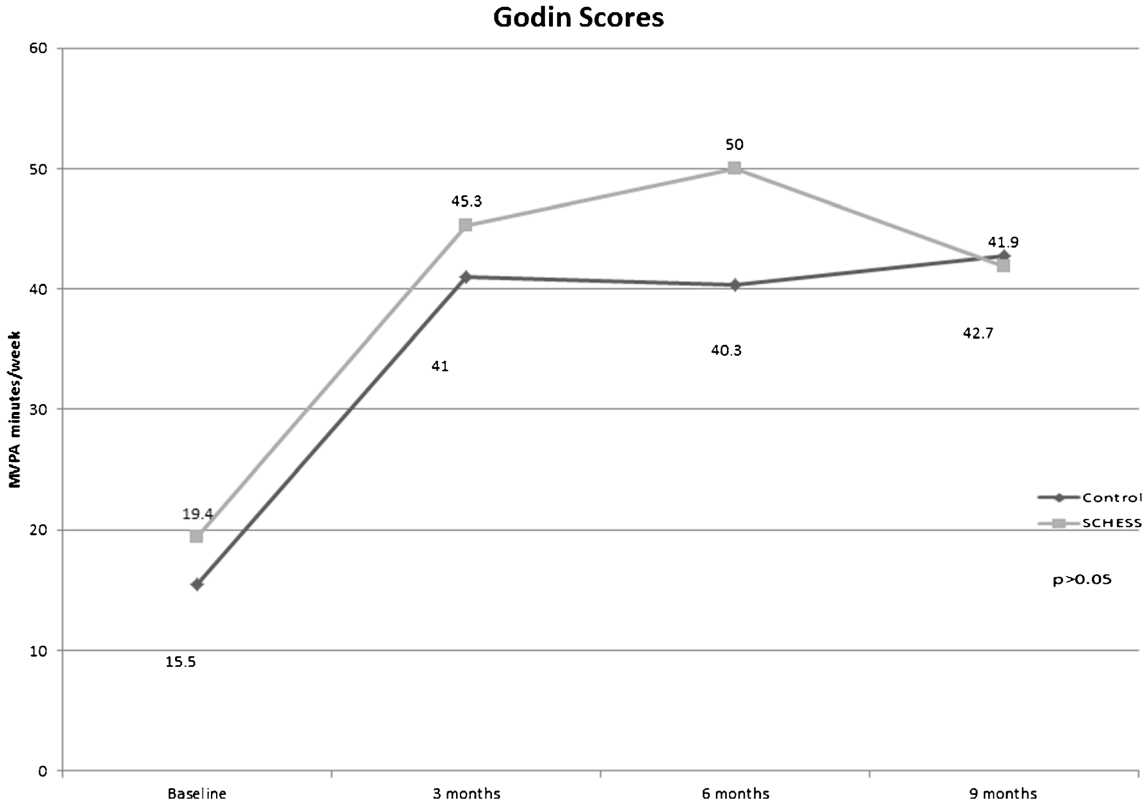

Fig. 4 Mean Godin scores

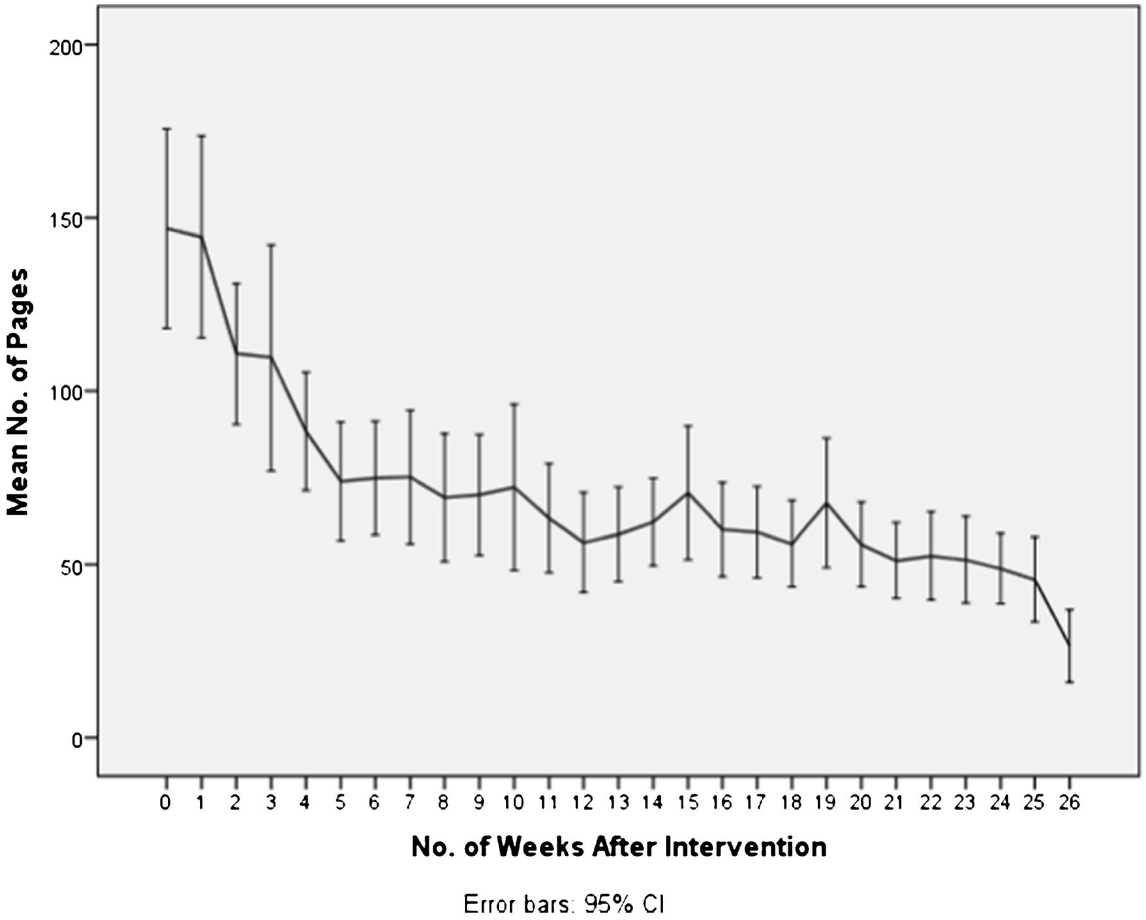

Fig. 5 Pages accessed over time

accessed the least with a mean of 30.63 (SD38.41, median 12, and range 1–200) (Fig. 8).

Mechanism of effect We considered three avenues through which the intervention may affect physical activity at 6 months: (1) the SDT construct of relatedness, as measured by the McTavish bonding scale; (2) the SDT construct of autonomous motivation, as measured by the treatment self-regulation scale; and (3) the act of self-monitoring exercise, defined as the number of days of using the SurvivorCHESS *My Tracker* service (in the intervention group). Temporal priority was assured by using assessments of the mediators from time points that preceded the primary endpoint (6 months): values for relatedness and autonomous motivation were taken from the 3-month survey, and exercise tracking was aggregated across the first 3 months of study. Relatedness was not found to be a significant mediator of the effect of SurvivorCHESS on physical activity; it was not a significant predictor of relatedness at 3 months, and this was not a significant predictor of physical activity at 6 months, controlling for the intervention group. Autonomous motivation was not found to mediate the effect of the SurvivorCHESS intervention on physical activity: the intervention did not significantly predict autonomous motivation at 3 months, though autonomous motivation at 3 months was significantly predictive of physical activity at 6 months when controlling for intervention group.

Post hoc analyses We then conducted an analysis that included intervention group; gender; colon cancer treatment group; baseline GLTPAQ, controlling for number of comorbid conditions (0 or 1 vs. > 1); and precancer exercise status (yes or no). We did not find prior exercise as significantly influencing outcomes ($p = .984$) but did find that the number of comorbid conditions did ($p = .004$) with higher number of conditions associated with less activity. It should be noted that the number of comorbid conditions was significantly associated with BMI, meaning higher BMI was associated with more comorbid conditions.

