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A feasibility study of an unsupervised, pre-operative exercise program for adults with lung cancer

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Abstract

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Objective: The purpose of this study was to explore the feasibility, acceptability, and perceived utility of the provision of a wearable fitness device and an exercise prescription from a surgeon, prior to surgery for lung cancer.

Methods: A single arm, pre-post feasibility study was conducted with 30 participants scheduled for surgery to treat stage I, II, or III lung cancer. Participants were given a Garmin Vivoactive HR device and a prescription for 150 minutes of moderately-vigorous exercise per week. Participants completed assessments on four occasions and completed a semi-structured interview on two occasions. Descriptive statistics were used to assess the feasibility and acceptability of study procedures, including synchronizing the Garmin device and engaging in study assessments.

Results: Seventy-nine percent of enrolled participants completed the pre-operative study activities. Seventy-one percent of enrolled participants successfully synchronized their device during the pre-operative period. Data was transmitted from the device to the study team for an average of 70% of the pre-operative days.

Conclusion: This pilot study demonstrated the feasibility and acceptability of a pre-operative exercise program for patients scheduled to undergo surgery for lung cancer.

Trial Registration: The study protocol was registered with ClinicalTrials.gov prior to the initiation of participant recruitment (NCT03162718).

Keywords

telemedicine; rehabilitation; neoplasms; thoracic surgery; exercise; fitness tracker

Introduction

Surgery offers a potential cure for certain lung cancers, yet it is physiologically stressful and associated with considerable morbidity. Reduced physical functioning (e.g., difficulty performing chores, walking, climbing stairs) can persist for months (Handy et al., 2002) to years (Kenny et al., 2008) following surgery. Reduced physical functioning can affect a patient's quality of life (Francesco Carli & Scheede-Bergdahl, 2015), likelihood of returning to work (Silver, Baima, Newman, Galantino, & Shockney, 2013), ability to tolerate further cancer treatment (Silver & Baima, 2013), and overall survival (Franco Carli & Zavorsky, 2005).

The paradigm of pre-operative exercise as a neoadjuvant therapy to reduce morbidity is increasingly promoted within general surgery (Francesco Carli & Scheede-Bergdahl, 2015; Santa Mina, Scheede-Bergdahl, Gillis, & Carli, 2015) and surgical oncology (Armstrong, Bravo-Iñiguez, Jacobson, & Jaklitsch; Singh, Newton, Galvão, Spry, & Baker, 2013). Pre-operative exercises generally involve breathing exercises and aerobic exercise at least five times a week (Sebio Garcia, Yáñez Brage, Giménez Moolhuyzen, Granger, & Denehy, 2016). Patients with lung cancer who participate in pre-operative exercise have better aerobic capacity (Crandall, Maguire, Campbell, & Kearney, 2014; Pouwels et al., 2015) and pulmonary function (Sebio Garcia et al., 2016), and shorter hospital length-of-stay after surgery (Crandall et al., 2014; Sebio Garcia et al., 2016).

While highly supervised, on-site exercise programs could be considered the gold standard for research and clinical care, (Crandall et al., 2014; Singh et al., 2013) these are labor-intensive for staff and often inaccessible for patients who live in rural communities. In order to translate promising research findings into sustainable clinical practice, some places and patients may need pragmatic and effective home-based exercise protocols. The main challenge of this translational research (Kleinman & Mold, 2009) is to identify efficient ways to ensure patients safely engage in and adhere to the prescribed amount of preoperative exercise while at home.

Wearable fitness devices offer a way to approximate the supervision that occurs in laboratory-based exercise research by allowing for synchronous and asynchronous monitoring of physical activity and vital signs during home-based exercise. To explore the feasibility of this approach, we conducted a single arm pilot study of an unsupervised, pre-operative exercise prescription augmented by a wearable fitness device. The study was designed to answer these questions: To what degree do participants enroll and comply with the study procedures? To what degree do the fitness devices successfully transmit data? To what degree do participants perceive the wearable fitness device and the exercise program as useful in supporting their preparation for and recovery from lung cancer surgery?

