Support Care Cancer (2015) 23:2525–2533
DOI 10.1007/s00520-014-2599-z

ORIGINAL ARTICLE

Health-related physical fitness assessment in a community-based cancer rehabilitation setting

Amy A. Kirkham · Sarah E. Neil-Sztramko · Joanne Morgan · Sara Hodson · Sarah Weller · Tasha McRae · Kristin L. Campbell

Received: 14 November 2014 / Accepted: 29 December 2014 / Published online: 25 January 2015

Abstract

Purpose Assessment of physical fitness is important in order to set goals, appropriately prescribe exercise, and monitor change over time. This study aimed to determine the utility of a standardized physical fitness assessment for use in cancer-specific, community-based exercise programs.

Methods Tests anticipated to be feasible and suitable for a community setting and a wide range of ages and physical function were chosen to measure body composition, aerobic fitness, strength, flexibility, and balance. Cancer Exercise Trainers/Specialists at cancer-specific, community-based exercise programs assessed new clients (n=60) at enrollment, designed individualized exercise programs, and then performed a re-assessment 3–6 months later (n=34).

Results Resting heart rate, blood pressure, body mass index, waist circumference, handgrip strength, chair stands, sit-and-reach, back scratch, single-leg standing, and timed up-and-go tests were considered suitable and feasible tests/measures, as they were performed in most (≥88 %) participants. The ability to capture change was also noted for resting blood pressure (−7/−5 mmHg, p=0.02), chair stands (+4, p<0.01), handgrip strength (+2 kg, p<0.01), and sit-and-reach (+3 cm, p=0.03). While the submaximal treadmill test captured a meaningful improvement in aerobic fitness (+62 s, p=0.17), it was not completed in 33 % of participants. Change in mobility, using the timed up-and-go was nominal and was not performed in 27 %.

Conclusion Submaximal treadmill testing, handgrip dynamometry, chair stands, and sit-and-reach tests were feasible, suitable, and provided meaningful physical fitness information in a cancer-specific, community-based, exercise program setting. However, a shorter treadmill protocol and more sensitive balance and upper body flexibility tests should be investigated.

Keywords Rehabilitation · Exercise tests · Cancer · Physical fitness

A. A. Kirkham · K. L. Campbell
Rehabilitation Sciences, University of British Columbia, 212-2177 Wesbrook Mall, Vancouver, BC, Canada V6T 1Z3

S. E. Neil-Sztramko · K. L. Campbell
School of Population and Public Health, University of British Columbia, 212-2177 Wesbrook Mall, Vancouver, BC, Canada V6T 1Z3

J. Morgan · S. Weller
Back on Track Fitness, 731 W 16th Avenue, Vancouver, BC, Canada V5Z 1S8

S. Hodson · T. McRae
Live Well Exercise Clinic, 306-1676 Martin Drive, White Rock, BC, Canada V4A 6E7

K. L. Campbell (✉)
Department of Physical Therapy, Faculty of Medicine, University of British Columbia, 212-2177 Wesbrook Mall, Vancouver, BC, Canada V6T 1Z3
e-mail: kristin.campbell@ubc.ca

Introduction

Exercise training is a safe and effective therapy to ameliorate side effects associated with cancer treatment, including reduced fitness and quality of life [1], but has not been universally adopted as part of standard care for cancer in North America [2]. Outside of research studies, there is little capacity for cancer survivors to receive guidance and supervision from fitness professionals with the appropriate training and education in exercise prescription and supervision related to the effects of cancer treatment. Recently, education and certification programs have been developed [3–5] to provide training for exercise and allied health professionals to design individualized exercise program specific to diagnosis, treatment, and recovery status. Following in suit, cancer-specific rehabilitative exercise programs staffed by individuals with these training certifications are beginning to be developed within the community [6, 7].

Assessment of health-related physical fitness is important in rehabilitative exercise programs in order to set goals, appropriately prescribe exercise, and monitor change over time [8]. It has been suggested that physical performance measures may also play a role in objective assessment of patient functional status in clinical oncology practice [9]. To date, there has been very little research on an appropriate, effective, and comprehensive physical fitness assessment among cancer survivors in a community-based setting.

The purpose of this study was to evaluate the utility of a standardized fitness assessment comprised of a comprehensive series of tests of the components of health-related physical fitness in a cancer-specific, community-based rehabilitation program setting. In this study, the utility of each test within this setting was defined as (i) the feasibility and suitability, measured as completion rate of each test during baseline fitness assessments; and (ii) the ability to detect change, measured as change over time following enrollment in a cancer-specific, community-based rehabilitation program.