Barriers to exercise The biggest barriers to use were similar to those that other people face when it comes to exercise such as not enough time in the day. For our study population, other

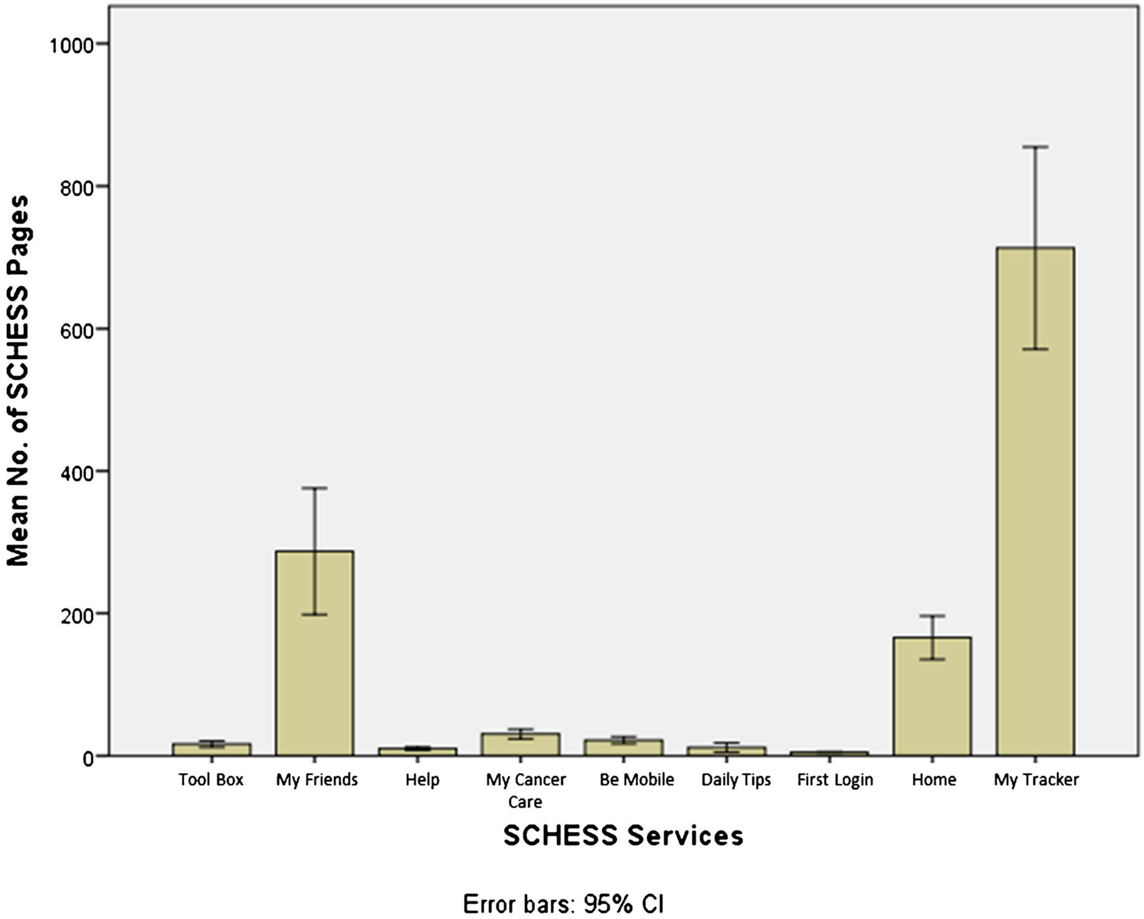

Fig. 6 Number of SurvivorCHESS pages by service category

commitments and other health challenges were reported as major barriers to exercising. Study participants reported that trying to balance caring for other relatives, managing doctor's appointments for their significant other and themselves, or having to work more was often the reason cited for not exercising more.