Methods

Design

The study reflects an overtly pragmatic approach (Sox & Lewis, 2016) where design choices were made to enhance external validity and reflect what could be integrated into busy clinical practices. We used a single arm, pre-post design with 30 participants scheduled for lung cancer surgery to establish feasibility and to optimize measures and procedures in preparation for a larger trial that would evaluate effectiveness. The study was reviewed and approved by the Committee for the Protection of Human Subjects of Dartmouth College (STUDY00030167) and was conducted in accordance with the revised (2000) Helsinki Declaration. All participants engaged in informed consent procedures throughout the study and signed a document to affirm their voluntary participation.

Participants

Eligibility Criteria.—We recruited English-speaking patients who: (a) were over the age of 18 and scheduled for surgery for suspected or biopsy-proven lung cancer, clinical stage I, II or III; (b) were able to tolerate surgery (i.e., segmentectomy, lobectomy or bilobectomy) as indicated by standard clinical pre-op evaluation, including pulmonary function tests and cardiac evaluation (if indicated); (c) had access to either Wi-Fi or cellular service and permission/ability to download the wearable fitness device app on an iOS or Android device or computer; (d) were able to provide voluntary, written consent.

Participants were excluded based on electronic health record review if they: (a) had a life expectancy of < 12 months or were receiving hospice services; (b) had a psychiatric diagnosis that would require significant study modification to meet their needs such as uncontrolled severe mental illness, substance abuse, or active suicidal ideation; (c) exhibited

American College of Sports Medicine contraindications to exercise which include a resting heart rate of >120bpm, blood pressure >180/100mmHg or unstable angina (American College of Sports Medicine, 2018); (d) were unable to walk or to complete the 6-minute walk test (American Thoracic Society, 2002). In accordance with the standard of care at our facility, participants unable to complete the six minute walk test would be excluded from the study due to safety concerns of unsupervised exercise and instead be referred to physical therapy.

Sample size and recruitment.—While there are no definitive guidelines for determining the size of a pilot study in healthcare research (Hertzog, 2008), our target sample was 30 participants. This number reflects the median sample size in a review of pilot study sample sizes (Billingham, Whitehead, & Julious, 2013). Surgeons referred patients to a project coordinator (KAF) who confirmed eligibility, obtained informed consent, and administered the baseline assessment. These procedures occurred immediately after the consultation with the referring surgeon in which the plan of care for surgery was established.

Intervention

Exercise prescription.—Upon enrollment, participants received the following verbal and written exercise prescription from their surgeon (McDermott et al., 2015): “Do any moderately-intense, aerobic physical activity (e.g., walking, jogging, stairclimbing, upper body ergometer, stationary bicycle) for 30 minutes a day and for 5 days each week. While doing the activity, you should be working hard enough that it is difficult to speak more than a few words at a time (i.e., it would be uncomfortable and impractical to carry on a conversation with another person). You may need to start slowly (e.g., 5-10 minutes at a time), but as you get stronger you can increase your activity so that you exercise for 30 minutes at a time.” In line with the pragmatic intent of our research, participants were allowed to choose the type of activity that they found most feasible or enjoyable. Participants were asked to follow this prescription, as tolerated, throughout the course of the study (i.e., through preparation for and recovery from surgery) and to record their aerobic exercise sessions within a paper-based log. The log included rows to record the date, type of aerobic exercise, minutes in exercise, perceived exertion (Likert scale from 1 [“low effort”] to 10 [“maximal effort]), and degree of confidence with their ability to continue exercising (Likert scale from 1 [“not at all confident”] to 10 [“extremely confident”]).

