A Framework for Assessment in Oncology Rehabilitation

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Although the incidence of cancer in the United States is high, improvements in early diagnosis and treatment have significantly increased survival rates in recent years. Many survivors of cancer experience lasting, adverse effects caused by either their disease or its treatment. Physical therapy interventions, both established and new, often can reverse or ameliorate the impairments (body function and structure) found in these patients, improving their ability to carry out daily tasks and actions (activity) and to participate in life situations (participation). Measuring the efficacy of physical therapy interventions in each of these dimensions is challenging but essential for developing and delivering optimal care for these patients. This article describes the acute and long-term effects of cancer and its treatment and the use of the World Health Organization's *International Classification of Functioning, Disability and Health* (ICF) as a basis for selection of assessment or outcome tools and diagnostic or screening tools in this population.

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Cancer has a high incidence in the United States, where 46% of all males and 41% of all females can expect to develop either an invasive or *in situ* cancer.[1] An estimated 1.4 million new cases of cancer are diagnosed each year, with nearly 13,500 of these cases occurring in individuals younger than 20 years of age.[2] In years past, survival following a diagnosis of cancer was problematic; however, dramatic progress in the ability to diagnose cancers earlier and to provide more-effective and targeted treatments has led to substantial increases in survival. The National Cancer Institutes Surveillance, Epidemiology, and End Results Program estimates that 65.3% of adults diagnosed with cancer between the years 2001 and 2005 will survive for at least 5 years.[1] In addition, about 80% of people younger than 19 years of age who are diagnosed with cancer today are expected to survive for 5 years or longer.[1,3] All told, an estimated 10 million people are living in the United States today who have or have had a diagnosis of cancer.[1] As the population ages and treatments improve, these numbers are expected to continue to rise. Currently available medical interventions for cancer are designed to eliminate or control disease by suppressing cell growth (chemotherapy, irradiation) or directly removing the tumor (surgery).[4–15] These treatments may lack specificity and can damage normal tissue.[16–19] Thus, cancer is no longer an acute disease, with mortality as the primary outcome. Rather, treatment successes have made cancer a chronic disease, with many survivors developing significant sequelae to either the disease itself or to the treatment.[20–23]

Oncology rehabilitation has long been a part of the management of cancer, but with increased survivorship, these efforts have evolved from simple supportive and palliative care to now include complex rehabilitation interventions designed to restore the integrity of organ structure and function, to remediate functional loss, and to adapt to the environment so as to allow full participation in daily activities and life roles. In the current medical environment, demonstrating treatment efficacy by means of quantifiable outcome measures is increasingly important. As such, the expansion of interventions provided to patients with cancer and survivors of cancer must be accompanied by the appropriate application of new and existing measures. Because the information generated by these tools may be seen by many health care professionals and can extend across broad spans of time, the utility of such information is greatest when it is presented within a framework of standardized language and concepts. Such a framework can be found in the *International Classification of Functioning, Disability and Health* (ICF).[24] This classification system is designed to describe health and health-related status from biological, personal, and societal perspectives. Disorders across the domains of body structure and function, activities, and participation are referred to as impairments, limitations, and restrictions, respectively. "Functioning" is an umbrella term that encompasses these 3 domains. Health conditions or disease states, personal factors, and the environment interact with these constructs to determine whether disordered functioning will result in disability.[24]

The primary purpose of this article is to use the ICF framework and its language to describe outcome measures and diagnostic screening tools that the rehabilitation therapist will find useful in assessing patients with an oncology diagnosis. Some of these outcome measures may be new to therapists; others may already be part of their routine assessment. However, factors unique to a diagnosis of cancer or to its treatment may influence how and when such routine measures are used. Thus, the second purpose of this article is to provide greater understanding of the clinical issues common to the oncology population. Collectively, we hope to improve clinical care, facilitate communication across different rehabilitation disciplines, and encourage further study in the area of oncology rehabilitation.