Harms There were no injuries reported during the course of the study. Two issues that interfered with use included unanticipated medical issues or procedures that limited the ability to exercise and technical difficulties with the phone/service that prevented ability to track exercise.

Discussion

This randomized controlled trial used a smartphone intervention in colon cancer survivors to increase physical activity within the first year of diagnosis. We did see an increase in both groups from insufficiently active at baseline to moderately active. SurvivorCHESS users' increase at 6 months was not sustained 3 months after the intervention ended. We also were not able to demonstrate support for the self-determination theory to mediate or explain our findings. We were able to demonstrate the ability to use the intervention but saw a decrease in use over time.

Limitations Limitations in this study included conducting a study in the face of rapidly changing technologies and increasing acceptance of technology over time. Our sample may have been biased toward those who are comfortable with new technologies. In addition, Caucasians were over-represented (89% Caucasian) and participants were more highly educated (46% had at least a bachelor's degree) and had more health insurance (97%) than the general US population. Challenges included finding reliable carriers to provide service to the geographically diverse groups of participants in urban, suburban, and rural settings.

Comparison with prior CHESS work

CHESS programs have been developed and tested (mostly in randomized trials) for numerous conditions ranging from breast [38] and lung cancers to HIV and addictive disorders

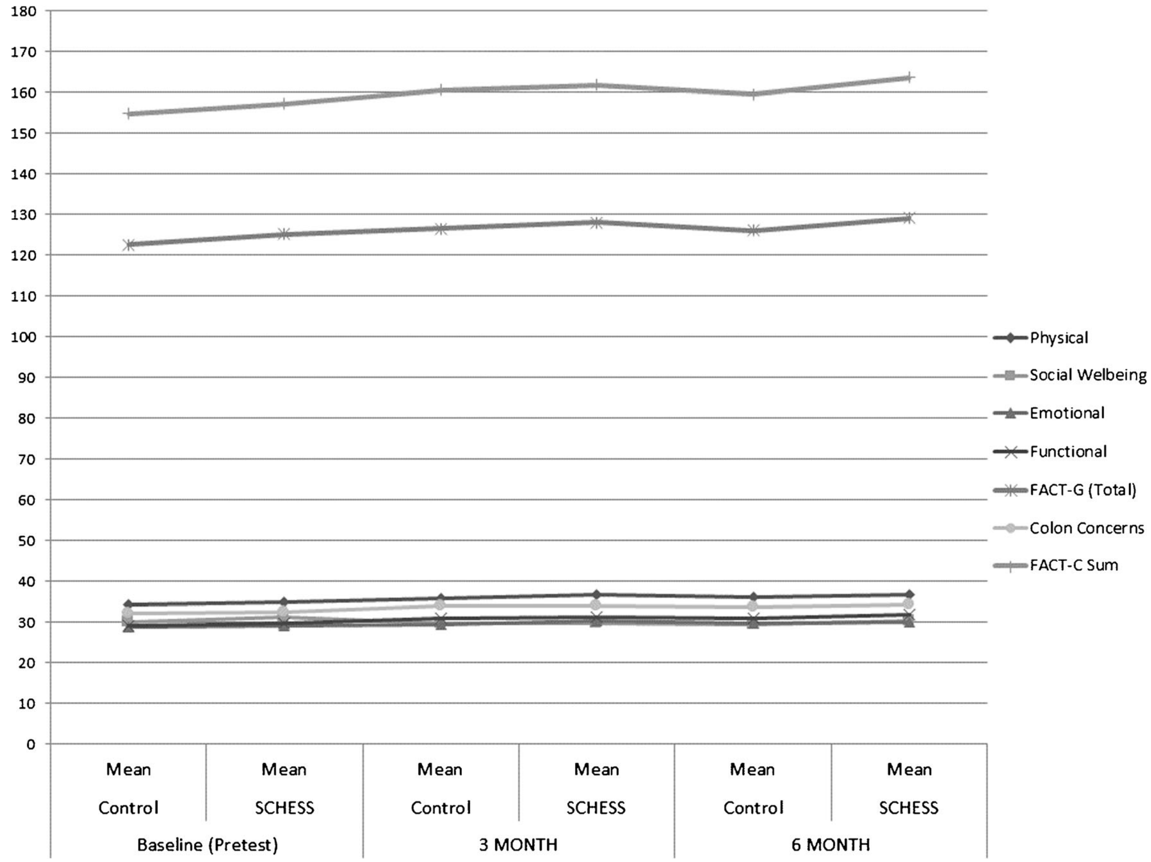

Fig. 7 FACT-C quality of life scores

[39] and others such as aging, asthma, menopause [40], and bone marrow transplant. CHESS has been created for patients, caregivers, and families. In general, their most common benefit is improvements in quality of life although positive changes in health service use [41], symptom distress, and social support have been noted for some conditions.

