

ARTICLES

Conceptualizing and Measuring Physical Functioning in Cancer Survivorship Studies

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Purpose/Objectives: To propose a conceptual model to guide the design of intervention studies to improve physical functioning in cancer survivors.

Data Sources: Conceptualizations of physical functioning in people without cancer and exercise studies in breast cancer survivors.

Data Synthesis: Most exercise studies measured only one of three possible dimensions of physical functioning, and mediators seldom were tested.

Conclusions: Careful selection, naming, and measurement of physical functioning outcomes could maximize generation of new knowledge. More frequent testing of mediators could show how interventions affect physical functioning.

Implications for Nursing: Nurse scientists designing interventions to increase exercise, reduce symptoms, or manage side effects of treatment in cancer survivors are likely to measure physical functioning outcomes. Consistent measurement, terminology, and reporting of physical functioning outcomes in these studies will facilitate communication among nurse scientists and hasten translation of knowledge into clinical practice.

Key Points . . .

- ▶ Consistent naming and measurement of physical functioning outcomes in intervention studies of cancer survivors are important.
- ▶ Physical functioning can be measured in three distinct dimensions: (a) performance tests of objective mobility, (b) self-reported perceived mobility, and (c) self-reported participation in life activities.
- ▶ Interventions may improve one or more physical functioning dimensions, depending on whether the intervention improves capacity or reduces demand.
- ▶ Valuable knowledge could be gained by more frequent testing of mediator effects in intervention studies to improve physical functioning in cancer survivors.

Many cancer survivors report declines in their physical functioning, including basic body mobility and engagement in work and leisure activities, during cancer treatment and immediately after (Hann et al., 1999; Kriegsman, Deeg, & Stalman, 2004; Kroenke et al., 2004; Nomori, Watanabe, Ohtsuka, Naruke, & Suemasu, 2004; Syrjala et al., 2004). For some survivors, post-treatment physical functioning eventually returns to pretreatment levels, though recovery of full participation in life activities after cancer treatment may take many years, especially when symptoms persist long-term (Curt et al., 2000; Flechtner & Bottomley, 2003). Across cancer diagnoses and types of treatment, many adult survivors report that they have not fully regained their precancer levels of physical functioning or engagement in social, work, or leisure activities (Ganz et al., 2003). Several causes of long-term decrements in physical functioning have been explored in prior research, including symptoms such as fatigue, pain, and sleep disturbance as well as psychological factors such as depression (Curt et al.; Dodd, Miaskowski, & Paul, 2001; Nail, 2001, 2002; Schwartz et al., 2000; Stone et al., 2000; Visser & Smets, 1998).

In previous studies of cancer survivors, the absence of a clear, consistent definition of physical functioning has created confusion in the way that physical functioning was measured and the results were interpreted. Physical functioning is a broad concept that includes physical abilities that range from simple mobility to engagement in complex activities that require adaptation to an environment. If the physical functioning outcome measured in a study is not carefully selected, an intervention may be deemed ineffective when it might have been effective on a different dimension of physical functioning.

Another difficulty in interpreting physical functioning outcomes in research studies arises from the plethora of outcome names used, such as functional status, physical functioning, functional recovery, functional limitations, disability, quality

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Digital Object Identifier: 10.1188/06.ONF.41-49

of life, and others. Even when the same measure has been used, the different naming of outcomes in studies may cause confusion in understanding the literature, comparing studies, and bringing research findings into clinical practice. A final problem with earlier studies of exercise interventions in cancer survivors is that many failed to measure physical functioning at all but instead measured a more global quality-of-life outcome. In such a study, a physical functioning outcome might have shown a stronger effect from the intervention or might have explained how or why quality of life improved.

The conceptualization and measurement of physical functioning is particularly relevant to exercise intervention studies in cancer survivors. Preliminary evidence indicates that exercise improves physical functioning by controlling symptoms or by increasing physical fitness, such as aerobic capacity or increased muscle strength (Courneya, Friedenreich, et al., 2003; Mock et al., 1997; Schwartz, 1999; Schwartz, Mori, Gao, Nail, & King, 2001; Young-McCaughan et al., 2003), but the number of studies with strong methodology and adequate sample sizes is limited (Courneya, 2003). As research on the effects of exercise during cancer survivorship matures, careful selection of physical functioning measures will facilitate comparisons among studies and advancement of knowledge. Similarly, other interventions, such as reduction of symptoms or mitigation of treatment side effects, can be evaluated in terms of physical functioning by pinpointing the dimensions and measures that capture changes over time.