Methods

Participants and consent

New clients with a prior cancer diagnosis at two cancer-specific, community-based, out-of-pocket expense exercise programs in Vancouver and White Rock, Canada, were invited to participate in this study. All participants provided written informed consent, and the University of British Columbia Clinical Research Ethics Board approved the study.

Procedure

The study authors reviewed the research literature to identify objective tests of the components of health-related physical fitness that most closely met the following criteria: (1) have prognostic value; (2) moderate-to-high reliability and validity (and therefore likely to capture change); (3) have published expected values for comparison; and (4) be feasible (i.e., required relatively little space, equipment, personnel, cost, time to administer) and suitable (i.e., safe and appropriate for cancer survivors of all ages) in a cancer-specific, community-based setting.

The cancer-specific, community-based programs' standard operating procedures include a baseline assessment for new clients performed by exercise trainers with a cancer-specific exercise certification [3, 10]. The baseline assessment includes collection of demographics, medical history, and assessment of physical fitness. The exercise trainers use the assessment results to develop an individualized 60-min exercise prescription for the client's needs and goals, generally consisting of 20–30 min of aerobic (50 to 80 % heart rate reserve (HRR)), 15–20 min of resistance, and 5–10 min of flexibility, balance, and core strength exercises delivered in small groups or one-on-one sessions with an exercise trainer. Clients were encouraged to attend two sessions a week, but actual attendance was dependent on the client's willingness to attend and pay for sessions. The programs offer a re-assessment 3 to 6 months after the baseline assessment, but completion is dependent on client availability, attendance, and willingness to pay for the re-assessment.

For the purposes of this study, both programs adopted the standardized fitness assessment in lieu of their usual fitness measures. The exercise trainers were trained on the standardized test procedures. There was no intervention with the programs' other standard operating procedures, nor was there a minimum attendance of supervised sessions required for study participants. This was done to ensure that the study reflected real-life use of these out-of-pocket expense programs.

Table 1 summarizes the tests comprising the assessment. Administration of each test was at the discretion of the exercise trainer. There were no pre-specified criteria to exclude participants from completing any of the individual tests.

Body composition: body mass index and waist circumference

The participant removed shoes and extra clothing layers for measurement of weight via digital scale and height via measuring tape [17]. To measure waist circumference, an inelastic tape was placed horizontally at the narrowest portion of the torso, above the umbilicus [8]. The average of two trials was used.

Estimated aerobic fitness: submaximal treadmill test

Resting blood pressure and heart rate were taken after 5 min of quiet, seated rest [11]. A heart rate target (75 % of HRR) at which the test is terminated was calculated: heart rate target=[(207−0.7×age)−resting heart rate]×0.75+resting heart rate [18, 19]. The modified Balke or Bruce treadmill test protocols (varied by program site) were used with 3-min stages to allow for achievement of steady state heart rate at each stage [8]. Heart rate was recorded at the end of every minute. The test outcome was recorded as the time to achievement of the target heart rate. An active cool-down (2.0 mph and 0 % grade) was performed for 2 min. The difference

Table 1 Summary of standardized tests comprising physical fitness assessment

Component of health-related physical fitness	Measure/test	Test outcome	Estimated duration (minutes)	Equipment required	Expected values/standards[a]
Body composition	Body mass index	kg/m^2	2	Scale, measuring tape	Normal, 18.5–24.9 $kg \cdot m^{-2}$ [11]
	Waist circumference	cm	2	Measuring tape	Low risk, women, ≤89 cm; men, ≤99 cm [11]
Resting cardiovascular function	Resting heart rate	Minimum beats per minute	5	Heart rate monitor	Norm, women, 74 bpm men, 71 bpm [12]
	Resting blood pressure	mmHg for systolic and diastolic blood pressure	3	Stethoscope, sphygmomanometer	Normal, systolic <120 mmHg, diastolic <80 mmHg [11]
Aerobic fitness	Submaximal treadmill test	Minutes to achievement of 75 % HRR	15–25	Treadmill, heart rate monitor	Age- and gender-specific percentiles for test duration 50th percentile[b], women age 50–59, 13.5 min men age 50–59, 18.0 min [11]
	Heart rate recovery	Beats per minute between HR target and HR 2 min later	2	Heart rate monitor	Normal prognosis, >22 beats after 2 min supine rest [11]
Strength	Grip strength	kg of force applied	3	Handgrip dynamometer	Norm, women, age 55–59, 29.9/27.2 kg (R/L) men, age 55–59, 44.1/41.0 kg (R/L) [13]
	30-s chair stand	Number of full stands completed	2	Chair, stopwatch	Norm, women, age 60–64, 14.5 stands men, age 60–64, 16.4 stands [14]
Flexibility	Back scratch	cm between middle fingers	3	Measuring tape	Norm, women, age 60–64, −0.7 cm men, age 60–64, −3.4 cm [15]
	Chair sit-and-reach	cm between middle finger and toes	3	Chair, measuring tape	Norm, women, age 60–64, 2.1 cm men, age 60–64, 0.6 cm [15]
Balance and mobility	Single-leg standing	Seconds of maintained balance	3	Stopwatch	Norm, age 50–59, open, 29.4 s, closed, 21.0 s [16]
	Timed up-and-go	Seconds required to complete task	2	Chair, stopwatch, cone	Norm, women, age 60–64, 5.2 s men, age 60–64, 4.7 s [15]
		Total	45–55		

