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Research

Aerobic capacity and upper limb strength are reduced in women diagnosed with breast cancer: a systematic review

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KEY WORDS

Meta-analysis
Breast neoplasms
Physical fitness
Physical endurance
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ABSTRACT

Question: What are typical values of physical function for women diagnosed with breast cancer and how do these compare to normative data? **Design:** Systematic review with meta-analysis. **Participants:** Women diagnosed with breast cancer who were before, during or after treatment. **Outcome measures:** Physical function was divided into three categories: aerobic capacity, upper and lower extremity muscular fitness, and mobility. Measures of aerobic capacity included field tests (6-minute walk test, 12-minute walk tests, Rockport 1-mile test, and 2-km walk time) and submaximal/maximal exercise tests on a treadmill or cycle ergometer. Measures of upper and lower extremity muscular fitness included grip strength, one repetition maximum (bench, chest or leg press), muscle endurance tests, and chair stands. The only measure of mobility was the Timed Up and Go test. **Results:** Of the 1978 studies identified, 85 were eligible for inclusion. Wide ranges of values were reported, reflecting the range of ages, disease severity, treatment type and time since treatment of participants. Aerobic fitness values were generally below average, although 6-minute walk time was closer to population norms. Upper and lower extremity strength was lower than population norms for women who were currently receiving cancer treatment. Lower extremity strength was above population norms for women who had completed treatment. **Conclusion**: Aerobic capacity and upper extremity strength in women diagnosed with breast cancer are generally lower than population norms. Assessment of values for lower extremity strength is less conclusive. As more research is published, expected values for sub-groups by age, treatment, and co-morbidities should be developed. **[Neil-Sztramko SE, Kirkham AA, Hung SH, Niksirat N, Nishikawa K Campbell KL (2014) Aerobic capacity and upper limb strength are reduced in women diagnosed with breast cancer: a systematic review. *Journal of Physiotherapy* 60: 189–200]**

Introduction

Worldwide, breast cancer remains the most commonly diagnosed cancer in women.[1] Due to advancements in treatment approaches for breast cancer, the 5-year survival rate has improved dramatically, and in Canada is approximately 88%.[2] Despite the efficacy of treatment in improving survival, women who have undergone treatment for breast cancer face both acute and chronic impairments in various aspects of physical function as a result of their treatment, which may involve a combination of surgery, chemotherapy, radiation therapy, hormonal therapy or other targeted biological therapies.[3] Physiotherapists have the potential to play an important role in cancer care by identifying and monitoring changes in physical function during and following breast cancer treatment, and by prescribing interventions to address deficits in physical function. For the purposes of the present review, three main aspects of physical function have been selected: aerobic capacity, muscular fitness of the upper and lower extremities, and mobility. These aspects of physical function were selected because they represent clinically relevant areas of focus for physical therapists, they are commonly assessed in exercise oncology literature, and each has established objective outcome measures available for comparison.

Aerobic capacity

Declines in aerobic capacity have been observed during breast cancer treatment, which is likely a combination of the direct and indirect effects of the treatment itself, and associated reduction in physical activity leading to deconditioning.[4] Maximal oxygen consumption (VO_2max) – the upper limit to the rate of oxygen utilisation, as measured by a cardiopulmonary exercise test – is the gold standard measurement of cardiorespiratory fitness and the capacity for physical work.[5] In clinical populations, VO_2max may not be achieved during a cardiopulmonary exercise test, so the peak oxygen consumption (VO_2peak) is used instead. VO_2peak is associated with all-cause,[6] cardiovascular disease-specific[7,8] and breast cancer-specific[9] mortality. A recent cross-sectional study reported that women diagnosed with breast cancer have a VO_2peak on average 27% lower than that expected for healthy sedentary women.[10]

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Although VO_2peak has a strong association with health outcomes, cardiopulmonary exercise testing requires expensive, specialised equipment and medical supervision for high-risk individuals, thereby limiting its feasibility. A submaximal exercise test, such as a progressive exercise test that is terminated at 85% of age-predicted maximal heart rate or 70% of heart rate reserve, is often a more feasible alternative in clinical practice because it poses less risk and can be done without collection of expired metabolic gases. VO_2max can be estimated with a submaximal exercise test.[11]

The 6-minute walk test (6MWT) is a widely used field test that offers a more practical approach to quantifying physical capacity than maximal or submaximal cardiopulmonary exercise tests. The 6MWT measures the distance walked over a flat, hard surface in 6 minutes.[12] The 6MWT distance correlates with VO_2peak (r = 0.59 to 0.73)[12,13] and is more a measure of an individual's ability to perform daily activities than a surrogate measure of aerobic capacity.[12] Although there is concern regarding the need for a familiarisation trial to account for a potential learning effect, the test-retest reliability of the 6MWT was recently reported for a cancer population (ICC = 0.93, 95% CI 0.86 to 0.97), and the 6MWT was significantly correlated with VO_2peak (r = 0.67).[14] Other field tests assessing aerobic capacity without the need for expensive equipment include the Cooper 12-minute walk test (12MWT),[12] Rockport 1-mile test[15] and 2-km walk time.[16]

Upper and lower extremity muscular fitness

Muscular fitness is a component of physical function that consists of muscular strength, endurance and power.[11] Following surgery for breast cancer, women may experience substantial impairment in upper extremity function. Functional limitations, including decline in strength and range of motion, may continue after acute recovery from surgery is complete.[17] Deconditioning during active cancer treatment (ie, chemotherapy and radiation) may also contribute to declines in upper and lower extremity strength and endurance. Aromatase inhibitors, commonly prescribed following the completion of chemotherapy and radiation therapy, are also associated with musculoskeletal symptoms such as pain, which may also reduce participation in physical activity, further contribute to deconditioning and, in turn, impact muscular fitness.[18]

Muscular strength refers to the ability to exert force. The gold standard for assessment of muscle strength is the force exerted in a maximum voluntary contraction with force output measured by a computerised dynamometer.[19] This type of equipment is very expensive and, thus, not commonly used outside of a research setting. In the field, strength is traditionally evaluated with a one repetition maximum (1RM) or maximum voluntary contraction, but four to 15 repetition tests to estimate 1RM have also been used to assess strength.[11] General upper extremity strength is typically assessed using a chest or bench press, while lower extremity strength is commonly assessed using leg press or leg extension.[11] Alternatively, muscle strength can be measured objectively in a clinical setting using a portable, tester-reliant tool called a hand-held dynamometer. Inter-tester reliability coefficients for this tool range from –0.19 to 0.99, depending on the study, and appears to be more reliable for upper than lower body strength measurements.[20] Muscular endurance refers to the ability to successively perform exertions of force and is evaluated via the maximum number of repetitions at a percentage of the 1RM or body weight, often with the repetitions performed at a standard rate.[11] The chair stand test is another commonly used field test of lower body strength and involves either the number of chair stands performed in 30 seconds or the amount of time required to perform a predetermined number of chair stands. The 30-second chair stand has moderately high test-retest reliability (ICC = 0.89) and moderate construct validity as demonstrated by a correlation with the leg press (r = 0.77).[21]

Finally, a commonly reported measure of global muscular strength is grip strength. Due to the internal consistency of strength measurements, grip strength may be used to characterise overall strength and has been shown to be a predictor of postoperative complications, functional limitations, disability and mortality.[22]

Mobility

Mobility assessment is intended to be a functional measure that is influenced by both muscular strength and agility. A common field test, the Timed Up and Go (TUG) test, requires a participant to perform a sequence of tasks that are all critical for independent mobility: rise from a chair, walk 3 metres, turn around, walk back to the chair, and sit down.[23] The test outcome is the total time required to complete the sequence. As such, the TUG test provides an overall assessment of mobility and does not identify problems with particular tasks.[23] This test is reliable and valid for quantifying functional mobility and for assessing clinical change over time.[24] Although intra-rater and inter-rater reliability of the test are high (ICC = 0.92 to 0.96), test-retest reliability is moderate (ICC = 0.56),[25] which is potentially due to a learning effect. Construct validity of this functional test has been supported by correlations with a number of functional measurements including: gait speed (r = 0.75), postural sway (r = 0.48), step length (r = 0.74), stair test (r = 0.59) and step frequency (r = 0.59).[25] Other assessments of mobility include measuring gait speed, time to ascend or descend a certain number of stairs, and the time it takes to get down and up from the floor.