Device.—A commercially available device that could be purchased by any patient or clinician was utilized in this study and was chosen for its potential for future generalizability. Each participant was given a Garmin Vivoactive HR that was to be worn on the wrist. Participants were assigned an email address and password, containing no identifiable information, which was used as the login information for the Garmin Connect Mobile Application. Unless the participant or a companion expressed interest and knowledge in the technology, the project coordinator downloaded the application onto the participant’s cellular phone and activated the fitness device during enrollment. Participants were asked to synchronize and charge the device daily and wear the device at all other times including showering and sleeping. Available data include heartrate time series every 15

seconds, number of steps, of floors climbed, minutes spent exercising, and near real-time GPS coordinates. The patients' geolocation (GPS) was never collected to ensure anonymity.

Data Collection

Study assessments.—Participants completed assessments at time of enrollment (T1; at least two weeks before their scheduled surgery), on the day of surgery (T2), two weeks after surgery (T3), and sixteen weeks after surgery (T4). The assessments included self-report of demographics (T1 only), physical health, (10 item physical health scale of Patient-Reported Outcomes Measurement Information System; PROMIS; T1 and T4 only) (Hays, Bjorner, Revicki, Spritzer, & Cella, 2009), and minutes of physical activity in the two weeks prior to study enrollment (section R of the Adult Physical Activity Questions on the National Health Interview Survey; T1 only) (National Center for Health Statistics, 2017). Participants then engaged in the six-minute walk test (American Thoracic Society, 2002) and used a dynamometer to measure grip strength.

Measures of Feasibility and Acceptability

Recruitment and retention.—The project coordinator recorded the number of patients referred by surgeons, screened, and enrolled and the length of time spent in recruitment per patient. The project coordinator also recorded the completion of study assessments, and reasons for screen failure, declining to enroll, missing assessments, and withdrawing from the study.

Acceptance of technology.—Exported data from the wearable fitness device tracked the days in which the device was active and providing us with data during the study.

Perceived utility.—A research team member who was not involved in the recruitment and assessments called participants in the week before surgery and in the week before completion of the study to conduct an audiotaped semi-structured telephone interview regarding the acceptability of the device and exercise prescription. The interviews solicited opinions about the exercise prescription (e.g., experiences when exercising, challenges, level of participation, motivation for enrolling in the study) and the device (e.g., ease of use, degree of engagement, usefulness), and advice for improvement of the study and the exercise program. The interviews were recorded and participant answers were transcribed by the Co-PI (KDL) and proofread by a project coordinator who listened to the recordings.

Analysis

Recruitment and retention data were compiled into a Consolidated Standards of Reporting Trial (CONSORT) diagram. We calculated the proportion enrolled (number enrolled/ number referred) and retained at each time point (number completing assessments/ number enrolled). We used descriptive statistics to summarize the time demands of screening, consenting, and data collection per patient.

To summarize the acceptance of the technology, we first determined the number of days in the pre-operative period for each participant (date of operation minus date of enrollment). There were two forms of data capture that we were interested in: (1) the number of days we

received any type of information from the device, which we refer to as “synch days” and (2) the number of days in which we specifically received data regarding heart rate (an indicator of exercise engagement), which was referred to as “data days.” These numbers are not always synonymous, as would happen if a participant had the device in his or her pocket instead of wearing it on his or her wrist.

In order to describe the proportion of time the participants synchronized the device, we divided the number of sync days by the number of pre-operative days to create a proportion score for each participant. In order to describe the proportion of time the device gave us heart rate data, we divided the number of data days by the number of pre-operative days. We then calculated descriptive statistics on the proportion scores of the sample. Finally, we repeated these analyses looking at the post-operative period.

Regarding the perceived utility of the program, the goal of the qualitative content analysis was to describe and summarize the full range and variation in responses to the study, exercise program, and device. This is in contrast to other forms of thematic analysis that identify common themes or experiences. For example, if only two of 30 participants experienced frustration regarding a feature of the device, it would not rise to the level of a “theme” in a thematic analysis, but it is important to capture that information in a pilot study so that future research can include safeguards to minimize this frustration and give each participant the best chance of succeeding with the program and device.