cm centimeter, *HR* heart rate, *HRR* heart rate reserve, *kg* kilograms, *mmHg* millimeters of mercury

[a] Where available criterion-reference standard provided for normal/healthy and expected value provided for closest age category available to study sample (median age 58 years)

[b] Time is for Balke protocol with 3 min added to account for the modified version used in the current study

between the target heart rate and the heart rate 2 min after target achievement was recorded as the heart rate recovery [20].

Muscular strength: handgrip strength and 30-s chair stand

For the handgrip strength test, a hydraulic handgrip dynamometer (Jamar by Lafayette Instruments, Lafayette, IN; or Baseline Evaluation Instruments by Fabrication Enterprises Inc., White Plains, NY) was held at the side of the body in the standing position. The dynamometer was squeezed with as much force as possible over two trials with a 20-s rest in between. The highest force applied over two trials was recorded.

For the 30-s chair stand, the participant sat on a chair against the wall with a straight back, feet flat on the floor, and hands folded across their chest. On the command "go," the participant rose to a full stand and returned to the starting position as many times as possible in 30 s [21]. The test outcome was the number of full stands completed.

Flexibility: back scratch test and chair sit-and-reach

To perform the back scratch test, the participant reached their right hand over their right shoulder while standing.

Their right palm faced the back with the fingers extended. Their left hand reached behind the back with the palm facing out and fingers extended toward the neck. The participant attempted to touch or overlap the middle fingers of each hand, holding for 2–3 s. The test outcome was the distance measured between (or overlap of) the two middle fingers [22]. The best of two trials per side was recorded.

To perform the chair sit-and-reach, the participant sat on the front edge of a chair with one leg extended, the ankle flexed 90°, and the other leg bent with the foot flat on the floor. The participant bent forward, reaching their overlapped hands toward their toes, holding for 2–3 s without bending the knee [22]. The test outcome was the distance measured from the tip of the middle fingers to the middle of the shoe. The best of two trials per side was recorded.

Mobility and balance: timed up-and-go and single-leg standing

To perform the timed up-and-go, the participant sat on a chair against a wall with hands resting on the knees, feet flat on the floor. On the command, "go," the participant stood, walked as quickly as possible to and around a cone eight feet away, then returned to the chair to sit down. There was one practice trial, and the test outcome was the time taken to perform the whole task [22].

To perform the single-leg standing test, the participant raised one foot off the ground and attempted to balance for up to a maximum of 30 s. If 30 s were reached with eyes open, the procedures were repeated with eyes closed [16]. Three attempts were given and the longest held time over the three trials for the most difficult test (closed eyes) was the test outcome.

Analysis

The completion rate for each test was calculated as the percentage of times the test was performed in all of the baseline assessments. Change between the initial and re-assessment of each test was assessed by paired t tests for parametric variables and Wilcoxon signed-rank tests for non-parametric variables. Independent t tests were used to compare baseline differences in demographics and fitness test results between those who were re-assessed and those who were not. R 3.0.02 for Linux was used for statistical analysis; significance set at $\alpha=0.05$.

Results

Of a possible 281 new clients, 60 (21 %) agreed to participate between May 2011 and January 2014. Participants were primarily female (83 %) and middle-aged (median 58, range 20–78 years) (Table 2).