In healthy populations, normative values of a variety of the tests described above have been published. These values help physiotherapists and other health professionals interpret a patient's result on a specific test relative to others of similar age and gender and may provide a goal for individuals and clinicians to attain. Research to date has documented the decline in various aspects of physical function during and following breast cancer treatment. In order to publish average values for this clinical population, a large sample of participants is required. The aim of this review was to summarise the available data that have been published in studies that measured physical function in women who have been diagnosed with breast cancer, to generate a resource for physiotherapists using the tests that are most commonly used in this field of research. The second aim is to compare reported values to published normative data, where available.

Methods

Identification and selection of studies

Due to the wide range of assessment tools available, the review was limited to the most commonly used, objective and validated tests reported in the exercise oncology literature that would also be relevant to physiotherapists, as identified in a previous literature review.[26] A list of MeSH terms and key words related to breast cancer, physical function, and the specific outcomes of interest were developed (see Appendix 1 in the eAddenda). MEDLINE, Embase and CINAHL were searched using these terms up to and including 27 December, 2012. Included studies were required to meet all inclusion criteria (Box 1). Case studies were excluded, as were studies including participants with other types of cancer, unless values were reported separately by cancer type. Studies that were limited to women with metastatic breast cancer were also excluded; however, we did not otherwise exclude studies on the basis of individual study eligibility criteria. Lack of consensus about eligibility was resolved through discussion.

Data extraction and synthesis

Relevant data were extracted from each identified paper, including demographic characteristics of the study participants, details of the study design, name of the test used, specifics of the test protocol, and reported values of the selected physical function tests. Data were extracted for the full study sample where available, and separate group data were pooled for simplicity.[27]

Box 1. Inclusion criteria.

Design
- Randomised trials
- Non-randomised intervention studies
- Observational studies

Participants
- Women diagnosed with breast cancer
- Before, during or after treatment

Intervention
- Any intervention or no intervention

Outcome measures
- Aerobic capacity (maximal or submaximal exercise test, six or twelve minute walk test, Rockport 1-mile test, 2-km walk time)
- Upper extremity strength and endurance (grip strength, bench/chest press)
- Lower extremity strength and endurance (leg press, knee flexion/extension, chair stands)
- Mobility (Timed Up and Go)

A second author checked the data extraction. Where baseline values of outcomes of interest were not reported, authors were contacted for missing data. Of 13 authors contacted, data were received from three. Where necessary, data were converted to metric units. The selection of the age range for normative values reported was based on the average age and mean body weight of participants in the included studies.

Data analysis

For outcomes in which at least three different studies used a comparable protocol, a meta-analysis was conducted. Using methods described by Neyeloff et al[27] for descriptive data analysis, the pooled mean for each outcome was calculated using a random-effects model. Studies for which the mean and standard deviation were not reported in the paper (eg, median and/or range were reported instead) were not included in the meta-analysis. All studies reporting the specific outcome of interest were plotted on the same forest plot, however pooled means were calculated separately for studies involving participants who were 'on treatment' and 'off treatment'. 'On treatment' was defined as measures taken prior to the completion of surgery, chemotherapy or radiation therapy. 'Off treatment' was defined as studies in which authors report that participants had completed surgery, chemotherapy and/or radiation therapy, but may have still been taking hormonal therapies. Heterogeneity was assessed using I^2 under the random-effects model using the methods described by Neyeloff et al.[27]

Results

The search identified 1978 papers, of which 361 were retrieved and screened for eligibility and 85 met our inclusion criteria (Figure 1). A full list of included studies can be found in Appendix 2 (in the eAddenda). The most common reasons for exclusion were that the outcomes assessed did not meet the inclusion criteria, or the studies did not examine women diagnosed with breast cancer. Study designs and relevant participant characteristics are listed in Table 1. Of the studies included, 42 were randomised trials, 19 were non-randomised intervention studies, and 24 were observational studies with no intervention. The majority of studies (n = 61) included women who were off treatment, while others included women following surgery but before chemotherapy/radiation therapy (n = 20) and/or during chemotherapy/radiation therapy (n = 9), and for the purposes of the present review were classified as on treatment (n = 28). Some observational studies included assessments at multiple time points and were included in both groups. Normative values for comparison are presented in Table 2.

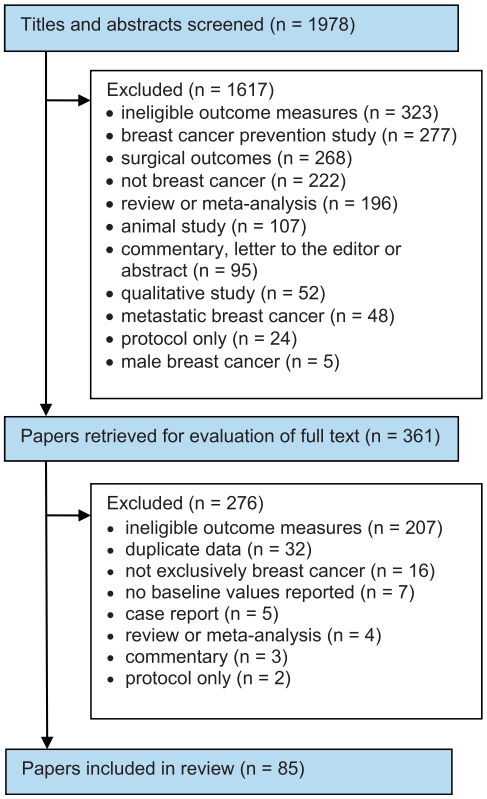

Figure 1. Flow of studies through the review.

Aerobic capacity

The most common test used to assess aerobic capacity was a maximal cardiopulmonary exercise test (n = 16) using either a cycle ergometer (n = 9) or treadmill (n = 8) protocol (see Table 3 in the eAddenda). Pooled relative VO_2peak was a mean of 23.7 mL/kg/min (95% CI 20.4 to 27.0) for women on treatment and 22.8 mL/kg/min (95% CI 20.7 to 24.9) for women off treatment (Figure 2). The pooled absolute VO_2peak was a mean of 1.65 L/min (95% CI: 1.59 to 1.72) from study groups on treatment and 1.60 L/min (95% CI 1.48 to 1.72) from study groups off treatment (Figure 3). Compared to published normative data, pooled means of VO_2peak fell into the 'very poor' category for women age 50 to 59 (Table 2).[11] No heterogeneity was identified (all I^2 values $< 30\%$).

Submaximal exercise tests were used to predict VO_2max in 15 studies, more commonly using a treadmill (n = 12) than a cycle ergometer (n = 3) protocol. Predicted VO_2max values tended to be higher than measured VO_2peak. The pooled mean for predicted VO_2max for women on and off treatment was 25.2 mL/kg/min (95% CI 19.1 to 31.3) and 23.9 mL/kg/min (95% CI 22.5 to 25.4), respectively (Figure 4). These mean values fall into the 'very poor' category for women age 50 to 59 (Table 2).[11] No heterogeneity was identified (all I^2 values $< 30\%$).

The 6MWT was used as a measure of aerobic capacity in nine studies. The pooled mean value for distance walked was 523 m (95% CI 499 to 548) for women on treatment, and 500 m (95% CI 476 to 524) in women off treatment (Figure 5). These pooled means fall between the 25th and 50th percentiles of community-dwelling adults aged 60 to 64 (Table 2).[28] The 12MWT was used in 11 studies. The pooled mean value for distance walked was 1020 m (95% CI 982 to 1058) in women on treatment and 904 m (95% CI 831 to 976) in women off treatment (Figure 6). All I^2 values were $< 30\%$ except for the 6MWT in the off-treatment groups only, which had moderate heterogeneity. Other less commonly used tests include the 2-km walk time with values ranging from 16.9 to 18.9 minutes, and Rockport 1-mile test (reported values of 17.45 and 17.65 minutes). There were no published norms identified for the 12MWT, 2-km walk test or Rockport 1-mile test.

Table 1
Included studies, study design and patient characteristics. References to included studies are available in Appendix 2 in the eAddenda.