The Co-PI extracted phrases from the proofed transcripts to list under the following pragmatic headings: positive feedback about the device, things that were frustrating about the device, things that were confusing about the device, reported exercise, and barriers to exercise. The identification number of the participant endorsing the phrases/feedback was recorded in order to create an audit trail. A project coordinator (KAF) used the audit trail to verify that all data from the transcripts were appropriately identified, categorized, and displayed in the tables. Discrepancies ($n = 8$) were resolved via discussion.

Results

Recruitment, Retention, and Feasibility of Study Procedures

Clinical characteristics of the sample are presented in Table 1. The sample had a mean age of 67.3 years and included more women (57%) than men. In the two weeks prior to enrollment, participants reported a mean of 522 minutes of any form of physical activity (*sd* = 869.0, range = 0 to 4140, median = 295). This high mean appears to be driven mainly by three outliers: participants reporting 4140, 1800, and 1440 minutes of physical activity over two weeks. When they are removed, the mean is 269 minutes (*sd* = 289.1, range 0 to 990, median = 173). Six participants (21%) reported no form of exercise during this time.

On average, participants were enrolled 28.5 days prior to surgery (*sd* = 29.9, median = 20, range = 10 to 129). The study coordinator spent approximately 45 minutes engaging in informed consent and baseline assessment procedures per participant. Subsequent visits were shorter, averaging 20 minutes (*sd* = 2.5, range = 15 to 30).

Recruitment and retention statistics are presented in the CONSORT diagram in Figure 1. There was an enrollment rate of 81% (30 consented/37 referred), with the primary reason for declining to enroll being a lack of interest. Two participants were found to be ineligible after consenting and before completing the baseline assessment (one did not have the required technology to access the device and the other one was diagnosed with small cell lung cancer). The remaining 28 (93%) completed the baseline assessment.

Retention was highest in the pre-operative period where 93% (26/28 enrolled) completed the pre-surgical semi-structured interview and 79% (22/28 enrolled) completed the study assessments on the day of surgery. Despite being one of the shortest visits, the assessment two weeks after surgery was least feasible for participants as only 36% (10/28 enrolled) completed the assessments. Participation rebounded as 57% and 61% of those initially enrolled completed the second semi-structured telephone interview and the final study assessments, respectively.

Twenty-nine percent of participants (8/28) utilized and returned the written exercise logs. Most participants (75%) returned the Garmin devices and charging accessories. Three of the participants who did not return the device were lost to follow-up or were not receiving post-surgical care at this facility; the other four reported not knowing where the device was.

Four patients (14%) experienced adverse events related to study participation. Three participants experienced an event related to the device: one developed a rash, one developed a bruise, and the other experienced a small ache on the wrist wearing the device. One participant fell on the ice while exercising during the winter months, but did not require any treatment and continued to exercise outside.

Acceptance of Technology

Pre-operative period.—In the pre-operative period, we received data from the devices of 20 of the 28 enrolled participants (71%). The proportion of days in pre-operative period where the device was synchronized and transmitted data ranged from 0.06 to 1.0, with a mean of 0.70 (*sd* = 0.30). Five participants (18%) synchronized their device every day of their pre-operative period. The proportion of days for which we received heart rate data ranged from 0.06 to 1.0 with a mean of 0.60 (*sd* = 0.40).

Post-operative period.—In the post-operative period, we received data from the devices of 15 of the 20 participants (75%) still active in the study at T4. The proportion of days in post-operative period where the device was synchronized and transmitted data ranged from 0.02 to 1.0, with a mean of 0.65 (*sd* = 0.36). One participant (5%) had synchronized the device for every day of the post-operative period. The proportion of days for which we received heart rate data ranged from 0.01 to 1.0 with a mean of 0.57 (*sd* = 0.36).