The purpose of this article is to propose a conceptual model for physical functioning that includes distinct measurable dimensions of physical functioning appropriate as outcomes in studies of cancer survivors. The model includes a conceptualization of interventions that affect particular dimensions of physical functioning, thus facilitating the selection of physical functioning outcomes in intervention studies. Exercise intervention studies in breast cancer survivors will exemplify use of the model to improve the measurement of physical functioning in future studies of cancer survivors.

History of Conceptual Models of Physical Functioning

In the past, conceptual models of physical functioning focused on a trajectory from illness to disability, a path that was expected to be more or less inevitable. Risk factors for poor physical functioning, such as symptoms, age, or health behaviors, were not incorporated into the model until the 1990s. The classic model of disability developed by Nagi (1976, 1991) consisted of four concepts ordered in a causal sequence: (a) pathology—a disruption of normal body processes, (b) impairment—physiologic loss or abnormality, (c) functional limitation—inability to perform an action or activity in a normal range, and (d) disability—inability to perform socially defined roles and activities. As disability research progressed, studies showed that a variety of factors, not just the medical conditions in the Nagi model, influenced physical functioning in healthy adults and in adults with chronic conditions. Verbrugge and Jette (1994) proposed the Disablement Process model that included risk factors that preceded Nagi's original four concepts. The Disablement Process also included personal factors and interventions that either mitigated or accelerated physical functioning declines over time (Femia, Zarit, & Johansson, 2001; Lawrence & Jette, 1996).

The authors propose a revised model of physical functioning, shown in Figure 1, that is specifically designed to guide intervention studies in cancer survivors. The proposed model not only retains evidence-based concepts from earlier disability models tested in older adults without cancer but also adds key predictors of physical functioning relevant to cancer survivors. The model should be useful in naming physical functioning concepts and selecting measures for studies of people at all stages of the survivorship experience, from diagnosis, through treatment, and beyond (National Cancer Institute Office of Cancer Survivorship, 2005).