Reference	Study design	Patient characteristics						
		n	Age (*yr*)	BMI (kg/m^2)	Stage (%)	Time since treatment	Treatment type (%)	Eligibility criteria
			mean (SD/range)	mean (SD)		mean (SD)		
On treatment								
Anderson 2012	RCT	104	54 (32 to 82)	NR	I: 49; II: 38; III: 12	0 to 2 wk	Mast: 50; Lump: 46	No LD
Beurskens 2007	RCT	30	55 (11)	NR	NR	2 wk	Mast: 77; Lump: 23; ALND: 100	Shoulder pain >1
Campbell 2005	RCT	22	47 (5)	NR	I-III	NA	CT: 27; RT: 27; CT+RT: 45	Inactive
Courneya 2007	RCT	242	49 (25 to 78)	27 (6)	I: 25; IIA: 41; IIB: 20; IIIA: 15	NA	Lump: 59; Mast: 41; CT: 100	–
Drouin 2005	RCT	21	50 (8)	NR	DCIS: 24; I: 14; II: 24; III: 38	NA	Sx: 24; Sx+CT: 76; RT: 100	Inactive
Haines 2010	RCT	89	55 (9)	NR	NR	NA	Sx: 100; CT: 36; RT: 92; HT: 39	–
Haykowsky 2009	Pre-post	17	53 (7)	BW (*kg*) 78 (21)	I: 29; IIA: 35; IIB: 24; III: 12	Immediately before Trastuzumab	Mast: 53; Lump: 47; CT: 100	HER1; ≥50% ejection fraction
Johansson 2001	Obs	61	56 (10)	NR	NR	Pre-op, 6 mo, 1 yr, 2 yr	Mast: 100; CT: 25; RT: 57; HT: 25	All ALND + Mast
Kaya 2010	Obs	67	54 (12)	NR	NR	9 mo (2 to 67)	Mast: 87; Lump: 13; CT: 90; RT: 44	LD node removal
Kilgour 2008	RCT	27	50 (5)	BW(*kg*) 75 (16)	NR	3 d post Sx	Mast: 100	Mast + ALND Sx
Kim 2006	RCT	41	50 (6)	29 (6)	0: 5; I: 41; II: 37; III: 17	"Shortly after diagnosis"	CT: 49; RT: 34; CT+RT: 17	Inactive
Kolden 2002	Pre-post	40	55 (8)	BW (*lb*) 155 (25)	I: 32; II: 55; III: 13	83% ≤12 mo post diagnosis	Mast: 45; Lump: 60; CT: 65; RT: 60; HT: 50	–
Ligibel 2010	Pre-post	41	47 (7)	NR	I: 27; II: 37; III: 34	NA	Lump: 34; Mast: 56; CT: 98; RT: 54	Inactive
Mock 1994	RCT	14	44	NR	I: 14; II: 86	NA	CT: 100; Sx+RT: 79; Mast: 21	–
Mock 2001	Pre-post	50	48 (11)	26 (5)	I: 54; II: 40; III: 6	NA	Lump: 62; Mast: 38; RT: 64; CT: 36	–
Mock 2005	RCT	119	52 (9)	26 (5)	0: 24; I: 43; II: 30; III: 3	NA	CT: 42; RT: 58	Inactive
Morimoto 2003	Pre-post	72	50 (10)	NR	I/II	NA	Mast: 54; Lump: 46	–
Nikander 2007	RCT	28	52 (5)	28 (5)	NR	NA	CT: 25; HT: 21; CT+HT: 54	–
Postma 1995	Obs	7	56 [a] (43 to 71)	NR	NR	NA	CT: 100	Anthracycline-resistant; Paclitaxel
Reitman 2003	Obs	204	56 (12)	NR	I: 42; IIa: 41; IIb: 17	6 wk post Sx	Mast: 42; Lump: 58	ALND
Rietman 2004		189			I: 42; IIA: 42; IIB: 16	1 yr post Sx	RT: 67; CT: 34; HT: 38	
Reitman 2006		181				2 yr post Sx		
Schneider 2007	Pre-post	17	56 (10)	BW (*kg*) 68 (12)	NR	NR	Sx: 99; CT: 50; RT: 43	–
Schwartz 2000a	Pre-post	27	47 (35 to 57)	NR	II/III: 70	>21 d post Sx	Sx: 100	–
Schwartz 2000b	Pre-post	71	47 (27 to 71)	23 (0)	II: 8; III: 73; IV: 18	>21 d post Sx	Sx: 100	–
Schwartz 2001	Pre-post	61	47 (8)	NR	II: 54	>21 d post Sx	Mast: 74	–
Schwartz 2007	RCT	66	48 (8)	BW (*kg*) 69 (2)	I: 23; II: 58; III: 20	NA	NR	Inactive
Wang 2011	RCT	72	50 (10)	BW (*kg*) 55 (7)	I: 22; II: 78	NA	NA	Chinese; BMI ≤30

Table 1 (*Continued*)

Reference	Study design	Patient characteristics						
		n	Age (*yr*)	BMI (kg/m^2)	Stage (%)	Time since treatment	Treatment type (%)	Eligibility criteria
			mean (SD/range)	mean (SD)		mean (SD)		
Off treatment								
Ahmed Omar 2011	RCT	50	54 (3)	27 (5)	II/III	40 (9) mo	Mast: 82; Lump: 18; RT+CT: 38; RT+HT: 14; CT+RT+HT: 48	LD
Ahmed 2006	RCT	46	52 (1)	27 (7)	DCIS: 4; I: 28; II: 57; III: 11	IG: 13 (5 to 32); CG: 13 (4 to 37) mo	RT: 74; CT: 87; Sx: 100; HT: 87	Inactive, stable BW
Basen-Engquist 2006	RCT	60	55 (8)	29 (8)	DCIS: 22; I: 28; II: 25; III: 18; IV: 3; unknown: 3	IG: 39.2 (16.7); CG: 37.1 (14.1) mo post diagnosis	Lump: 40; Mast 60; None: 12; RT: 22; CT: 22; RT+CT: 45	Inactive
Brdareski 2012	RCT	18	52 (8)	27 (4)	I-IIIA	IG1: 5 (4); IG2: 3 (3) yr	Sx: 100; CT: 72; RT: 72; HT: 50	< 65 yr old
Campbell 2012	Pre-post	14	55 (8)	30 (4)	I: 7; II: 64; III: 14	24 (22) mo	Sx: 7; Sx+RT: 14; Sx+CT: 7; Sx+RT+CT: 71	BMI 25 to 35; Inactive
Cantarero-Villanueva 2012a	RCT	67	49 (8)	NR	I: 24; II: 58; IIIA: 18	<12 mo: 76%; >12 mo: 24%	Lump: 63; Mast: 37; RT: 3; CT: 9; RT+CT: 88	Functional problems
Cantarero-Villanueva 2012b	Obs	95	NR	NR	I: 30; II: 53; IIIA: 17	≤6 mo	Lump: 68; Mast: 32; HT: 78; Trastuzumab: 12	Functional problems
Cheema 2006	Pre-post	27	58 (7)	BW (*kg*) 71 (12)	DCIS: 7; I: 22; II: 22; III: 33	5 (5) yr	Lump: 59; Mast: 48; RT: 67; CT: 52; HT: 22	Dragon boat team post season
Courneya 2003	RCT	52	59 (6)	29 (7)	I: 40; IIA: 33; IIB: 21; IIIA: 6	14 (6) mo	Mast: 54; Lump: 46; RT: 71; CT: 40; HT: 46	Age 50 to 69 yr, PostM
Daley 2007	RCT	108	51 (10)	28 (0)	NR	IG: 18 (7); ExCG: 18 (7); CG: 17 (6) mo	Mast: 53; Lump: 47; CT: 74; RT: 79; HT: 73	Inactive
Damush 2006	Pre-post	29	60 (7)	NR	I: 45; II: 55	3 yr post diagnosis	Mast: 59; CT: 62	≥ 50 yr
Dawes, 2008	Obs	50	59 (10)	27 (5)	I/II	NR	Sx: 100%	LD symptom
Dolan 2012	Obs	12	55 (6)	26 (6)	I: 42; IIA: 50; IIIA: 8	<5 yr: 50%; 5 to 10 yr: 33%; >10 yr: 17% post diagnosis	Mast: 83; Lump: 17; CT: 83; RT: 75; HT: 58	–
Evans 2009	Obs	7	54 (7)	26 (4)	II: 43; III: 57	≤6 mo	NR	Inactive
Eyigor 2010	RCT	42	49 (6)	NR	NR	IG: 39 (40); CG: 38 (52) mo post diagnosis	Mast: 100	Inactive
Fillion 2008	RCT	87	52 (10)	NR	0: 7; I: 44; II: 35; III: 15	257 (107) d post diagnosis	Mast: 14; Lump: 86; CT: 56; RT: 100; HT: 74	–
Garner 2008	Pre-post	11	51 (6)	26 (6)	I/II	4 (3) yr post diagnosis	NR	Inactive, PostM
Hayes 2005	Obs	214	53 (10)	NR	I: 27; II: 31; III: 32	6 mo post diagnosis	Mast: 28; Lump: 72; RT: 71; CT: 41; HT: 42	–
Herrero 2006	RCT	16	50 (8)	25 (4)	I: 44; II: 56	36 mo	Lump: 56; Mast: 44; CT: 100	Inactive, ALND, PostM
Hokken 2009	Pre-post	75	49 (9)	26 (9)	NR	AC: 23 (13); FEC: 17 (9) wk	CT: 100; RT: 73	–
Hsieh 2008	Pre-post	96	58 (10)	BW(*lb*) 168 (39)	NR	Immediately	Mast: 69; Lump: 28, CT: 57; RT: 44	–
Hughes 2008	Obs	25	50 (8)	NR	I/II: 60; III: 4; IV: 4	61 (35) mo post diagnosis	NR	Hispanic only
Hutnick 2005	RCT	49	50 (7)	27 (7)	I/II: 90	2 wk to 2 mo	Lump: 53; Mast: 45; RT+CT: 71	–
Johansson 2001	Obs	61	56 (10)	NR	NR	Pre-op, 6 mo, 1 yr, 2 yr	CT: 25; RT: 57; HT: 25	All ALND + Mast