Within those studies, we have periodically examined meditational effects of the self-determination theory and the general conclusion is that it varies with the condition. For instance, the benefits to asthma caregivers seem to be mediated by relatedness but not by competence. This may make sense in asthma because many of the key interventions (avoid smoking, use an inhaler) are not particularly hard to learn. But for parents of young kids who can resist things like inhalers, the key is to keep on keeping on [25]. And for that, the ongoing support of other parents who understand what one is going through can be particularly important. In addition, competence, such as building refusal skills, may be particularly important and thus competence mediated the effect of A-CHESS on risky drinking days [19]. We were not able to measure a mediation effect of SDT on physical activity outcomes. As more mobile phone apps are developed to change health behaviors, attention to use of health behavior and communication theories will still be important [42].

In a review of mobile phone apps' ability to change health behaviors, self-monitoring was the most common change noted [15]. We found that the *My Tracker* was the most used function of the intervention. Apps that were more effective included having user-friendly designs, real-time feedback, individualized elements, detailed information, and health professional involvement [15]. We were disappointed that the other features, specifically the colon cancer-specific follow-up care guidelines, were less well-utilized.

Comparisons with other physical activity studies

Web-based Kuijpers and colleagues identified seven elements common to web-based physical activity studies in chronic diseases including education, self-monitoring, feedback/tailored information, self-management training, personal exercise programs, and communication with healthcare providers or fellow patients [43]. SurvivorCHESS included all seven elements. They identified 19 papers in their systematic review with eight demonstrating increased physical activity. The use of mobile or tablet apps has been shown to benefit others with chronic illnesses [14]. While we found a