Conceptual Model of Physical Functioning in Cancer Survivors

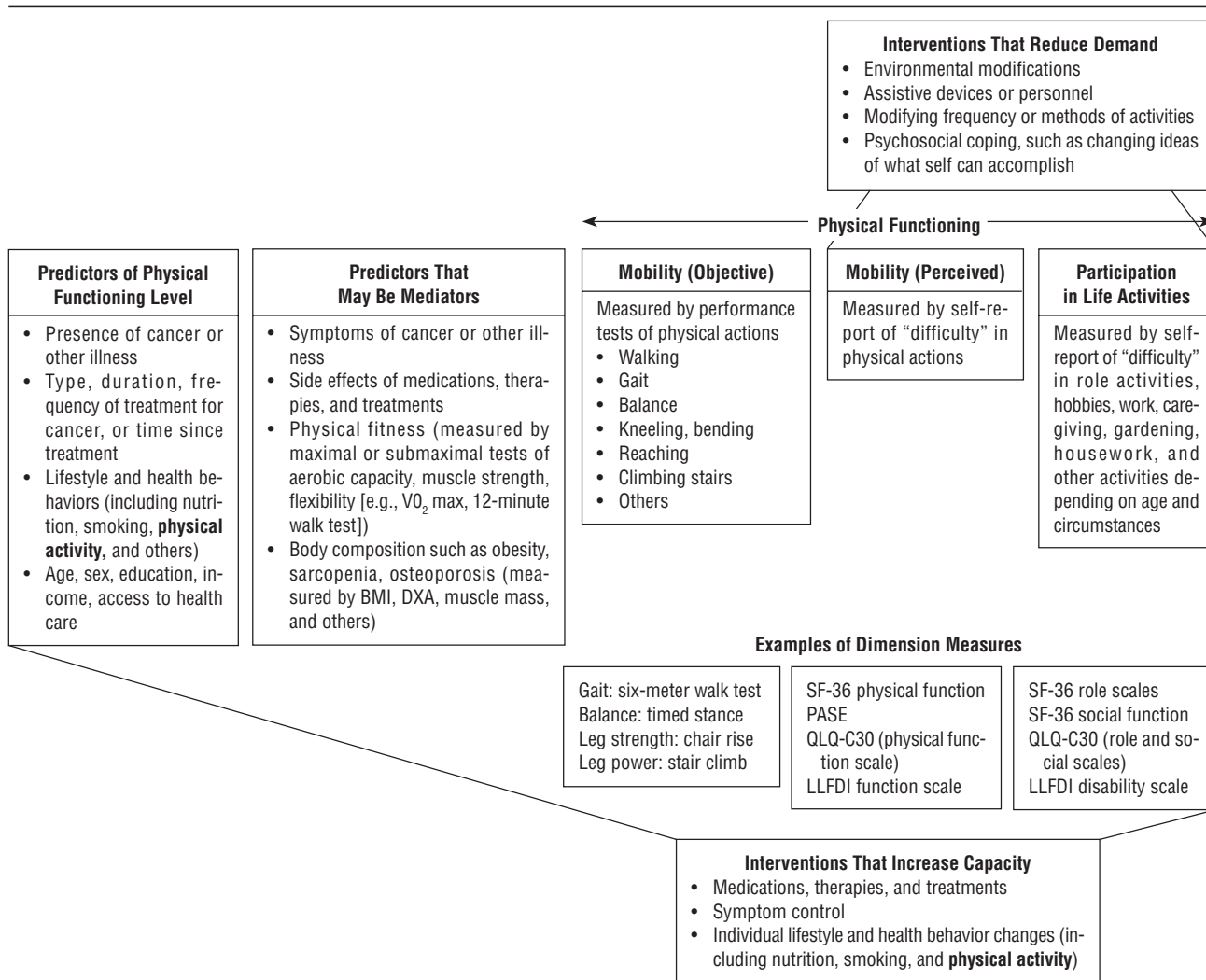
Physical Functioning of Cancer Survivors Can Improve as Well as Decline

Previous conceptual models of physical functioning have consisted of a main pathway that began with pathology and progressed through impairments, functional limitations, and disability. The proposed model eliminates the negative valence of the concept names, a change that has been suggested by researchers who study physical functioning in older adults without cancer (Lawrence & Jette, 1996; Stewart, 2003). To eliminate a presumed negative valence, the term “predictors” is used instead of “risk factors” because predictive factors may reduce rather than increase risk. “Physical functioning” replaces the traditional negative terms of functional impairment, disruption in function, functional limitations, and disability. For cancer survivors, removing the negative descriptors is important because it emphasizes the expectation that physical functioning will improve rather than decline following cancer treatment, depending on individual circumstances.

Predictors and Mediators of Physical Functioning in Cancer Survivors

The proposed model includes predictors of physical functioning that are germane to studies of cancer survivors but have not been included in prior conceptual models of physical functioning. For example, symptoms of cancer, modality and duration of cancer treatments, side effects of treatments, and health behaviors are likely to predict levels of physical functioning in cancer survivors during and after treatment.

Some predictors—symptoms, side effects, physical fitness, and body composition—may mediate the relationships between other predictors and physical functioning in cancer survivors. Previous conceptual models did not include potential mediators. A mediator is a predictor variable that explains a substantial portion of the relationship between another predictor and an outcome variable. For example, cancer treatment modalities (predictor) cause different side effects (mediator) that, in turn, can affect physical functioning (outcome or endpoint). Mediator effects can be tested using a variety of statistical methods (Baron & Kenny, 1986; Bennett, 2000; Holmbeck, 1997; MacKinnon & Dwyer, 1993), yielding valuable information about how relationships work or how interventions affect outcomes. Cancer studies seldom have reported on mediator effects, even when potential mediators were measured as predictor variables in a study. For example, even though studies in people without cancer have



BMI—body mass index; DXA—dual-energy x-ray absorptiometry; LLFDI—Late Life Function and Disability Instrument; PASE—Physical Activity Scale for the Elderly; QLQ-C30—European Organization for Research and Treatment of Cancer Quality of Life Questionnaire-Core 30; SF-36—Medical Outcomes Study Short Form-36; VO₂ max—maximal oxygen consumption

Figure 1. Conceptual Model of Physical Functioning in Cancer Survivors

shown that symptoms mediate the relationship between illness and physical functioning (Bennett, Stewart, Kayser-Jones, & Glaser, 2002; Rejeski, Ettinger, Martin, & Morgan, 1998; Stewart, 2003), symptoms seldom have been tested as mediators in cancer studies.