Table 1 (*Continued*)

Reference	Study design	Patient characteristics						
		n	Age (*yr*)	BMI (kg/m^2)	Stage (%)	Time since treatment	Treatment type (%)	Eligibility criteria
			mean (SD/range)	mean (SD)		mean (SD)		
Jones 2007b	Obs	47	57 (7)	28 (5)	NR	3 yr	Lump: 28; Mast: 72; RT: 98; CT: 100	PostM
Jones 2007a	Obs	26	48 (9)	29 (6)	I/II: 65	20 (10) mo	Mast: 52; CT: 100; RT: 65; HT: 62	Node positive or high-risk node negative; operable HER2/neu
Kaltsatou 2011	RCT	27	57 (5)	NR	NR	2.2 yr	NR	–
Lane 2005	Pre-post	16	52 (7)	24 (3)	I: 44; II: 38; III: 19	>6 mo	Lump: 75; Mast: 25; Lump+Mast: 25; RT: 94	–
Linterman 2011	Obs	33	AI: 64[a] (51 to 74); Tam: 61[a] (54 to 68)	AI: 24[a] (18 to 45); Tam: 23[a] (21 to 26)	NR	NR	CT: 12	PostM
Merchant 2008	Obs	40	57 (12)	NR	NR	29 (21) mo	Mast: 40; Lump: 60; CT: 10; RT: 43; CT+RT: 30; HT: 53	Unilateral Sx > 6 mo prior
Mulero Portela 2008	RCT	34	51 (6)	30 (6)	I: 15; II: 29; III: 26; IV: 3	>2 mo	Lump: 53; Mast: 47	–
Musanti 2012	RCT	55	51 (8)	BW (*lb*) 169 (36)	I: 45; II: 44; III: 11	6 wk to 2 yr	CT: 87; RT: 73; HT: 56	Inactive
Mustian 2006	RCT	21	52 (9)	26 (5)	0/IIIb	1 wk to 30 mo	Lump: 61; Mast: 39; CT: 84; RT: 61; HT: 56	Inactive
Mutrie 2007	RCT	201	52 (10)	27 (6)	0/III	162 (74) d	CT: 8; RT: 28; CT+RT: 64; Mast: 40; Lump: 60	Inactive
Neil 2012	Obs	27	53 (10)	25 (5)	I/IIIa	F: 21 (18); CG: 23 (19) mo	CT+RT: 78; RT: 22; HT: 52	RT
Nikander 2012	RCT	67	53 (8)	BW(*kg*) 72 (16)	I: 15; II: 60; III: 25	< 4 mo	CT: 90; RT: 78; HT: 88	–
Nuri 2012	RCT	29	58 (6)	28 (5)	I/IIIb	NR	NR	Inactive, Stable BW, PostM
O'Neill 2006	Pre-post	17	64 (45 to 76)	NR	NR	3 to 28 yr	Mast: 100; RT: 29; CT: 12; RT+CT: 47	LD
Pinto 2005	RCT	86	53 (9)	28 (9)	0: 16; I: 37; II: 47	IG: 2 (1); CG: 2 (1) yr	Lump: 72; Mast: 28; RT: 69; CT: 56; HT: 62	Inactive; Diagnosis <5 yr
Rietman 2004b	Obs	189	56 (12)	NR	I: 42; IIA: 42; IIB: 16	1 yr post Sx	RT: 67; CT: 34; HT: 38	ALND
Reitman 2006		181				2 yr post Sx		
Rietman 2004a	Obs	55	57 (13)	BW (*kg*) 74 (17)	0: 4; I: 47; IIa: 35; IIb: 15	3 (1) yr	RT: 43; CT: 20	Mast + ALND
Rogers 2009	RCT	41	53 (9)	31 (6)	I: 29; II: 51; III: 20	33 (36) mo	Sx: 100; CT: 83; RT: 17; HT: 100	Current HT; Inactive
Rogers 2013	RCT	28	56 (11)	32 (5)	I: 54; II: 32; III: 14	74 (71) mo post diagnosis	Sx: 100; CT: 75; RT: 79; HT: 50	Inactive
Saarto 2012	RCT	498	IG, PreM: 46 (36 to 54); PostM: 58 (48 to 68); CG, PreM: 46 (35 to 57); PostM: 58 (46 to 68)	26 (0)	NR	IG, PreM: 33.5 (8.2); PostM: 33.9 (9.3); CG, PreM: 31.3 (9.2); PostM: 33.6 (8.7) wk	Sx: 100; CT: 91; RT: 78; HT: 84	–
Schmitz 2010	RCT	154	55 (12)	28 (0)	DCIS: 1; I: 56; II: 9; III: 34	IG: 39 (15); CG: 42 (16) m o post diagnosis	Sx: 100; CT: 71; RT: 76; HT: 35	≥2 nodes removed; No LD
Schneider 2007	Pre-post	96	56 (10)	BW (*kg*) A: 76 (19)	NR	NR	Sx: 99; CT: 50; RT: 43	–
Scott 2013	RCT	90	56 (9)	30 (0)	I/II/III	3 to 18 mo	Mast: 41; Lump: 59; CT: 56; RT: 83; HT: 78	BMI >25; Inactive

Table 1 (*Continued*)

Reference	Study design	Patient characteristics						
		n	Age (*yr*)	BMI (kg/m^2)	Stage (%)	Time since treatment	Treatment type (%)	Eligibility criteria
			mean (SD/range)	mean (SD)		mean (SD)		
Smoot 2010	Obs	144	56 (12)	26.1 (5)	NR	No LD: 5 (4) LD: 7 (6) yr post diagnosis	Lump: 57; Mast: 43; CT: 70; RT: 74	–
Sprod 2005	RCT	12	53 (3)	BW (*lb*) 179 (17)	NR	IG: 20 (5); CG: 26 (5) mo	Sx: 100; Mast: 92; CT: 83; RT: 58	–
Sprod 2010	Pre-post	114	59 (0)	BW (*lb*) 169 (11)	NR	IG3: 13 (1); IG6: 29 (1); CG: 35 (5) mo	CT: 60; RT: 40	–
Taylor 2010	RCT	260	55 (9)	31 (5)	IA: 42; IB: 3; IIA: 20; IIB: 2; IIIA: 23; IIIB: 0.1; DCIS: 6	5 (3) yr post diagnosis	Sx: 10; Sx+CT: 13; Sx+ RT: 26; Sx+ CT+RT: 49	BMI > 25.0
Tolentino 2010	Obs	22	49 (9)	27 (4)	IIA: 18; IIB: 41; IIIA: 41	<14 mo post diagnosis	Sx+CT+RT: 100	–
Tosti 2011	Obs	7	51 (3)	29 (1)	I: 14; II: 43; III: 43	< 6 mo	Sx: 100; CT: 71 RT: 86; HT: 86	–
Turner 2004	Pre-post	10	47 (8)	NR	NR	17 [a] (4 to 60) mo	Sx+CT+RT: 100	–
Twiss 2009	RCT	223	59 (8)	27 (4)	0/I/II	6 (6) yr	Sx: 98; RT: 45; CT: 68; HT: 50	BMD < –1.0; Inactive PostM
Wampler 2007	Obs	20	50 (9)	BW (*kg*) 68 (9)	NR	< 30 d	CT: 100	Taxane-based CT
Winters-Stone 2008	Obs	47	68 (7)	NR	0: 3; I: 37; II: 22; III: 7	8 (7) yr post diagnosis	RT: 58; CT: 37; HT: 48	>60 yr old
Winters-Stone 2011	Obs	59	59 (10)	28 (7)	0: 5; I: 29; II: 39; III: 19	< 2 yr	CT: 29; HT: 32; CT+HT: 39	< 70 yr, PostM
Winters-Stone 2012	RCT	106	62 (10)	IG: 30 (6) CG: 30 (6)	0: 6; I: 40; II: 42; III: 6	IG: 57 (40); CG: 65 (35) mo post diagnosis	CT: 60; RT: 88; HT: 57	> 50 yr at diagnosis; Inactive, PostM
Yuen 2007	RCT	22	54 (12)	NR	NR	9 d to 35 mo	Sx: 100; Mast: 41; Lump: 55; CT: 82; RT: 77	Inactive; Moderate fatigue