The completion rate of tests at the baseline assessment is outlined in Fig. 1. Reasons for non-completion related to the participant's inability to perform the test were recorded (e.g., orthopedic dysfunction or injury limiting treadmill walking). However, the exercise trainers had to prioritize some tests over others if the available assessment time was running low, and in some cases, the skipped test was based on their perception of low utility of tests (e.g., timed up-and-go not often performed in younger participants). In the cases of the latter two reasons, the trainers did not always record the reason for non-completion of the test. The completion rate reflects

Table 2 Baseline demographics and cancer diagnosis and treatment characteristics (n=60)

Demographics	Median (range)/n (%)
Age	58 (20–78)
Female	50 (83 %)
Marital status	
Married/living with partner	38 (66 %)
Divorced/separated/widowed	11 (19 %)
Never married	9 (24 %)
Diagnosis and treatment	
Months since diagnosis	8.7 (1–128)
Cancer type	
Breast	36 (60 %)
Gynecological	4 (7 %)
Head and neck	3 (5 %)
Hematological	3 (5 %)
Other	17 (28 %)
Stage	
0	1 (2 %)
I	7 (12 %)
II	14 (23 %)
III	12 (20 %)
IV	4 (7 %)
Undetermined/don't know	22 (37 %)
Received surgery	50 (83 %)
Chemotherapy	
None	23 (38 %)
Planned/current	12 (20 %)
Completed	25 (42 %)
Radiation	
None	26 (43 %)
Planned/Current	11 (18 %)
Completed	23 (38 %)

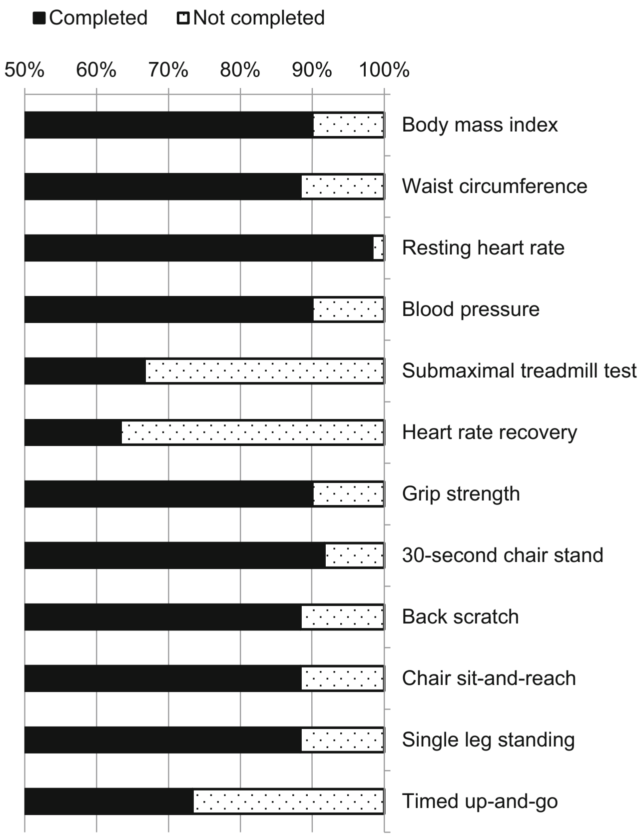

Fig. 1 Completion rate of individual tests in baseline assessment for a cancer-specific, community-based exercise program (n=60, mixed diagnoses, age range 20–78)

all of these reasons, and therefore the overall utility of each test in this population and setting. Resting heart rate was most commonly performed, followed by blood pressure, body mass index, grip strength, and 30-s chair stand (all in ≥88 % of baseline assessments). The submaximal treadmill test, heart rate recovery, and the timed up-and-go were the least commonly completed tests: 67, 63, and 73 % of assessments, respectively.

Thirty-four participants were re-assessed 22±11 weeks after their baseline assessment and had attended an average of 1.1±0.8 (range 0–2.9) supervised sessions/week. The main reasons for non-completion of re-assessment were illness, withdrawal from the program, and participant refusal based on cost or perception of lack of change. The completion rate of tests was similar to the baseline findings (data not shown). Compared to those who completed the re-assessment, at baseline those who were not re-assessed had significantly lower aerobic fitness levels (i.e., less time to heart rate target) (13.8 vs. 11.1 min, p=0.04) and significantly lower left handgrip strength (28.5 vs. 24.5 kg, p=0.05), but no differences in demographics, time since diagnosis, cancer stage, or treatment status were observed.

The test results for those who completed both assessments are shown in Table 3. There were no changes in body mass index (p=0.80), waist circumference (p=0.68), or resting heart rate (p=0.84). Systolic and diastolic blood pressure decreased (p=0.02).

Despite a mean increase of 62 s, the change in length of submaximal treadmill test time was not significant (p=0.17), nor was heart rate recovery (p=0.35). Significant improvements in strength were captured by handgrip dynamometry and 30-s chair stands (all p<0.01). Improvements in lower body flexibility using the chair sit-and-reach test were significant and nearly significant for the left and right, respectively (p=0.03, p=0.09). There were no changes in upper body flexibility as measured by the back scratch test (left, p=0.21, right, p=0.89). No change in balance was shown using the single-leg standing tests (left, p=0.49, right, p=0.87). A significant improvement in the timed up-and-go was observed (p<0.01).