Body composition is a predictor that may be an important mediator of the effect of cancer treatments on physical functioning. Cancer treatments may cause changes in body composition, such as muscle wasting (sarcopenia), increased body fat, reduced bone mass, or dehydration. These body composition changes are likely to cause declines in physical functioning. To the authors’ knowledge, no study has assessed whether changes in body composition mediate the effects of cancer, other illnesses, cancer treatments, or health behaviors on physical functioning in cancer survivors, although some exercise studies (Kolden et al., 2002; Turner, Hayes, & Reul-Hirche, 2004; Waltman et al., 2003) have measured body composition as an outcome.

Physical fitness is likely to affect physical functioning in cancer survivors, and exercise studies routinely measure concepts such as aerobic capacity and muscle strength. Physical activity should not be confused with physical fitness; physical activity and exercise can be interventions to maintain or improve physical fitness but should not be used as a proxy for physical fitness. Physical fitness is a set of measurable attributes, such as aerobic capacity or muscle strength, that people have or achieve. Thus, physical activity or exercise (a predictor) may improve physical fitness (a mediator), which, in turn, may improve physical functioning.

Physical Functioning Has Three Distinct Dimensions, Allowing for More Precise Measurement of Intervention Effects

An important innovation in this model is the conceptualization of physical functioning in three distinct, measurable dimensions: objective mobility, perceived mobility, and participation

in life activities. In people without cancer, studies have shown that declines in physical functioning occur sequentially in the order they are placed in the authors' model, although this has not yet been tested in cancer survivors.

In older adults without cancer, early declines in physical functioning are measured easily by objective performance tests of mobility, such as an eight-meter walk or time to complete five chair rise-and-sits. These performance tests may show decrements before problems are reported by an individual; in earlier studies, they predicted declining ability to perform self-care activities, hospitalization, and nursing home admission four years later (Fried, Bandeen-Roche, Chaves, & Johnson, 2000; Fried & Guralnik, 1997; Guralnik et al., 2000; Guralnik, Ferrucci, Simonsick, Salive, & Wallace, 1995). Currently, performance tests of objective mobility rarely have been measured in studies of cancer survivors, but including them in future studies would serve three purposes: (a) as an early sign of later problems with physical functioning, (b) as a precise outcome measure of the effects of interventions intended to improve physical fitness rather than using a distal measure such as quality of life, and (c) as a mediator to explain how some interventions affect participation in life activities.

In the proposed model, the second dimension of physical functioning is perceived mobility. Conceptually, by the time a person perceives and reports problems with mobility, the decrements are more advanced than those shown by performance tests of objective mobility. Perceived mobility has been measured in studies of cancer survivors, often by the Medical Outcomes Study Short-Form 36 (SF-36) physical functioning scale (Demark-Wahnefried et al., 2004; Hodgson & Given, 2004; Kroenke et al., 2004). Perceived mobility is currently the most common measure of physical functioning in studies of cancer survivors.

The third dimension of physical functioning in the model is participation in life activities. Life activities include role and social activities, such as caregiving, volunteering, working, engaging in hobbies, and shopping. The activities are more complex than the basic mobility tasks in the other dimensions, requiring interactions in social and physical environments; thus, declines in life activities occur later than declines in mobility in people without cancer (Guralnik et al., 1995, 2000; Guralnik, Seeman, Tinetti, Nevitt, & Berkman, 1994; Guralnik, Simonsick, et al., 1994). Although no studies have yet confirmed this sequence in cancer survivors, mobility problems seem likely to cause difficulty in life activities (for example, a problem walking a block because of fatigue caused by cancer treatment may cause a person to give up visiting with friends). In research studies, the selection of a self-report measure of participation in life activities will depend on the age and abilities of the participants. For example, older adults might be asked about self-care activities of daily living, whereas younger adults could be asked about work, hobbies, sports, and household activities.