AI = Aromotase inhibitors, AET = aerobic exercise training, BW = body weight, BMI = Body Mass Index, CG = control group, CT = chemotherapy, HER-2/neu = human epidermal growth factor receptor 2, HT = hormonal therapy, IG = intervention group, Lump = lumpectomy, LD = lymphoedema, Mast = mastectomy, NR = not reported, Obs = observational study, Pre-post = pre-post non-randomised intervention, PreM = premenopausal, PostM = postmenopausal, RCT = randomised controlled trial, RET = resistance exercise group, RT = radiation therapy, SE = standard error, Sx = surgery, Tam = Tamoxifen.

[a] Median reported instead of mean.

Table 2
Normative values for common tests of physical function.

Aerobic capacity			
Cardiopulmonary exercise test, VO_2max *(mL/kg/min)*; females only [11]			
	Age 40 to 49	*Age 50 to 59*	*Age 60 to 69*
very poor	22.2 to 28.2	20.1 to 25.8	19.5 to 23.9
poor	29.4 to 32.3	26.8 to 29.4	24.6 to 26.6
fair	32.8 to 35.2	29.9 to 32.3	27.3 to 29.4
good	35.9 to 38.6	32.6 to 35.2	29.7 to 32.3
excellent	39.6 to 43.1	36.7 to 38.8	32.7 to 35.9
superior	45.3 to 51.1	41.0 to 46.1	37.8 to 42.4
6-min walk distance *(m)* in community dwelling adults, reported as mean (SD) [28]			
	Age 60 to 64	*Age 65 to 69*	*Age 70 to 74*
10th percentile	452.6	402.3	384.0
25th percentile	498.3	457.2	438.9
50th percentile	553.2	521.2	502.9
75th percentile	603.5	580.6	562.4
90th percentile	649.2	635.5	617.2
Upper extremity strength			
Grip strength *(kg)* [29]			
	Age 40 to 49	*Age 50 to 59*	*Age 60 to 69*
5th percentile	21.8	20.4	18.1
median	28.6	27.7	25.4
Bench press one repetition max *(weight pushed/body weight)* [11]			
	Age 40 to 49	*Age 50 to 59*	*Age 60+*
very poor	<0.35 to 0.42	< 0.31 to 0.38	< 0.26 to 0.36
poor	0.43 to 0.48	0.39 to 0.43	0.38 to 0.41
fair	0.50 to 0.53	0.44 to 0.47	0.43 to 0.46
good	0.54 to 0.60	0.48 to 053	0.47 to 0.53
excellent	0.62 to 0.71	0.55 to 0.61	0.54 to 0.64
superior	> 0.77	> 0.68	> 0.72
Elbow flexion *(kg)* obtained using hand-held dynamometry, reported as mean (SD) [42]			
	Age 50 to 59	*Age 60 to 69*	*Age 70 to 79*
dominant	17.0 (2.9)	16.0 (3.0)	14.1 (2.7)
non-dominant	16.3 (2.7)	15.4 (2.7)	14.4 (2.4)
Lower extremity strength			
Leg press one repetition max *(weight pushed/body weight)* [11]			
	Age 40 to 49	*Age 50 to 59*	*Age 60+*
well below average	0.94 to 1.02	0.78 to 0.88	0.72 to 0.85
below average	1.08 to 1.13	0.95 to 0.99	0.88 to 0.93
average	1.18 to 1.23	1.05 to 1.10	0.99 to 1.04
above average	1.29 to 1.37	1.17 to 1.25	1.13 to 1.18
well above average	> 1.48	> 1.37	> 1.32
Chair stands *(number in 30s)*, reported as mean (SD) [28]			
	Age 60 to 64	*Age 65 to 69*	*Age 70 to 74*
	13.3 (3.6)	13.7 (3.5)	12.8 (3.1)
Knee flexion *(kg)* obtained using hand-held dynamometry, reported as mean (SD) [42]			
	Age 50 to 59	*Age 60 to 69*	*Age 70 to 79*
dominant	17.2 (4.1)	16.0 (2.8)	14.0 (3.5)
non-dominant	17.3 (4.7)	15.6 (3.0)	14.4 (3.9)
Mobility			
Timed Up and Go *(s)*, reported as mean (SD)			
3-m course [43]	*Age 40 to 49*	*Age 50 to 59*	*Age 60 to 69*
	6.24 (0.67)	6.44 (0.17)	7.24 (0.17)
8-foot course [28]	*Age 60 to 64*	*Age 65 to 69*	*Age 70 to 74*
	5.4 (1.2)	5.6 (1.0)	6.0 (1.3)

Upper extremity muscular fitness

Grip strength was the most commonly used upper extremity function test; it was used in 26 studies (see Table 3 in the eAddenda). The mean of the grip strength data that could be pooled was 24.6 kg (95% CI 23.7 to 25.5) in women on treatment and 22.8 kg (95% CI 20.6 to 25.1) in women off treatment (Figure 7). These values fall below the median reported values of 27.7 kg for healthy adults aged 50 to 59 (Table 2).[29] No heterogeneity was identified (I^2 values < 20%).

1RM using a bench or chest press protocol was estimated in four studies and measured directly in four studies. The pooled mean for bilateral bench press 1RM was 20.9 kg (95% CI 17.0 to 24.7) in women on treatment and 23.9 kg (95% CI 21.0 to 26.8) in women off treatment (Figure 8). Moderate heterogeneity was identified (I^2 = 36%) for women off treatment. Normative values for 1RM are

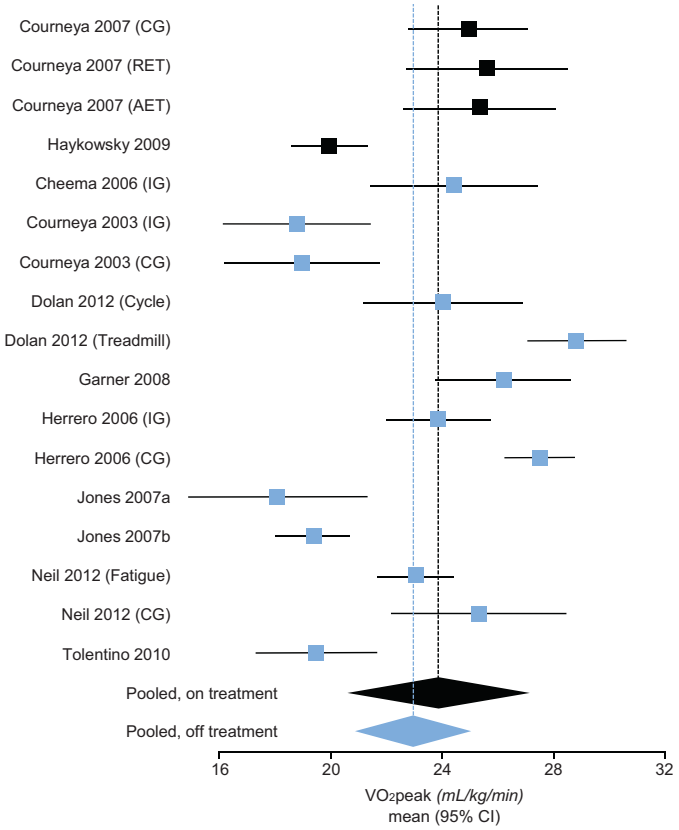

Figure 2. Forest plot of weighted mean (95% CI) VO_2peak corrected for body weight from a maximal exercise test. References to included studies are available in Appendix 2 in the eAddenda.
AET = aerobic exercise training, CG = control group, IG = intervention group, RET = resistance exercise training.

reported in weight pushed per kg of body weight, but for a woman weighing 70 kg, these pooled values fall into the 'very poor' category across all age groups (Table 2).[11] Other methods of assessing upper extremity strength include a bench press 6RM, bench press endurance with various protocols, and elbow flexion.