Perceived Utility

Exercise.—Participants generally reported enrolling because they hoped the study would encourage their efforts to exercise, as recommended by the surgeons. The vast majority of participants walked for exercise (*n* = 19). Other forms of exercise included climbing stairs (*n* = 2), doing housework (*n* = 2), sit to stand exercises (*n* = 2), biking (*n* = 2), elliptical (*n* = 1),

combination of strength and cardio exercises (n = 1), pulmonary rehabilitation program (n = 1), Zumba (n = 1), tai chi (n = 1), yoga (n = 1), and physical activity involved in work (n = 1), and gardening (n = 1). These numbers exceed 28 participants because some participants reported engaging in more than one form of exercise.

Twenty participants (71%) indicated that at least one aspect of life made it difficult to exercise and those issues are listed in Table 2. Weather, pain, and illness were the most common challenges offered by participants.

Fitness device.—Ten participants (36%) provided positive feedback about using the device. Primarily, they liked that the device provided feedback about their activity level (n = 6) or improvement over time (n = 2) and that it reminded them to move with alerts/vibration (n = 2). Other things they appreciated included: fun to interact with (n = 1), gave more information than another popular fitness device (n = 1), alerts for text messages or calls (n = 1), and that it can be linked to family members to allow you to share and see others' activity level (n = 1).

There was a long, idiosyncratic list of things people did not like or found confusing about the fitness device (Table 3). Twenty-two participants (79%) reported at least one aspect of the fitness device that they disliked and eight participants (29%) reported at least one thing they did not understand regarding the device.

Discussion

The purpose of the present study was to explore the feasibility and acceptability of the study procedures, the exercise program, and the use of a commercially available fitness device to provide information regarding exercise engagement in order to inform subsequent effectiveness trials. Our results demonstrate reasonably high engagement with the devices and study assessments in the pre-operative period, with a decline in participation after surgery. Our enrollment rate was similar to another pilot study (Granger et al., 2018) for lung cancer patients, where 89% of the patients approached enrolled, similar to our enrollment rate of 81%. However, in that study, only 16% of the sample participated in the pre-operative portion of the study, primarily because they were recruited relatively close to the date of surgery. In another recent pilot study (Sommer et al., 2016) of perioperative exercise, 32% of eligible patients enrolled and pre-operative exercise was deemed not feasible due to a short time between enrollment and surgery. Our average pre-operative period was approximately one month, which could increase the feasibility of pre-operative exercise engagement.

A common reason for enrolling in this study was a desire to augment motivation and monitoring of exercise engagement after the direct exercise prescription from the surgeon. A recent systematic review reinforced this idea, noting that recommendation from healthcare providers influences the adoption of exercise habits (Granger et al., 2017). Similar to a recent qualitative study (Granger et al., 2019), the participants showed variation in their type of preferred exercise and personal barriers to exercise. This suggests that tailored feedback

and behavioral support might be needed to maximize adherence to home-based exercise (Granger et al., 2019).

Excluding the people who actively withdrew from the study, 71% of the sample were able to synchronize their device and provide data in the pre-operative period. This is a higher usage rate than seen in the pilot study by Granger and colleagues (Granger et al., 2018), where only 50% of the sample wore the fitness device provided by the study. Participants were reasonably consistent with keeping it charged and synchronized. We generally received information for a little more than two-thirds of the days and we received heart rate data for a little less than two-thirds of the days in the pre-operative period. The device use is somewhat impressive when considering more participants had negative versus positive comments and impressions regarding the device. While not perfect, the fitness device was utilized more than the exercise logs, which many people explicitly stated they felt unmotivated to utilize.

Enrollment procedures were completed in less than one hour. However, a greater investment of time may be warranted as a number of participants voiced confusion as to how to use the device. More education regarding the functions of the device and the advantages of self-monitoring one's exercise is warranted in future trials. This echoes research that indicates while an aging population is growing more comfortable and savvy with technology, many people still need extra information to adopt technology into lives and routines (Batsis et al., 2019; Chun, Dey, Lee, & Kim, 2017).