Discussion

Cancer-specific, community-based, exercise programs are needed to increase the opportunities for cancer survivors to receive safe and effective exercise programming outside of a research setting. There is little to no research regarding appropriate, informative, and standardized fitness assessments in this setting. The objective of this study was to test the utility of a standardized fitness assessment within cancer-specific, community-based rehabilitation programs. In developing the standardized assessment, specific tests were chosen based on their anticipated feasibility in this setting, suitability for use in a wide age and function range, and evidence of moderate-to-high reliability and criterion validity. An additional consideration was published expected values, although not available for age 59 and younger for some tests. None of the tests had expected values, reliability, or validity established specifically for cancer populations.

While no change in body composition or resting heart rate was noted, a clinically meaningful decrease in systolic and diastolic resting blood pressure of 7 and 5 mmHg was observed. At the population level, a systolic blood pressure change of 5 mmHg is estimated to reduce all-cause mortality by 7 % [23]. Despite a lack of change in body composition and resting heart rate, inclusion of these measures in a community-based assessment of a clinical population is likely warranted because they were feasible to collect and have established prognostic value [11].

Although maximal exercise testing with open-circuit spirometry is the gold standard for aerobic fitness assessment, a submaximal exercise test is more feasible in a community setting as it does not require expensive gas analysis equipment and, in most cases, requires less medical supervision. There is some error associated with the use of a submaximal test to estimate peak oxygen consumption, yet the reduction in heart rate for a fixed work

Table 3 Test results for participants who completed the baseline and re-assessments ($n=34$)

Measure	N	Baseline assessment	Re-assessment	Mean difference	p value
Body composition					
Body mass index (kg·m^{-2})	30	28.2±6.3	28.1±5.8	−0.1	0.80
Waist circumference (cm)	28	92.3±14.5	91.9±14.5	−0.4	0.68
Resting cardiovascular function					
Resting heart rate (bpm)	32	75±10	75±9	0	0.84
Systolic blood pressure (mmHg)	28	122±17	115±16	−7	0.02*
Diastolic blood pressure (mmHg)	28	73±9	68±9	−5	0.02*
Aerobic fitness					
Submaximal treadmill test (min)	21	14.0±3.8	15.1±3.9	1.0	0.17
Heart rate recovery (bpm)	19	35±13	32±9	−3	0.35
Strength					
Grip strength (kg)					
Left	30	28.5±8.8	30.7±8.9	2.1	<0.01[a]*
Right	31	28.9±8.6	31.2±9.9	2.4	<0.01*
30-s chair stand[a]	32	13±6	18±9	4	<0.01[a]*
Flexibility					
Back scratch (cm)					
Left	29	−12.9±13.0	−11.5±13.2	1.4	0.21[a]
Right	28	−6.0±9.6	−5.9±10.8	0.1	0.89
Chair sit-and-reach (cm)					
Left	31	2.7±9.9	5.9±10.6	3.2	0.03*
Right	31	3.9±11.0	6.6±10.8	2.6	0.09
Balance and mobility					
Single-leg standing (s)					
Left	29	15.3±15.0	13.6±9.6	−1.6	0.49[a]
Right	29	13.4±9.9	12.8±8.8	−0.5	0.87[a]
Timed up-and-go (s)	27	5.5±2.6	4.9±2.9	−0.6	<0.01*

Baseline and follow-up values are mean±standard deviation

kg kilograms, *m* meters, *cm* centimeters, *bpm* beats per minute, *mmHg* millimeters of mercury, *min* minutes, *s* seconds

*$p \leq 0.05$ (statistically significant difference)

[a] Non-parametric Wilcoxon signed-rank test used instead of paired *t* test

rate, which results in a longer test time, can be assumed to indicate improved aerobic fitness [8]. One consideration is that this assumption may not hold for cancer survivors who may have autonomic dysfunction as a side effect of cancer treatment, which was not assessed in the current study [24, 25]. Although the change in treadmill time was not statistically significant, the mean improvement was clinically meaningful. A 1-min increase in incremental treadmill test time, as noted in the study, is associated with an 8 % decline in mortality [26]. However, this test was only completed in two thirds of participants. This test can last substantially longer for more fit individuals, which may limit its feasibility in this setting where assessments are restricted to a finite length of time. A shorter incremental treadmill test protocol may increase feasibility by accommodating individuals with higher baseline fitness. Additionally, a cycle ergometer test may also increase feasibility by accommodating individuals with balance or mobility issues. The 6-min walk or incremental shuttle walk tests are alternative options, but were not selected for this study as they were not feasible in this setting due to space restrictions in the program facilities. As well, steady state walking tests may have a ceiling effect in the younger individuals who enroll in these programs.