Lower extremity muscular fitness

The most commonly reported test of lower extremity strength was the 1RM for leg press, estimated in three studies and measured in five studies (see Table 4 in the eAddenda). The pooled mean for 1RM was 67.6 kg (95% CI 61.2 to 73.8) for women on treatment and 95.8 kg (95% CI 88.3 to 103.4) for women off treatment (Figure 9). Heterogeneity was found to be substantial for women off treatment only (I^2 = 69%). Reported normative values are reported in weight pushed per kg of body weight, but for a woman weighing 70 kg, values for women on treatment fall into the 'below average' category for women aged 50 to 59, while values for women off treatment fall into the 'above average' category for women aged 50 to 59 (Table 2).[11] A leg-press protocol was also used to measure maximum isometric contraction and muscle endurance. Other protocols requiring resistance-training equipment include knee flexion and knee extension machines. Chair stands were also used as a functional measure of lower extremity function (n = 7), although pooled analysis was not possible due to the heterogeneity of protocols used.

Mobility

The TUG test was used to evaluate functional mobility in two included studies (see Table 5 in the eAddenda). However, the results from the two are not directly comparable as they used two different protocols: one used an 8-foot course and the other a 3-metre course. In both studies, reported times were slower than population normative values for similar age groups (Table 2).

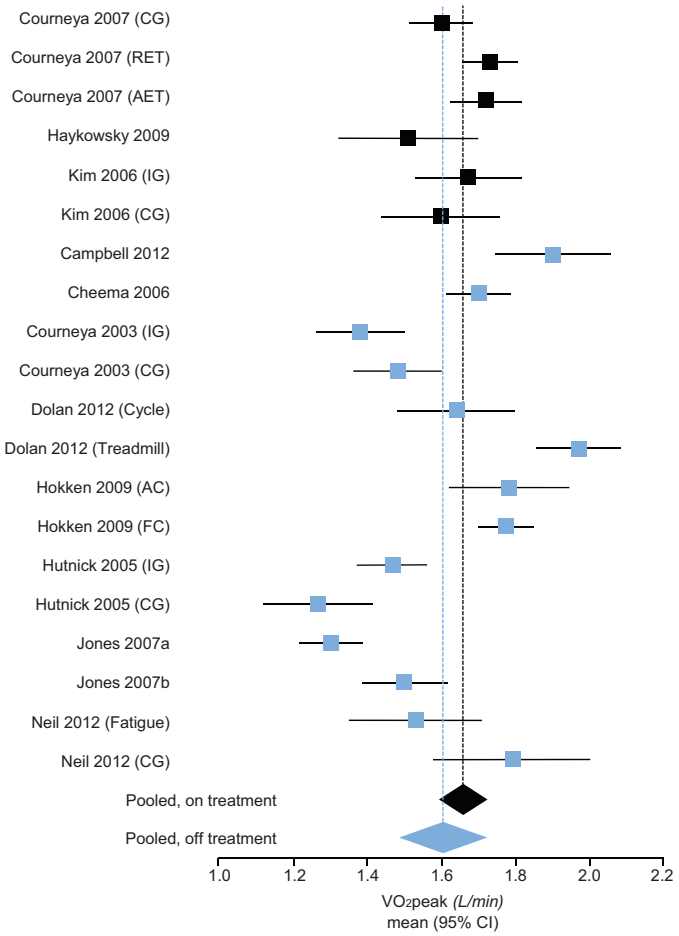

Figure 3. Forest plot of weighted mean (95% CI) VO_2peak from a maximal exercise test. References to included studies are available in Appendix 2 in the eAddenda.
AC = four cycles of adjuvant chemotherapy with doxorubicin/cyclophosphamide, AET = aerobic exercise training, CG = control group, FC = five cycles of 5-fluorouracil/epirubicin/cyclophosphamide, IG = intervention group, RET = resistance exercise training.

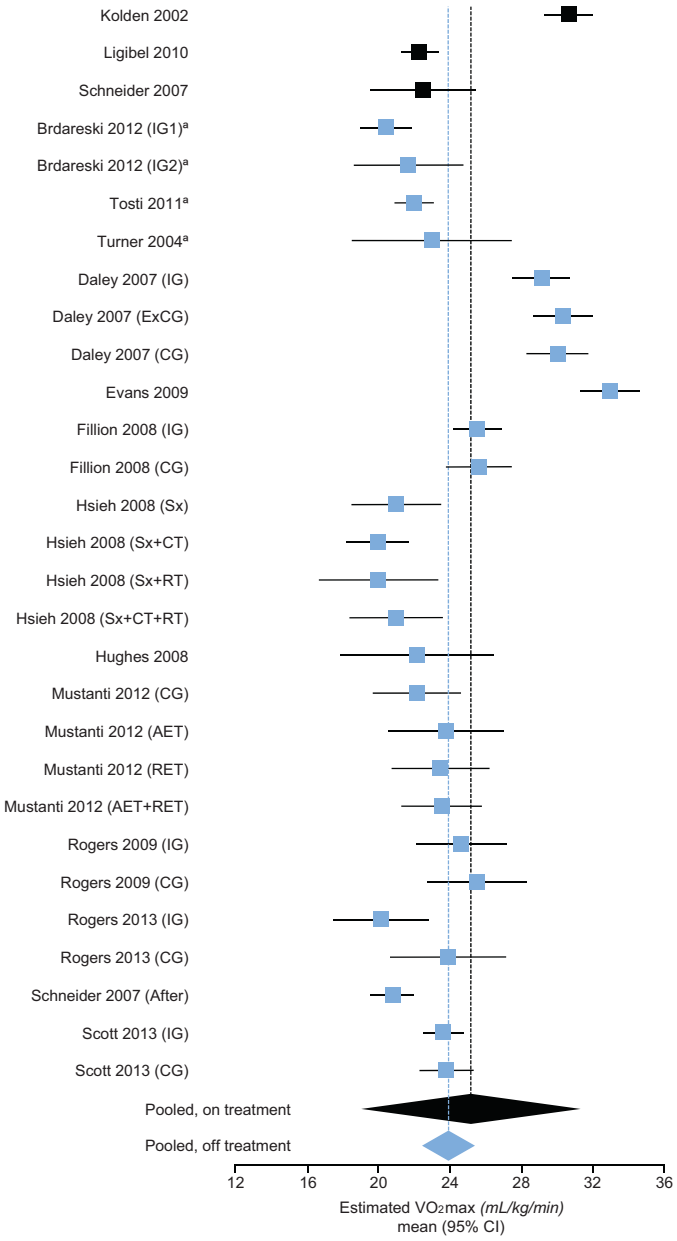

Figure 4. Forest plot of weighted mean (95% CI) VO_2max estimated from a submaximal exercise test. References to included studies are available in Appendix 2 in the eAddenda.
AET = aerobic exercise training, CG = control group, CT = chemotherapy, ExCG = exercise control group, IG = intervention group, RET = resistance exercise training, RT = radiotherapy, Sx = surgery. [a] Cycle ergometer.

Discussion

Monitoring physical function during and after cancer treatment may help physiotherapists and other health professionals to identify declines in physical function, and prescribe interventions to mitigate these declines and improve functional outcomes. We aimed to summarise the published values in the literature to date in order to provide clinicians with expected values in this population for the tests of physical function most commonly reported in the literature and to inform clinicians and researchers of testing options. A longer-term goal of the research is greater standardisation of testing in both clinical and research settings. We also aimed to compare the values that are currently being reported in women who have been diagnosed with breast cancer to normative values that have been published in healthy populations, with the goal of contextualising the physical function deficits experienced by women with breast cancer.

Reported values of aerobic capacity, upper extremity strength and mobility were generally lower than reported normative values in similar age groups. This was not surprising given the various side effects of cancer treatment and fatigue leading to decline in overall physical activity. Jones and colleagues compared VO_2peak between women with breast cancer at various stages of the disease and expected values for healthy sedentary women.[10] Similar to the findings of the present review, VO_2peak was much lower in women diagnosed with breast cancer than would be expected. Women in the Jones study who were 50 years old and diagnosed with breast cancer were on average 30% less aerobically fit, which is similar to the present review's finding that pooled mean reported VO_2peak values were 22 to 30% lower than published norms for those aged 50 to 59.