In some studies, measuring several, or all, dimensions of physical functioning could be useful. In the past, measuring only one dimension of physical functioning may have caused an intervention effect to be missed. For example, an intervention to introduce home modifications that measured only participation in life activities as the outcome, might miss an even stronger effect on perceived mobility (such as ease of walking if throw rugs are removed) because it was not

measured. Similarly, a performance test of objective mobility may be a useful adjunct to self-reported measures of physical functioning in long-term cancer survivors whose perceptions are susceptible to response shift as their internal standards change over time (Schwartz & Sprangers, 2000). Although all studies will not need measures of all dimensions, the model provides guidance on the sequence of physical functioning difficulties demonstrated in populations without cancer and thus provides a guide to selecting an outcome measure of physical functioning that is appropriate for a given intervention or a specific population of cancer survivors.

Interventions That Reduce Demand or Increase Capacity Affect Different Concepts in the Model

Lawrence and Jette (1996) suggested that interventions to maintain physical functioning work in two different ways: Some reduce demand on the body or environment, and some increase capacity of the individual for performing physical functioning tasks and activities. In the proposed model, interventions to reduce demand are shown as likely to affect perceived mobility and participation in life activities, whereas interventions to increase capacity may affect all concepts in the model.

Thinking about how an intervention affects physical functioning, by decreasing demand or increasing individual capacity, may help to clarify which outcome measures are appropriate for a particular study. For example, energy conservation interventions to reduce activities that cause fatigue in cancer survivors are expected to reduce demand, and appropriate outcomes would be perceived mobility or participation in life activities. In contrast, interventions to increase capacity would be appropriately measured by outcomes in any physical functioning dimension. In studies of interventions that increase capacity, an opportunity exists to test the mediating effects of physical fitness, symptoms, or other predictors if the intervention is designed to affect these concepts.

Exercise Interventions in Breast Cancer Survivors as an Example

A number of studies have demonstrated the beneficial effects of exercise interventions in reducing symptoms, improving perceived mobility, and improving quality of life in breast cancer survivors. Given this compelling but preliminary body of evidence, the authors selected exercise studies in breast cancer survivors to demonstrate the ways in which the proposed conceptual model could improve the design, analysis, and reporting of future studies.

Table 1 summarizes experimental and quasi-experimental studies that evaluated the effects of exercise or physical activity interventions in breast cancer survivors in terms of symptoms, physical fitness, physical functioning, or quality of life. Although quality of life is a global concept that is not included in the current model of physical functioning, most conceptualizations of quality of life include some aspect of physical functioning. Quality of life often is measured in exercise studies in breast cancer survivors. In some studies, it seems to have been used instead of a physical functioning outcome, so the authors included it in Table 1 to demonstrate the full spectrum of outcomes measured in this group of studies.

The physical functioning column headings shown in Table 1 represent study outcomes according to the dimensions in the

Table 1. Summary of Exercise Studies in Breast Cancer Survivors With Symptoms, Fitness, Physical Functioning, or Quality-of-Life Outcomes