Handgrip strength and 30-s chair stands were performed in most participants in this study and captured change over time. Furthermore, the change in 30-s chair stand exceeded the minimally clinically important difference, which has been reported as two stands in patients with hip osteoarthritis [27]. The change in grip strength did not meet the minimally clinically important difference, noted as 5–6 kg early after stroke or in healthy women [28, 29]. Other upper body strength tests such as the chest press estimated one repetition maximum may not be appropriate for this population due to surgery restrictions and may not be feasible for the setting due to the equipment required. Handgrip strength is considered a good proxy of overall strength and functioning [30], has a strong established relationship with disability and mortality [30], and has published expected values [13]. Therefore, grip strength may still be the most appropriate test and reliability should be investigated specifically for this population and setting.

Flexibility assessment is important because shoulder range of motion and hamstring flexibility are factors in the ability to perform activities of daily living [8, 31]. There are mixed reports on whether the chair sit-and-reach test can capture changes in flexibility following an exercise intervention, despite high reliability (r=0.92–0.96) and moderate criterion validity (r=0.76–0.81) compared to goniometer measurement of hamstring flexibility [32]. In this study, a mean change of 3 cm per side was noted. The chair sit-and-reach test was designed to allow more older adults who may have trouble getting up from the floor version of the test to participate [32], and was performed in 88 % of participants in this study. The back scratch test is a reliable and common proxy for upper body flexibility [33], yet there were no changes, despite most of the baseline tests being below expected values (data not shown). Although these flexibility tests were performed in 88 % of participants, there may be an alternative upper body flexibility test better able to capture change in this population.

The timed up-and-go test has been shown to predict mortality [34]. It is easily performed in elderly individuals [35], but was not performed in 27 % of participants in this study. The individuals who attended the community programs in this study, at a median age of 58 years, were younger than the population for which this test is suggested to work best [35]. The change in timed up-and-go test performance was statistically significant, but the mean change of 0.6 s did not exceed the minimal detectable change of 2.9 s in chronic stroke [36]. Therefore, further research into the suitability of this test in a cancer-specific setting is needed to establish if this test has clinical utility, or is most appropriate for use in cancer survivors aged 65 years and older.

Single-leg standing can predict functional dependence [37] and mortality [38]. This test was performed in 88 % of participants in this study, but it did not capture a change. This finding differs from the change in standing time noted in 7 of 15 randomized controlled trials of supervised exercise in community-dwelling older adults [37]. Although some of these positive trials included yoga, Tai Chi, or intensive balance training in the interventions, others involved programs similar to the one current study participants performed.

Only 57 % of enrolled participants completed re-assessment in this study. Consistent with a study of a community-based program in older adults [12], individuals who completed the re-assessment had higher fitness in some measures at baseline, compared to those who did not complete the re-assessment. This finding has relevance for community programs for two reasons. First, if those individuals with lower levels of baseline fitness are identified to potentially have lower adherence or greater risk of dropout, strategies to boost adherence can be employed. Second, the typical 60-min session could be too difficult for those with lower initial fitness levels, which could contribute to eventual drop-out [11]. Shorter initial sessions or rest segments could be employed in this case to increase adherence. In addition, data on comorbid conditions and previous exercise experience were not collected, and if these factors differed in those with lower levels of baseline fitness, it could help to explain their non-compliance.

The use of private for-profit cancer-specific rehabilitative exercise programs in this study incorporates some methodological limitations for this research study. First, there was no quality assurance over the extent that program staff followed the standardized procedures for each test. Second, due to the appointment-based nature of these programs, if the assessment was taking longer than expected, some components had to be skipped to meet with the next client on time. Third, the out-of-pocket expense of attending the program likely played a factor in completion of the re-assessment and may have resulted in recruitment of individuals with high socioeconomic status. Fourth, a lack of measured change in any test could be due to either the inability of this test to capture change in this population or a lack of effect of the exercise programs on the aspect of physical fitness being measured. As the aim of this study was to determine the utility of specific tests, we did not collect information on the specific goals of each individuals' program (e.g., improve aerobic fitness, strength, etc.), which likely varied. However, the program staff have received training and certification for designing individualized programs for cancer survivors to target the health-related components of physical fitness that were captured by the standardized fitness assessment. These methodological limitations are a reality of the nature of the community-based programs. However, this approach also provides results that are more generalizable than tightly controlled, laboratory-based research.