An important consideration when comparing results across studies is the age range of the participants. While mean ages were extracted from the papers included, individual level data would be needed in order to compare values of physical function amongst different age groups. For example, aerobic capacity has been shown to decline by approximately 9% per decade after the age of 50, so comparisons of mean VO_2peak values across a wide range of ages may not be appropriate.[30]

In the present meta-analysis, pooled values of all measures of aerobic capacity and grip strength were lower for women who were off treatment than women who were on treatment. The opposite was observed for bench press and leg press 1RM values. Findings from 1RM should be interpreted with caution, due to its substantial heterogeneity among women off treatment. The 1RM data were a combination of estimated and objectively measured values. It is possible that the predictive equations used to estimate

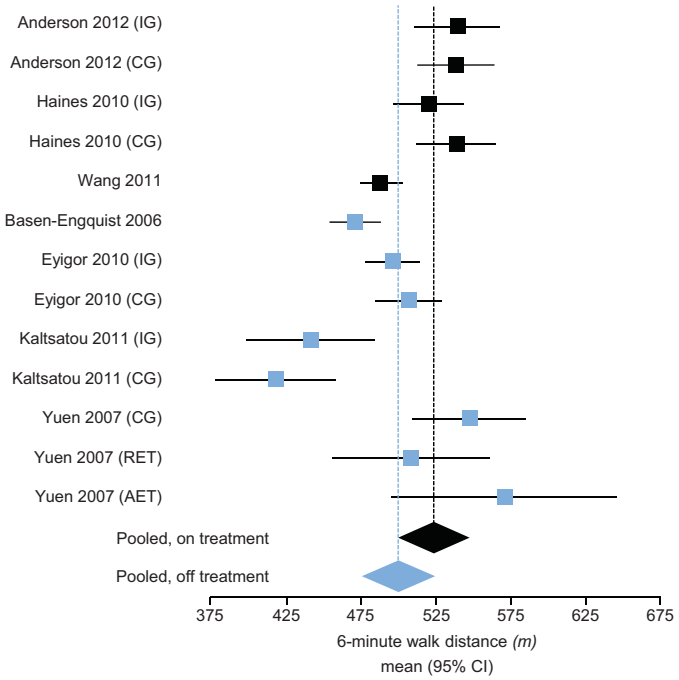

Figure 5. Forest plot of weighted mean (95% CI) 6-minute walk distance. References to included studies are available in Appendix 2 in the eAddenda.
AET = aerobic exercise training, CG = control group, IG = intervention group, RET = resistance exercise training.

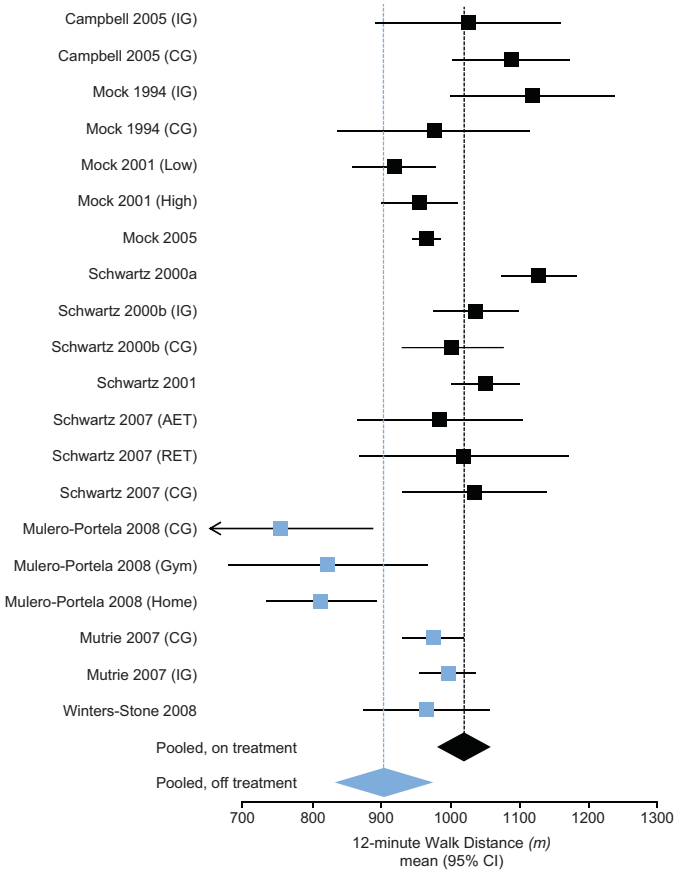

Figure 6. Forest plot of weighted mean (95% CI) 12-minute walk distance. References to included studies are available in Appendix 2 in the eAddenda.
AET = aerobic exercise training, CG = control group, IG = intervention group, RET = resistance exercise training.

1RM overestimated the true value. The timing of measurement also varied between studies, which should be kept in mind when comparing groups on and off treatment. Women classified as on treatment may have completed surgery, or been at any point

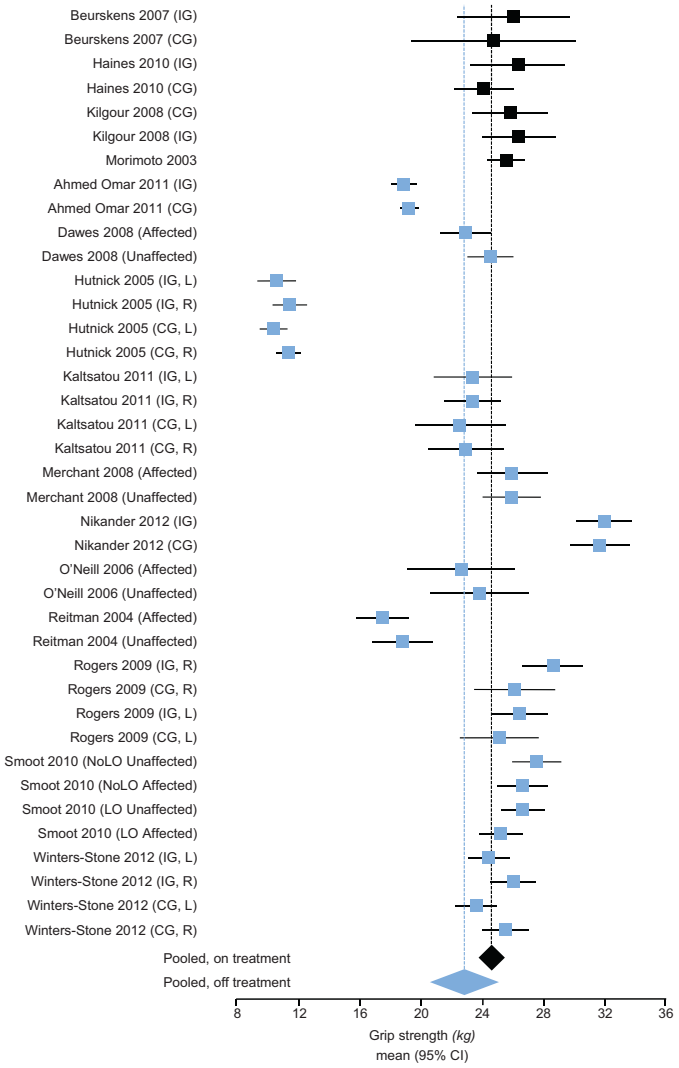

Figure 7. Forest plot of weighted mean (95% CI) grip strength. References to included studies are available in Appendix 2 in the eAddenda.
CG = control group, IG = intervention group, L = left, LO = lymphoedema, NoLO = no lymphoedema, R = right.

during chemotherapy or radiation; however, the majority were assessed at the beginning of chemotherapy treatment. Women classified as off treatment ranged from a few months to many years after treatment. Future observational studies repeating measures of physical function before, during, and after treatment are needed to more accurately determine the expected pattern of change in physical function throughout the cancer trajectory.

Another source of variation between studies was the specific testing protocol used. Submaximal and maximal exercise tests may be performed on either a cycle ergometer or a treadmill and may use a ramp or incremental protocol with a number of possibilities in length of test stage and workload increment per stage. Values for VO_2peak have been shown to be higher using a treadmill than cycle ergometer protocol in women diagnosed with breast cancer.[31] Values for upper and lower extremity strength, such as grip strength, maximal contraction for leg press, or knee flexion/extension, may be reported as average of three trials or maximum value obtained. There was also variation in the protocols used for assessing muscular endurance and the chair stand test, which prevented pooling of the results together. This highlights the importance of reporting full details of the testing protocol in order to determine whether comparisons can be made between studies.