Use of the device and participation in the study assessments dropped off after surgery. Patients often voiced fatigue and disinclination to extend time at the hospital for assessments, particularly if they were traveling a distance. Further, more people reported shortness of breath, illness or surgical complications, and being busy/working as barriers to exercising in the post-operative period compared to the pre-operative period. It is possible that more active or tailored support may be needed to promote exercise in the post-operative period. This may include reinforcement of device use as they are being discharged from the hospital as well as when they are contacted 2-4 days after discharge from the clinic nursing staff for their standard post-discharge phone calls.

One limitation of the study is that we are unable to determine the cause of missing device data. For example, four of the eight participants with missing device data in the pre-operative period indicated that they were wearing and/or interacting with the devices when they were interviewed at T2. We are unable to determine whether the missing data indicates a device malfunction versus a choice not to wear, charge, or synchronize the device versus an inability to successfully operate the device. In future research, we plan to monitor the device data in real time so that we can determine the cause of any missing data and intervene accordingly (e.g., troubleshoot technical problems or initiate motivational interviewing to address disinterest) to maximize study retention.

Sampling issues should be considered when interpreting these findings. It is difficult to determine the degree to which this sample is representative of the population of patients scheduled for lung cancer surgery ($N = 153$) because the project coordinator was only alerted by the surgeons when a patient expressed interest in the study. We do not have

documentation regarding reasons the project coordinator was not alerted, though we know they include things like not having the requisite WiFi or cellular service, incompatible mobile phone, or patient's lack of interest. Less frequently, unavailability of the project coordinator or a surgeon forgetting to mention the study occurred as well. People who were willing to enroll in the study may be more active than the average lung cancer patient. Though most of our participants have some pulmonary or cardiac co-morbidities, they do not appear to be grossly debilitated, as their PROMIS physical functioning scores are only slightly lower than the general population (Reeve et al., 2007), their grip strength scores do not indicate the presence of frailty (Studenski et al., 2014), and they report a considerable amount of baseline minutes of physical activity (i.e., above the 300 minutes of exercise recommended for a two-week period). For example, our sample's self-reported physical activity was higher than the amount of pre-operative exercise participation reported in another study (Granger et al., 2014), which found patients with lung cancer were less physically active than healthy controls. However, it is important to note (1) our baseline assessment asked about *any physical activity* as opposed to moderate to vigorous exercise and includes things like golf and gardening and (2) physical activity assessed via self-report is frequently overestimated (Fukuoka, Haskell, & Vittinghoff, 2016; Prince et al., 2008).

This pilot study demonstrated the feasibility and acceptability of a pre-operative exercise program for patients scheduled to undergo surgery for lung cancer. Semi-structured interviews revealed participant endorsement of the potential for the fitness device to provide motivation and monitor exercise engagement; however, more thorough instruction and consideration of a less "bulky" device might increase use and acceptability of the device. A strength of this study was the ability to enroll participants weeks (as opposed to days) before surgery; such a window could promote adoption and/or reinforcement of exercise habits. Future research will explore the potential effectiveness of this approach and the potential to augment post-operative exercise engagement thorough tailored support that addresses each participant's idiosyncratic barriers to and facilitators of exercise.