In summary, a fitness assessment composed of established tests of health-related physical fitness was assessed for feasibility, suitability, and ability to detect change in fitness within a community-based, cancer-specific rehabilitation setting. A submaximal treadmill test combined with handgrip dynamometry, chair stand, and sit-and-reach tests provided meaningful information on aerobic, strength, and flexibility changes in the cancer-specific, community-based setting. However, a shorter treadmill test protocol or cycle ergometer alternative would likely help to increase the feasibility and suitability of estimated aerobic fitness assessment in this population and setting. Simple body composition and resting cardiovascular measures are easily measured and can provide prognostic value to the assessment. The back scratch, single-leg standing, and timed up-and-go tests failed to capture changes in performance. Further investigation is required to determine if there are tests that are more sensitive to changes in upper body flexibility, balance, and mobility, or whether exercise programs in this setting do not adequately address these aspects.

Acknowledgments Amy Kirkham and Sarah Neil-Sztramko are supported by Canada Graduate Scholarship Doctoral Awards from the Canadian Institute of Health Research.

Conflict of interest Joanne Morgan and Sara Hodson are the respective owners of Back on Track Fitness and Live Well Exercise Clinic, which were the two centers included in this study. They were involved in study design and data collection and reviewed the manuscript but were not involved in data analysis, interpretation, or reporting of results.