Study Description		Predictors or Mediators		Physical Functioning ^a		
Study	Protocol	Fitness	Symptoms	Objective Mobility	Perceived Mobility	QOL
Experimental						
Courneya et al., 2003	RCT; N = 52; 15 weeks; aerobic	↑ aerobic capacity ^b (VO ₂ max) ↔ % body fat	↔ fatigue (FACT-B subscale)	–	–	↑ QOL (FACT-B)
MacVicar et al., 1989	RCT; N = 45; 10 weeks; aerobic	↑ aerobic capacity (VO ₂ max)	–	–	–	–
McKenzie & Kalda, 2003	RCT; N = 14; 8 weeks; resistance and aerobic	–	↑ vitality (SF-36 vitality scale)	–	↑ physical functioning (SF-36 scale)	↑ QOL (SF-36 general health scale)
Mock et al., 1994	RCT; N = 14; 4–6 months; aerobic	↑ aerobic capacity (12 MWT)	↔ symptom intensity (SAS)	–	↔ physical functioning (Karnofsky)	–
Mustian et al., 2004	RCT; N = 21; 12 weeks; tai chi	–	–	–	–	↑ HR-QOL (FACIT-F total score)
Neiman et al., 1995	RCT; N = 12; 8 weeks; aerobic and resistance	↑ aerobic capacity (6 MWT)	–	–	–	–
Pinto et al., 2003	RCT; N = 21; 12 weeks; aerobic	↔ aerobic capacity (VO ₂ max)	↔ fatigue (POMS subscale)	–	–	–
Segal et al., 2001	RCT; N = 99; 26 weeks; aerobic	↔ aerobic capacity (VO ₂ max)	–	–	↔ physical functioning (SF-36 scale)	↔ HR-QOL (SF-36 and FACT-B)
Winningham & MacVicar, 1988	RCT; N = 42; 10 weeks; aerobic	–	↓ nausea (SESC)	–	–	–
Winningham et al., 1989	RCT; N = 24; 10 weeks; aerobic	↓ % body fat	–	–	–	–
Quasi-experimental						
Kolden et al., 2002	One group; N = 40; 16 weeks; aerobic and resistance	↑ aerobic capacity (VO ₂ max) ↑ flexibility ↑ strength ↔ % body fat	–	–	–	↑ well-being; functioning (FACT-B, CARES, GAS, LFS)
MacVicar & Winningham, 1986	Three groups; N = 16; 10 weeks; aerobic	↔ aerobic capacity (VO ₂ max)	↔ fatigue or inertia (POMS subscale)	–	–	–
Mock et al., 1997	Nonrandom groups; N = 46; 6 weeks; aerobic	↑ aerobic capacity (12 MWT)	↔ symptoms (SAS) ↓ fatigue (PFS)	–	–	–
Mock et al., 2001	Nonrandom groups; N = 50; 6–36 weeks; aerobic	↑ aerobic capacity (12 MWT)	↔ fatigue (PFS, SCFS, POMS)	–	↔ physical functioning (SF-36 scale)	↔ QOL (SF-36 scales)
Mock et al., 2005	Nonrandom groups; N = 119; 6–36 weeks; aerobic	↑ aerobic capacity (12 MWT)	↓ fatigue (PFS)	–	↑ physical functioning (SF-36 scale)	–

(Continued on next page)

^a Participation in life activities, a component of physical functioning in the model, was not measured in any study.

^b Detected mediating effects of symptoms or fitness on QOL

6 MWT—6-minute walk test; 12 MWT—12-minute walk test; CARES—Cancer Rehabilitation Evaluation System; FACIT-F—Functional Assessment of Chronic Illness Therapy—Fatigue; FACT-B—Functional Assessment of Cancer Therapy—Breast; GAS—Global Assessment Scale; HR-QOL—health-related quality of life; LFS—Life Functioning Scales; PFS—Piper Fatigue Scale; POMS—Profile of Mood States; QOL—quality of life; RCT—randomized controlled trial; SAS—Symptom Assessment Scale; SCFS—Schwartz Cancer Fatigue Scale; SESC—Side Effect Symptom Checklist; SF-36—Medical Outcome Study Short Form-36; VAS-F—Visual Analogue Scale—Fatigue; VO₂ max—maximal oxygen consumption

Note. Arrows denote directional change (↓ = decrease; ↑ = increase; ↔ = no effect) for statistically significant (p < 0.05) between-group or within-group differences (depending on study design).

Table 1. Summary of Exercise Studies in Breast Cancer Survivors With Symptoms, Fitness, Physical Functioning, or Quality-of-Life Outcomes (Continued)

Study Description		Predictors or Mediators		Physical Functioning		
Study	Protocol	Fitness	Symptoms	Objective Mobility	Perceived Mobility	QOL
Schwartz, 1999	One group; N = 27; 8 weeks; aerobic	Aerobic capacity used to define exercisers	↔ side effects or symptoms (SESC) ↓ fatigue (SCFS, POMS vigor, VAS-F) ^b	–	–	QOL (QOL index for patients with cancer)
Schwartz, 2000a	One group; N = 27; 8 weeks; aerobic	Aerobic capacity defined exercisers	↓ fatigue days (VAS-F)	–	–	–
Schwartz, 2000b	One group; N = 78; 8 weeks; aerobic	Weight ↑ aerobic capacity (12 MWT)	↔ side effects or symptoms (SESC) or fatigue (SCFS)	–	–	–
Schwartz et al., 2001	One group; N = 72; 8 weeks; aerobic	Aerobic capacity defined exercisers	↓ fatigue (VAS-F)	–	–	–
Turner et al., 2004	One group; N = 10; 8 weeks; aerobic and resistance	↔ aerobic capacity (VO ₂ max)	↔ fatigue (PFS)	–	–	↑ QOL (FACT-B)
Waltman et al., 2003	One group; N = 21; 12 months; resistance plus supplemental calcium, vitamin D, alendronate	↔ % body fat ↑ hip and spine bone density ↓ forearm bone density ↑ muscle strength	–	↑ dynamic balance (backward tandem walk)	–	–