Overall, 56 (66%) studies included some measure of aerobic capacity, indicating recognition of the importance of this component of health-related physical fitness. The most common method of measurement used was the gold-standard, maximal, cardiopulmonary exercise test, followed by a submaximal exercise test

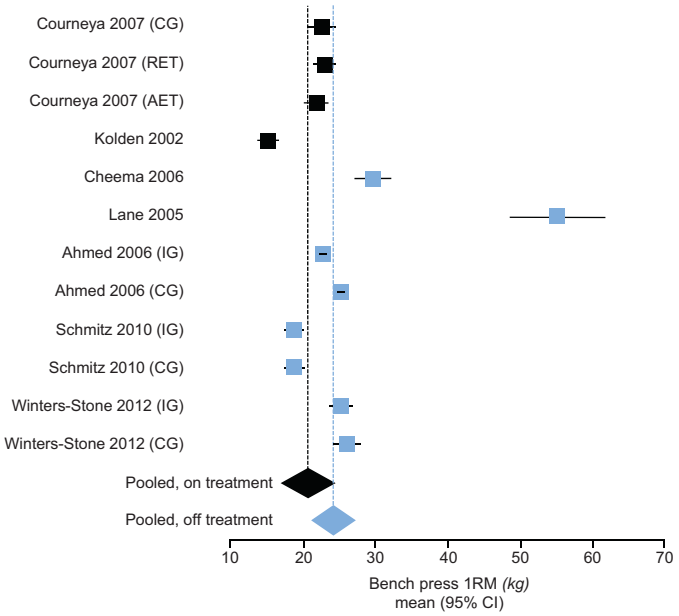

Figure 8. Forest plot of weighted mean (95% CI) one-repetition maximum (1RM) for bench press. References to included studies are available in Appendix 2 in the eAddenda.
AET = aerobic exercise training, CG = control group, IG = intervention group, RET = resistance exercise training.

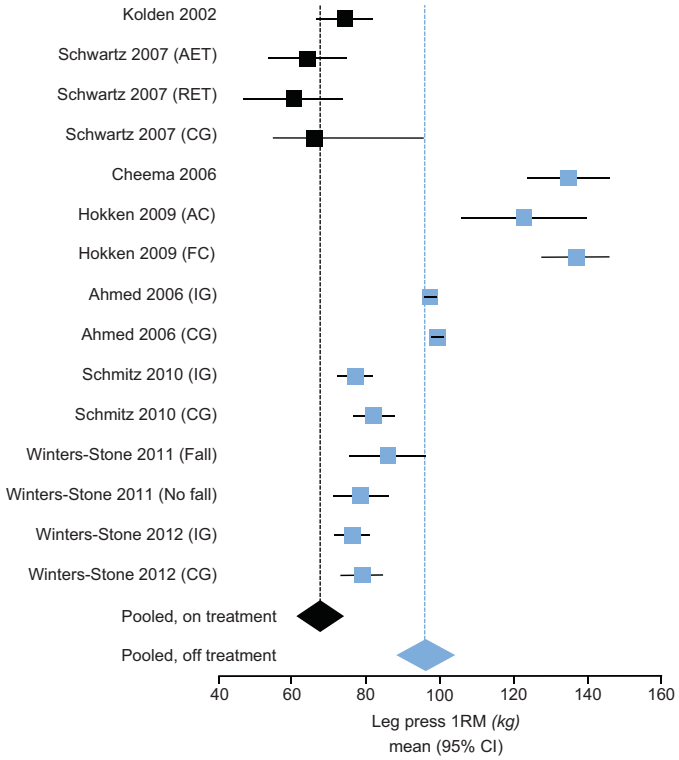

Figure 9. Forest plot of weighted mean (95% CI) one-repetition maximum (1RM) for leg press. References to included studies are available in Appendix 2 in the eAddenda.
AC = four cycles of adjuvant chemotherapy with doxorubicin/cyclophosphamide, AET = aerobic exercise training, CG = control group, FC = five cycles of 5-fluorouracil/epirubicin/cyclophosphamide, IG = intervention group, RET = resistance exercise training.

terminated at a specified percentage of age-predicted heart rate reserve or maximal heart rate. Although formal, large-scale assessment of the safety of the cardiopulmonary exercise testing procedure in individuals with cancer has not been performed, it does appear to be relatively safe with appropriate screening and monitoring during the test.[32] Submaximal exercise testing is considered to be a safer option, and may not require medical supervision, but is not as accurate for quantifying VO_2peak.[11] Finally, walking tests (6MWT and 12MWT) were commonly reported. Research is needed to determine if the 12MWT is a more appropriate test for capturing physical function in women with breast cancer than the 6MWT. It may be that women diagnosed with breast cancer have greater physical capacity than individuals in cardiac and pulmonary rehabilitation where the 6MWT is commonly used, and therefore may experience a ceiling effect with the 6MWT.[12]

Grip strength was the most commonly used measure of strength in this review and has been recommended as an assessment of muscle function for oncology rehabilitation.[33] Grip strength dynamometry is an attractive measure of strength in all populations due to its ease of use, reliability, generalisability to overall strength, and availability of published age and gender norms.[22] Additionally, grip strength is reported to be a significant predictor of health-related quality of life in breast cancer survivors.[34] While 1RM testing may be more sensitive and specific for strength training interventions, the small number of studies performing 1RM testing for upper body testing could be attributed to fear of musculoskeletal injury in a population likely to be naïve to strength training, and concern regarding risk of precipitating lymphoedema. However, guidelines from the American College of Sports Medicine published in 2010 advocate that 1RM testing is safe in women with breast cancer, even those with or at higher risk for lymphoedema.[35]

Only two studies included measurements of mobility. This may be because the TUG test and other mobility tests have been developed for and validated in older adults,[25] and thus may not be sufficiently sensitive to capture impairment experienced following breast cancer treatment. An alternative explanation is that mobility impairments following breast cancer and its treatment have not been widely recognised in the literature, and as a result few studies have measured this. Thus the utility of mobility testing in this population requires further investigation.

One limitation of this review is the likely presence of selection bias in the individuals included in the research studies, limiting the generalisability of these results to all women diagnosed with breast cancer. Due to the nature of the outcome measures of interest in this review, many of the studies included were physical activity interventions. While some studies did restrict eligibility to women who were sedentary or not currently exercising routinely, due to the nature of the intervention, these studies likely recruited a select group who were the most healthy or health-conscious. Other studies specifically limited their study populations to women who experienced functional limitations[36–40] or women with lymphoedema.[8,41] In these cases, values below those reported for the average woman diagnosed with breast cancer can be expected. Other studies excluded women with functional problems that may be worsened by exercise, such as shoulder pain. Therefore, we decided to include all relevant papers with the caveat that results from individual studies reported may be more relevant to different subgroups of women diagnosed with breast cancer, and the pooled meta-analysis may not be applicable to all women. As more research becomes available, future work should aim to analyse physical function in these groups of women separately.

One strength of this review is the inclusion of objective gold-standard tests of physical function, such as measured VO_2peak and 1RM testing for muscular strength. While these tests may provide the best assessment of physical function, they require the use of specialised, often expensive equipment and individuals who have been trained to conduct the testing. Therefore, submaximal and field tests to estimate maximal values are invaluable in clinical practice, and may also be quite useful in some research settings. A second strength is the meta-analysis used to combine data from multiple studies, which provides a general estimate of expected values in this population.

This review summarises the values that have been reported in the literature to date for various components of physical function,

namely aerobic capacity, upper and lower extremity strength and mobility in women diagnosed with breast cancer. Values for aerobic capacity and upper extremity strength are generally lower than published normative values in similar age groups. Lower extremity strength does not appear to follow this pattern, with values higher than population norms. This review also highlights the variety of tests used in the literature to assess physical function and the variations in testing protocols that may potentially contribute to the heterogeneity in values reported. Objective assessments of various aspects of physical function are important for documenting deficits in physical function and reporting change in response to specific interventions and monitoring individual progress in physiotherapy practice and research settings. As more research becomes available, expected values for sub-populations of different ages, stages of treatment and with various co-morbidities will be useful for both researchers and clinicians working with women after a breast cancer diagnosis.

What is already known on this topic: Breast cancer and its treatment can cause impairment in physical function in women.
What this study adds: Compared to normative data, women during and after treatment for breast cancer had reduced aerobic fitness. Upper and lower extremity strength was also reduced for women who were currently receiving cancer treatment. Lower extremity strength was above population norms for women who had completed treatment.

eAddenda: Tables 3, 4, 5 and 6, and Appendix 1 and 2 can be found online at doi:10.1016/j.jphys.2014.09.005

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Competing interests: Nil.

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