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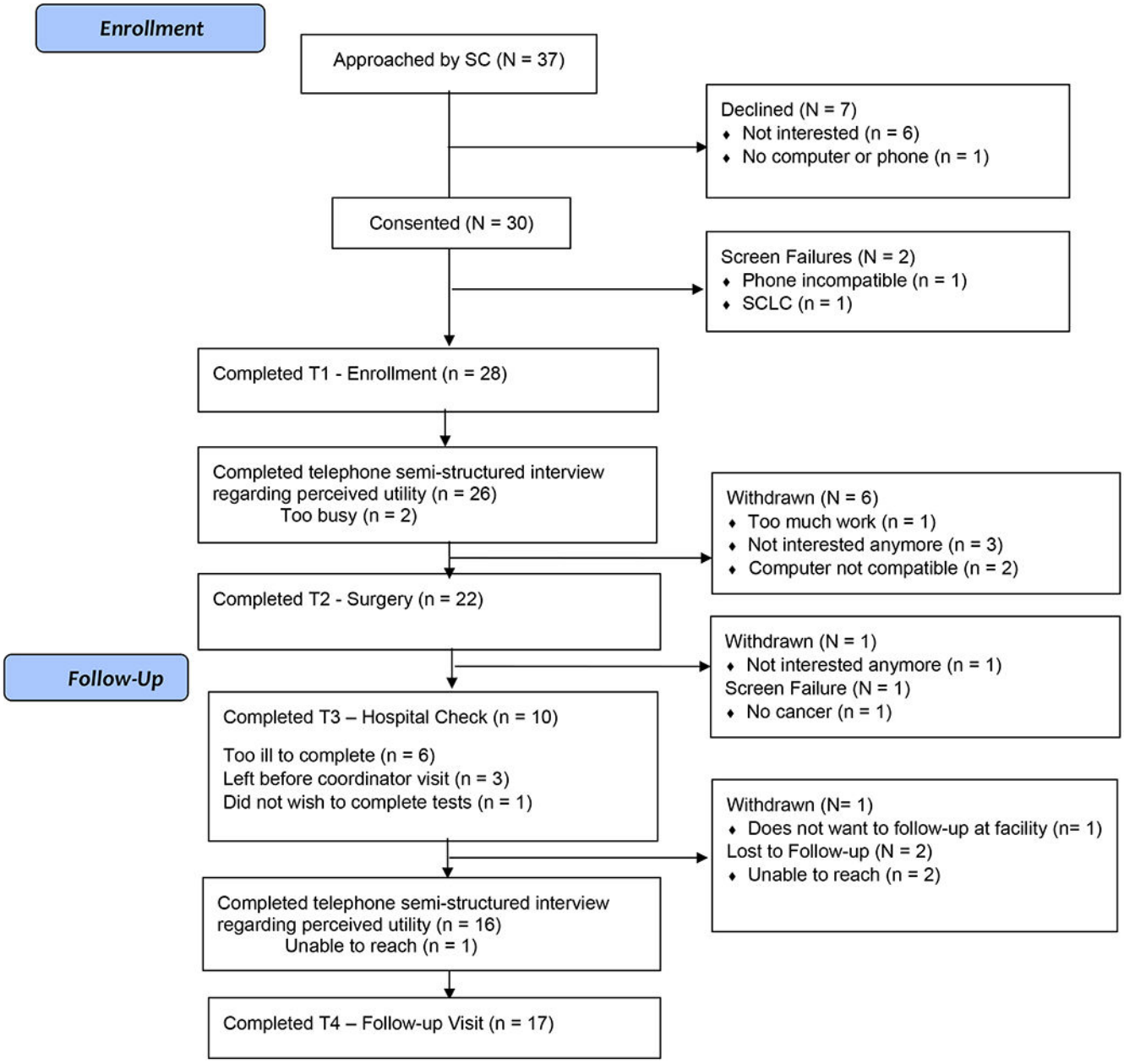

Figure 1.
Recruitment Flow

Table 1.

Participant Characteristics at Baseline (N = 28)

Characteristic	Value	*n* (%)	Mean (*sd*)
Gender			
	Male	12 (43)	
	Female	16 (57)	
Race			
	White	28 (100)	
Ethnicity			
	Non-Hispanic	26 (93)	
	Unknown/Declines to List	2 (7)	
Marital Status			
	Married	16 (58)	
	Single	4 (14)	
	Divorced	4 (14)	
	Widowed	4 (14)	
Household Members[a]			
	Spouse	15 (54)	
	Parents	1 (3)	
	Children	6 (21)	
	Friends	1 (3)	
	Significant Other	2 (7)	
	Other Relatives	2 (7)	
	Live Alone	5 (18)	
Current Employment Status			
	Full Time	7 (25)	
	Part Time	4 (14)	
	Retired	15 (54)	
	On Disability	2 (7)	
Education			
	Some High School	1 (4)	
	High School Graduate or GED	7 (25)	
	Some College or Technical School	9 (32)	
	College Graduate	2 (7)	
	Graduate Degree	9 (32)	
Pulmonary Co-morbidities			
	Chronic Obstructive Pulmonary Disease	10 (35)	
	Asthma	3 (11)	
	None	15 (54)	
Cardiac Co-morbidities[a]			
	Hypertension	16 (57)	
	Coronary Artery Disease	4 (14)	