References

1. Schmitz KH, Courneya K, Matthews C et al (2010) American College of Sports Medicine roundtable on exercise guidelines for cancer survivors. Med Sci Sports Exerc 42:1409–1426. doi:10.1249/MSS.0b013e3181e0c112
2. Courneya KS (2009) Physical activity in cancer survivors: a field in motion. Psychooncology 18:337–342. doi:10.1002/pon.1546
3. American College of Sports Medicine (2013) ACSM/ACS Certified Cancer Exercise Trainer[SM]. American College of Sports Medicine. http://certification.acsm.org/acsm-cancer-exercise-trainer. Accessed 12 Nov 2014
4. Canadian Physiotherapy Association (2014) Oncology Physiotherapy. Canadian Physiotherapy Association. http://www.physiotherapy.ca/Divisions/Oncology. Accessed 12 Nov 2014
5. American Physical Therapy Association (2014) Oncology Section, American Physical Therapy Association. American Physical Therapy Association. http://www.oncologypt.org. Accessed 12 Nov 2014
6. Noble M, Russell C, Kraemer L, Sharratt M (2012) UW WELL-FIT: the impact of supervised exercise programs on physical capacity and quality of life in individuals receiving treatment for cancer. Support Care Cancer 20:865–873. doi:10.1007/s00520-011-1175-z
7. Rajotte EJ, Yi JC, Baker KS et al (2012) Community-based exercise program effectiveness and safety for cancer survivors. J Cancer Surviv 6:219–228. doi:10.1007/s11764-011-0213-7
8. Thompson WR, Gordon NF, Pescatello LS (2010) ACSM's guidelines for exercise testing and prescription, 8th edn. Wolters Kluwer Lippincott Williams & Wilkins, Philadephia
9. Van Londen GJ, Livesey KM, Lemberskey BC (2012) Breast cancer: never too young for a functional assessment? Oncology 26:1–5
10. Hayward R (2014) Rocky Mountain Cancer Exercise Specialist Workshop. University of Northern Colorado. http://www.unco.edu/rmcri/cancer_ex_spec_workshop.html. Accessed 12 Nov 2014
11. Pescatello LS, Arena R, Riebe D, Thompson PD (2014) ACSM's guidelines for exercise testing and prescription, 9th edn. Wolters Kluwer Lippincott Williams & Wilkins, Philadephia
12. Baruth M, Wilcox S, Wegley S et al (2011) Changes in physical functioning in the Active Living Every Day program of the Active for Life Initiative®. Int J Behav Med 18:199–208. doi:10.1007/s12529-010-9108-7
13. Bohannon RW, Peolsson A, Massy-Westropp N et al (2006) Reference values for adult grip strength measured with a Jamar dynamometer: a descriptive meta-analysis. Physiotherapy 92:11–15. doi:10.1016/j.physio.2005.05.003
14. Ostchega Y, Porter KS, Hughes J, Dillon CF, Nwankwo T (2011) Resting pulse rate reference data for children, adolescents, and adults: United States, 1999–2008. Natl Health Stat Report 41:1–16
15. Rikli RE (1999) Functional fitness normative scores for community residing older adults ages 60–94. J Aging Phys Act 7:162–181
16. Bohannon RW, Larkin PA, Cook AC et al (1984) Decrease in timed balance test scores with aging. Phys Ther 64:1067–1070
17. Swain DP (2014) ACSM's resource manual for guidelines for exercise testing and prescription, 9th edn. Lippincott Williams & Wilkins, Philadelphia
18. Gellish RL, Goslin BR, Olson RE et al (2007) Longitudinal modeling of the relationship between age and maximal heart rate. Med Sci Sports Exerc 39:822–829. doi:10.1097/mss.0b013e31803349c6
19. Karvonen M, Kentala E, Mustala O (1957) The effects of training on heart rate: a longitudinal study. Ann Med Exp Biol Fenn 35:307–315
20. Cole CR, Foody JM, Blackstone EH, Lauer MS (2000) Heart rate recovery after submaximal exercise testing as a predictor of mortality in a cardiovascularly healthy cohort. Ann Intern Med 132:552–555
21. Jones CJ, Rikli RE, Beam WC (1999) A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. Res Q Exerc Sport 70:113–119. doi:10.1080/02701367.1999.10608028
22. Jones CJ, Rikli RE (2002) Measuring functional fitness in older adults. J Act Aging 1:24–30
23. Stamler J, Rose G, Stamler R et al (1989) INTERSALT study findings. Public health and medical care implications. Hypertension 14:570–577. doi:10.1161/01.HYP.14.5.570
24. Viniegra M, Marchetti M, Losso M et al (1990) Cardiovascular autonomic function in anthracycline-treated breast cancer patients. Cancer Chemother Pharmacol 26:227–231
25. Stone CA, Kenny RA, Nolan B, Lawlor PG (2012) Autonomic dysfunction in patients with advancedcancer; prevalence, clinical correlates andchallenges in assessment. BMC Palliat Care 11:3. doi:10.1186/1472-684X-11-3
26. Blair SN, Kohl HW, Barlow CE et al (1995) Changes in physical fitness and all-cause mortality: a prospective study of healthy and unhealthy men. JAMA 273:1093–1098
27. Wright AA, Cook CE, Baxter GD et al (2011) A comparison of 3 methodological approaches to defining major clinically important improvement of 4 performance measures in patients with hip osteoarthritis. J Orthop Sports Phys Ther 41:319–327. doi:10.2519/jospt.2011.3515
28. Nitschke JE, McMeeken JM, Burry HC, Matyas TA (1999) When is a change a genuine change?: a clinically meaningful interpretation of grip strength measurements in healthy and disabled women. J Hand Ther 12:25–30
29. Lang CE, Edwards DF, Birkenmeier RL, Dromerick AW (2008) Estimating minimal clinically important differences of upper-extremity measures early after stroke. Arch Phys Med Rehabil 89:1693–1700. doi:10.1016/j.apmr.2008.02.022
30. Bohannon RW (2001) Dynamometer measurements of hand-grip strength predict multiple outcomes. Percept Mot Skills 93:323–328
31. Triffitt PD (1998) The relationship between motion of the shoulder and the stated ability to perform activities of daily living. J Bone Joint Surg Am 80:41–46
32. Jones CJ, Rikli RE, Max J, Noffal G (1998) The reliability and validity of a chair sit-and-reach test as a measure of hamstring flexibility in older adults. Res Q Exerc Sport 69:338–343. doi:10.1080/02701367.1998.10607708
33. Rikli RE, Jones CJ (1999) Development and validation of a functional fitness test for community-residing older adults. J Aging Phys Act 7:129–161
34. Idland G, Engedal K, Bergland A (2013) Physical performance and 13.5-year mortality in elderly women. Scand J Public Health 41:102–108. doi:10.1177/1403494812466460
35. Lin MR, Hwang HF, Hu MH et al (2004) Psychometric comparisons of the timed up and go, one-leg stand, functional reach, and Tinetti

balance measures in community-dwelling older people. J Am Geriatr Soc 52:1343–1348

36. Flansbjer U-B, Holmbäck AM, Downham D, Patten C, Lexell J (2005) Reliability of gait performance tests in men and women with hemiparesis after stroke. J Rehabil Med 37(2):75–82. doi:10.1080/16501970410017215
37. Michikawa T, Nishiwaki Y, Takebayashi T, Toyama Y (2009) One-leg standing test for elderly populations. J Orthop Sci 14:675–685. doi:10.1007/s00776-009-1371-6
38. Cooper R, Strand BH, Hardy R et al (2014) Physical capability in mid-life and survival over 13 years of follow-up: British birth cohort study. BMJ 348:g2219. doi:10.1136/bmj.g2219