The ICF Function Classification Framework

The ICF was developed by the World Health Organization[24] to provide a framework to describe health and health-related states and to suggest standardized language to describe these states. The ICF framework (Figure) is increasingly being used in the rehabilitation field and has recently been endorsed by the American Physical Therapy Association (APTA) House of Delegates for incorporation into all relevant Association publications, documents, and communications.[25]

Based on the work of Nagi,[26,27] the ICF model shifts the focus of disablement from cause to impact, from disability to health and function, and from a static process to a dynamic process.[24,28] As stated previously, the ICF defines 3 domains of human function (Figure): body function and structure, activity, and participation. *Body function and structure* refers to the anatomical and physiological function of the body systems, and these body functions and body structures are categorized into the subdomains listed in the Figure. Deficits in this domain are called "impairments" (eg, muscle weakness, restricted joint motion, poor cardiorespiratory fitness) and often are identified, measured, and treated by physical therapists. The activity domain describes the ability of an individual to perform specific tasks such as sweeping the floor, raking the yard, or putting away groceries. Dec-

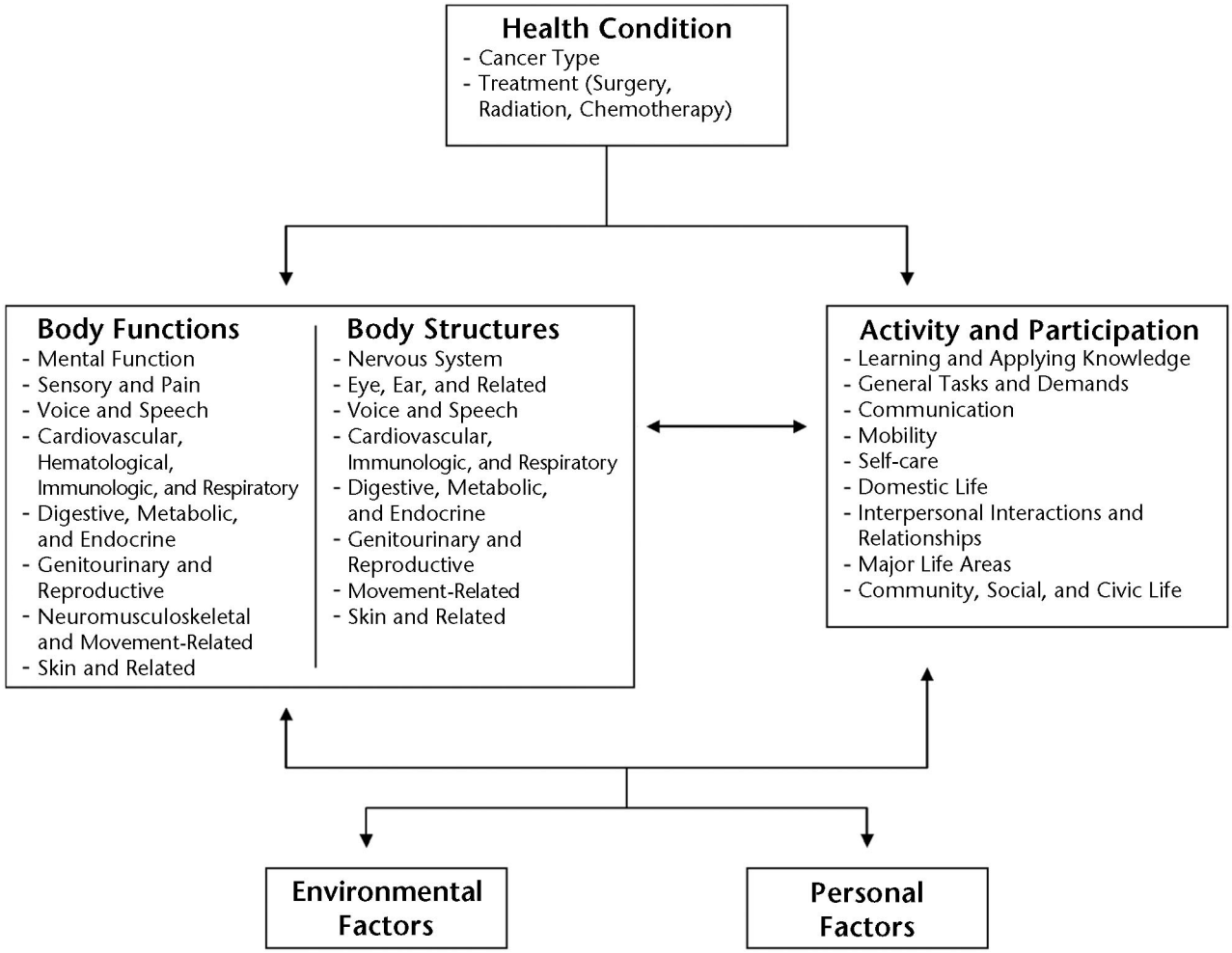

Figure.
International Classification of Functioning, Disability and Health (ICF) model[24] modified for populations of people with cancer. Modified and reprinted with permission of the World Health Organization from: *International Classification of Functioning, Disability and Health: ICF.* Geneva, Switzerland: World Health Organization; 2001.

rements in the activity domain are called "limitations" and describe the difficulty an individual has performing a particular task.[24] Physical therapy goals often are aimed at reversing or normalizing such activity limitations. The participation domain describes the ability of a person to be involved in life situations. Participation restrictions describe the reduced ability of a person to maintain normal role functions and interact with society.[24,29,30] Physical therapy interventions are designed, directly or indirectly, to enhance participation levels for every client at home, school, or work; on the athletic field; or in any community setting. The activity and participation subdomains are given as a single list (Figure), and their use will be discussed in the "Measurement of Activity and Participation" section of this article.

In the ICF model, health conditions, personal factors, and the environment interact dynamically across the 3 domains of body function to help determine whether disordered function results in disability. For example, if a cancer treatment (eg, chemotherapy) causes a patient to develop unresolved peripheral neuropathy and ankle weakness,[31] this patient may have a limited ability to walk (limitation) and may require long-term use of an ankle brace. Limited ability to walk could result in an employment restriction for a firefighter, but not for a computer programmer. Participation restrictions occur when activity limitations cannot be sufficiently overcome to maintain role functions in the person's normal environment.[29,30]