Characteristic	Value	*n* (%)	Mean (*sd*)
	Congestive Heart Failure	2 (7)	
	History of Myocardial Infarction	4 (14)	
	None	11 (39)	
Smoking History			
	Current	5 (18)	
	Former	18 (64)	
	Never	5 (18)	
Mean Pack Years			40.8 (27.7)
Age			67.3 (10.6)
PROMIS Physical Function Short Form 10a T-score [b]			47.6 (6.6)
Minutes of physical activity (two weeks before enrolling) [c]			521.5 (869.0)
Six-minute walk test (meters)			450.3 (71.6)
Grip strength (kg)			
	Male		34.4 (7.4)
	Female		24.1 (4.7)

Note.

[a] Percentages do not add to 100 because categories are not mutually exclusive

[b] PROMIS = Patient reported Outcomes Measurement Information Systems; Raw scores for our sample were transformed into T-scores that are standardized scores with a mean of 50 (*sd* = 10).

[c] *N* = 26; Two participants declined to provide this information.

Table 2.

Number of Participants Reporting Challenges in Exercise (N = 20)

Barrier	***Reported Pre-surgery n (%)***	***Reported post-surgery n (%)***
Pain	5 (25)	3 (15)
Weather	5 (25)	5 (25)
Fatigue	3 (15)	0
Illness	2 (10)	3 (15)
Hard to remember or track	2 (10)	0
Medical appointments or treatment	2 (10)	2 (10)
Being busy	1 (5)	2 (10)
Works hard and likes to relax at home	1 (5)	0
Weakness	1 (5)	0
Surgical complications	0	3 (15)
Shortness of breath	0	3 (15)
Arthritis	0	2 (10)
Work	0	1 (5)

Note. Percentages do not add to 100 as some participants identified more than one barrier

Table 3.

Number of Participants Reporting Frustrating or Confusing Things Related to Using the Fitness Device (N = 23)

Frustration	***n* (%)**
It is bulky or cumbersome	12 (52)
Dislike of technology	5 (22)
Appears to shut self off or drop heart rate	3 (13)
The activity I wanted to do for exercise was not an option	3 (13)
Burdensome to charge or sync	2 (9)
Too hot to wear	2 (9)
Ugly	2 (9)
Bothered me when it seemed inaccurate	2 (9)
Irritated my skin	1 (4)
Gave me an ache	1 (4)
Touchscreen was hard to use	1 (4)
It's a little spooky that it maps my location	1 (4)
Doesn't seem to work inside my house	1 (4)
Doesn't seem to have much useful information for me	1 (4)
Study staff did not help me troubleshoot problems in use of device	1 (4)
Manual was too small to read	1 (4)
Couldn't get it to work on my computer (no smart phone)	1 (4)
Couldn't get it to sync to the new phone that I replaced midway through study	1 (4)
Source of confusion	***n* (%)**
Did not understand how to use it (quick demonstration wasn't enough)	2 (9)
Do not understand what the signals mean (e.g., footprints, goal met?)	1 (4)
How to navigate the screens	1 (4)
How to get it back to where it started after I "messed up the buttons"	1 (4)
Why does it beep at 4am? Can I change it? Is it alarm or low battery?	1 (4)
Why does it turn self off or say no heart rate?	1 (4)
Why did it reset itself?	1 (4)
Not sure how tight to wear it	1 (4)
Not sure why it wasn't synching with phone	1 (4)
Why does data disappear from screen and I can't see it later?	1 (4)
How do you change the time of day?	1 (4)

Note. Percentages do not add to 100 as some participants identified more than one complaint