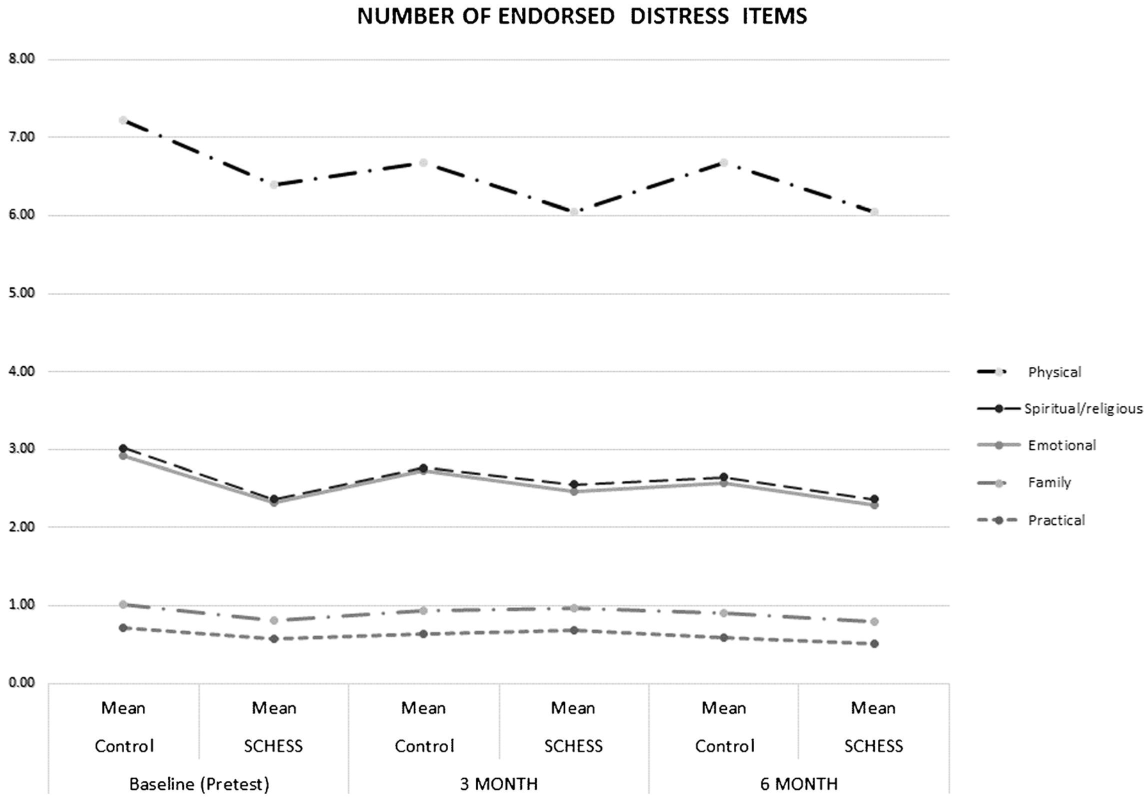

Fig. 8 Endorsed distress items

significant improvement in physical activity in the intervention group at 6 months, it was not sustained at 9 months.

Like the RENEW trial, which was conducted in a sample of 641 colorectal, breast, and prostate cancer patients, SCHESS survivors who had lower comorbidity and BMI were more apt to respond to the intervention [44, 45], though in the current study, the impact on physical functioning was not observed. Unlike RENEW, however, SurvivorCHESS did not lead to durable improvements in physical activity. While this may be attributable to the different behavioral theories (self-determination theory vs. social cognitive theory) and a different mode of intervention delivery (Web-based/smartphone vs. tailored print and telephone counseling), it could very well be the result of the intervention being too brief, since Project LEAD (a forerunner of the RENEW intervention) [46] also did not show durable changes in behavior with a 6-month intervention, whereas the 12-month intervention tested in the RENEW trial resulted in durable changes in physical activity, dietary behaviors, and weight loss [47].

In person Courneya and colleagues reported on a structured physical exercise program in colon cancer survivors and demonstrated an increase in activity and resulting objective fitness improvements [48]. Other studies have shown a reduction of fatigue during treatment with increasing physical activity in this population [49].

Comparison to other mHealth interventions

The personal use of smartphones has grown tremendously from 11% in 2011 to 77% in 2016 [50]. The development of apps for health promotion and management has grown as well and has demonstrated some efficacy in changing health behaviors and in promoting self-management of chronic conditions [14, 15, 51]. Mechanisms for behavior change include self-monitoring, performance feedback, and message tailoring and are approaches used in SurvivorCHESS [15, 51]. Our results were disappointing as we did not find a difference between groups although both groups did improve their activity over time. An eHealth intervention to increase physical activity and healthy eating for older cancer survivors saw a decline in physical activity in both the intervention and control groups [52]. A face-to-face intervention to increase recreational physical activity in colon cancer survivors was found to be successful [48].

Implications for cancer survivors

Colorectal cancer (CRC) is the third leading cancer in the USA with a prevalence of over 1 million representing 9% of the 15.5 million survivors [53]. This is a large group that could benefit from interventions to increase physical activity to improve quality of life and other clinical outcomes [6, 54].

However, they do not often receive or adhere to health behaviors such as being physically active, maintaining a healthy weight, and eating a healthy diet [55–57]. Developing and delivering eHealth interventions may be one way to encourage health behavior change in cancer survivors [15, 42]. However, efforts will need to be made in sustaining any improvements in behaviors.

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Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institution.

Conflict of interest Deborah K. Mayer, Stock Holder for CareVive. The other authors declare that they have no conflict of interest.

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