Formal work is emerging that uses the ICF classification scheme to de-

scribe overall function of populations who have specific chronic health conditions, including, but not limited to, multiple sclerosis,[32] stroke,[33,34] osteoarthritis,[35] diabetes,[36] low back pain,[37] obesity,[38] osteoporosis,[39] and rheumatoid arthritis.[40,41] This growing body of literature uses the ICF framework to identify measurements relevant to a specific illness. The ICF Core Sets provide clinicians and researchers with comprehensive but concise measurement categories that describe a patient's global function from a biopsychosocial view. Some investigators[42–46] have used the ICF Core Sets as the comparison standard for the assessment of function and disability when evaluating the content of a previous or newly developed measurement tool.

A limited number of ICF Core Sets have been developed for patients with head and neck cancer[47] and breast cancer.[48] Although the ICF Core Sets have not been widely used in the US physical therapy or oncology communities, the ICF framework is a useful model for describing global function in patients with a new or previous cancer diagnosis.[49] Consideration of the interaction among cancer as a health condition, impairments in body function and structure, activity limitations, and participation restrictions in the context of the person and the environment are essential to the design of an effective oncology rehabilitation intervention.[50]

Selecting Appropriate Measures

In this article, we describe measures as potential descriptors of particular ICF function domains. We encourage therapists to use this schema to assist them in deciding which measures to include in their baseline, continuing, and final outcome assessments of their patients and clients. To do this, the therapist should review the primary goals of the intervention and determine how these goals fit into the ICF domains. That is, which of the ICF domains is the intervention intended to affect? If the intervention is designed to make a change at the tissue level, then the appropriate measure would assess a specific change at the body function and structure level. For example, a patient with restricted shoulder mobility (decreased range of motion [ROM]) after a mastectomy may be treated with a regimen of stretching and scar tissue mobilization where the intended outcome is lengthened tissue, making ROM an appropriate measure. By increasing ROM, this intervention also may improve the patient's ability to reach overhead, making certain daily tasks possible (an activity-level measure), which, in turn, may increase the patient's ability or willingness to engage in life activities such as work or education (a participation-level measure). In this example, outcome measures at each level would be appropriate, and such information would speak to the efficacy of the intervention across functional domains.