^a Participation in life activities, a component of physical functioning in the model, was not measured in any study.

^b Detected mediating effects of symptoms or fitness on QOL

6 MWT—6-minute walk test; 12 MWT—12-minute walk test; CARES—Cancer Rehabilitation Evaluation System; FACIT-F—Functional Assessment of Chronic Illness Therapy—Fatigue; FACT-B—Functional Assessment of Cancer Therapy—Breast; GAS—Global Assessment Scale; HR-QOL—health-related quality of life; LFS—Life Functioning Scales; PFS—Piper Fatigue Scale; POMS—Profile of Mood States; QOL—quality of life; RCT—randomized controlled trial; SAS—Symptom Assessment Scale; SCFS—Schwartz Cancer Fatigue Scale; SESC—Side Effect Symptom Checklist; SF-36—Medical Outcome Study Short Form-36; VAS-F—Visual Analogue Scale—Fatigue; VO₂ max—maximal oxygen consumption

Note. Arrows denote directional change (↓ = decrease; ↑ = increase; ↔ = no effect) for statistically significant (p < 0.05) between-group or within-group differences (depending on study design).

proposed conceptual model. If a mediator effect was analyzed in a study, it is indicated in the column of the mediating variable. In general, this analysis shows that exercise interventions improved fitness, perceived mobility, and quality of life in breast cancer survivors, though not all studies measured these concepts. In future studies, the utility of research findings for clinicians and other researchers could be improved if researchers use consistent names for the dimensions of physical functioning, adopt conceptually clear measures for the dimensions, and test mediator effects when appropriate.

Careful Selection, Naming, and Measurement of Outcomes

Table 1 indicates that most studies of exercise in breast cancer survivors measured perceived mobility as the only dimension of physical functioning. Careful selection of the appropriate dimension of physical functioning (or more than one dimension) could increase researchers’ knowledge about the specific effects of predictors or interventions. In contrast, selection of an inappropriate measure of physical functioning may result in missing a relationship that actually exists. For example, in Table 1, many studies measured physical fitness (although some studies incorrectly called it physical functioning or functional ability) by aerobic capacity. However, no study measured objective mobility using performance

tests, which would be a logical, closely related outcome of improved aerobic capacity. Instead, researchers commonly used self-reported measures of perceived mobility, usually the SF-36 physical functioning scale. Perceived mobility can be affected by more factors, such as response shift or reporting bias, and therefore is less likely to be affected by an increase in physical fitness, such as aerobic capacity (Mock et al., 1994, 2005; Segal et al., 2001). Performance tests of objective mobility are appropriate measures of an intervention intended to increase aerobic capacity, muscle strength, and other physical fitness domains. Performance tests are quite easy to include in research studies, especially when study participants are coming to a site for a structured exercise intervention. Short, timed tests, such as walks, chair rise-and-sits, and stair climbing, have been developed for adults without cancer (Guralnik et al., 2000; Guralnik, Seeman, et al., 1994; Guralnik, Simonsick, et al., 1994). They take little time and can be conducted by a trained lay person. In some studies, measuring objective mobility might have produced a stronger relationship between the exercise intervention and a physical functioning outcome and certainly would have been preferable to skipping physical functioning dimensions entirely and measuring quality of life, as was done in some studies (Kolden et al., 2002; Schwartz, 1999; Turner et al., 2004).

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Discussion

All studies of exercise in breast cancer survivors failed to include a measure of participation in life activities. This should be an important outcome for cancer survivors, and questions about these activities would be appropriate for every study, although the specific measure might change depending on the particular study (e.g., whether middle-aged adults return to work, whether older adults engage in activities of daily living). Participation in life activities is the dimension of physical functioning that is conceptually closest to global quality of life. Some researchers argue that a quality-of-life scale substitutes for participation in life activities, but quality of life scales such as the Functional Assessment of Cancer–Breast and the full SF-36 include a variety of items about symptoms, cognition, physical functioning, social functioning, emotional well-being, and more. These dimensions are likely to be influenced by factors other than exercise, making it more difficult to establish a statistically significant link between exercise and improved quality of life. For exercise studies, including at least one measure of physical functioning is logical, even if quality of life also is measured.

Several studies shown in Table 1 failed to measure outcomes beyond physical fitness. Although exercise improved fitness in cancer survivors, knowing whether physical functioning outcomes changed as well would be helpful. Fitness measures are important indicators of the physiological results of exercise, but the effects of improved fitness on mobility or participation in life activities is even more important.

Testing Mediator Effects of Predictors

In studies with an array of predictor variables, failure to consider analysis of mediator effects among those variables is a missed opportunity. For example, the results of several studies in Table 1 showed that exercise affected fitness, symptoms, and physical functioning or quality of life. If mediator effects had been tested in those studies, researchers could describe the specific mechanism—increase in fitness, reduction in symptoms, or both—that explained how exercise produced the beneficial effect on physical functioning or quality of life. Understanding these mechanisms could provide information beyond simple associations between variables. Two studies in Table 1 tested mediator effects. One showed that 15 weeks of cycle exercise was sufficient to increase cardiopulmonary fitness, which, in turn, improved quality of life in breast cancer survivors post-treatment (Courneya, Mackey, et al., 2003). The other showed that eight weeks of home-based aerobic exercise reduced fatigue, which then improved quality of life in breast cancer survivors undergoing chemotherapy (Schwartz, 1999). These two studies are not enough to confirm whether short- or long-term programs of exercise have an equal effect on quality of life or whether reduction of symptoms or increase in physical fitness is a more important mechanism. If more studies test mediator effects in the future, conclusions may be drawn that could influence the design of future studies or clinical programs or help identify which cancer survivors are likely to benefit from exercise.

Moving work on exercise interventions in cancer survivorship forward requires increased specificity in the conceptualization and operationalization of physical functioning as an outcome of intervention studies, especially exercise studies. The model presented ties together several threads that appear in the literature on physical functioning in adults without cancer and challenges investigators and clinicians to refine the model to incorporate concepts germane to the study of cancer survivors.

Exercise studies in breast cancer survivors were used as an example in this article because most research on exercise interventions in cancer has been in this population (Courneya, 2003). Examination of those studies shows opportunities to increase the understanding of how exercise interventions work in cancer survivors. In prior studies, selection of outcome concepts has been inconsistent, with some measuring symptoms and quality of life, some measuring symptoms and perceived mobility, some measuring symptoms only, and some measuring quality of life only. Physical functioning, when measured as an outcome, almost always was measured by perceived mobility, whereas including performance tests of objective mobility might have yielded a stronger association between interventions and improved physical functioning. Overall, evidence of benefits from exercise in breast cancer survivors is piecemeal at best, showing that some symptoms, self-reported physical function, and global quality of life improve in some studies and not in others.

The proposed conceptual model of physical functioning could guide future research in cancer survivors. Although this article focused on exercise intervention studies, the model should be equally useful in selecting physical functioning outcomes for other intervention studies. Interventions that increase capacity could be evaluated in all three dimensions of physical functioning to identify the most potent effect. In general, skipping physical functioning outcomes altogether and measuring only global quality of life produces little useful information because so many other factors could affect quality of life.

For exercise studies, use of a common model for outcome measurement in terms of physical functioning would aid in comparing the results of studies and eventually reaching a consensus on the role of exercise in cancer survivorship. Future studies that compare different types of the same intervention—for example, resistance versus aerobic exercise—may show that dimensions of physical functioning are affected differentially. Importantly, working within a conceptual framework will help the research community compare the results of various studies and develop a precise recommendation that ultimately can be adopted into clinical practice guidelines for type, dose, and timing of exercise programs for cancer survivors.

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