Selecting an outcome measure also requires consideration of the psychometric properties of the instrument or tool the therapist is planning to use. Validity, reliability, and responsiveness are 3 properties the therapist should consider.[51] The measure should make sense (face validity), be accepted by experts in the field (content validity), and correlate with an expected outcome (predictive validity) and with other measures that evaluate the same construct (concurrent validity). The instrument should yield the same results (reliability) when repeated by separate examiners (interrater reliability), by the same examiner on the same patient (intrarater reliability), or on separate occasions within a time period when no changes would be expected (test-retest reliability). The therapist also will want to select an instrument that is capable of detecting change resulting from an intervention (responsiveness).[51] Instruments that place individuals into a limited number of categories,[51] such as the Functional Independence Measure,[52] tend not to be responsive because very large changes are required to move from one category to another. Additionally, instruments should not have a ceiling effect. If many respondents initially score at the highest level, there is no room for improvement, and change will not be detected.[51]

It is important to understand that the psychometric properties of validity for diagnostic and screening measures are different than for outcome measures.[53] Clinicians need to know how accurate the diagnostic tool is in identifying the presence or absence of the target condition. Often a new tool is compared with a gold standard, and its validity is described using sensitivity and specificity. *Sensitivity*, often referred to as a "true positive rate," is defined as a test's ability to correctly identify the target condition when the target condition is present. A high sensitivity is desirable, as it will rarely miss someone who has the condition. *Specificity* describes a test's ability to identify those without the target condition who really do not have the target condition, a "true negative rate." If an instrument has a high specificity, then this instrument will rarely test positive when a person does not have the disease (ie, a low chance of false positive predictions).

In this article, we provide examples of measures that are relevant to particular impairments, limitations, and restrictions experienced by patients with cancer or survivors of cancer. The list is not exhaustive and is not restricted by documented reliability, validity, or responsiveness of the particular instrument; however, it

does include instruments commonly used by physical therapists, some specifically developed for oncology populations. When choosing a measurement tool, the therapist should investigate its psychometric properties in relation to the population of interest. The references given in Tables 1, 2, and 3 provide a starting point for those searches.

Measurement of Body Function and Structure

The specific tests and measures used by the physical therapist to measure body function and structure in patients with a cancer diagnosis often are not unique to the assessment of this population. However, these measures provide relevant information about cancer-related impairments, prognostic considerations, and safety factors. This section highlights some common cancer-related changes in body function and structure and suggests some appropriate measurement tools for assessing these impairments.

Mental Functions

Mental functions (Tab. 1, Mental Functions), although not the primary interest of most physical therapists, play an important role in determining how best to interact with and provide interventions for our patients. Both radiation and chemotherapy can alter the structure and function of the central nervous system and may result in impaired mental function in patients during or following treatment for their cancer.[54–65] Specific mental function sequelae, including impaired memory and difficulty with sustained attention (concentration), may be evident years after treatment.[58,66] Proposed mechanisms for these impairments include chemical toxicity, oxidative damage, inflammation, and destructive autoimmune responses.[67–69] The Mini-Mental State Examination[70] is a simple tool for screening mental functions and has been used by physical therapists. Although an array of more-complex and detailed neuropsychological tests are available to measure the various domains of cognitive function, information is lacking regarding the sensitivity and specificity of the tests to detect changes in cognitive function from chemotherapy. The identification of sensitive neuropsychological tests is crucial to further understanding of chemotherapy-induced cognitive impairments.[71]

Emotional functions also may affect the ability of a patient to participate in the physical therapy intervention. A tool that has been used to evaluate emotional functions in patients with cancer is the Profile of Mood States.[72,73] This self-report instrument is easy to use and may provide insight into our patient's ability to respond to and participate in a physical therapy program.

Sensory Functions and Pain

Table 1 (Sensory Functions and Pain) describes several potential measures for vestibular, somatosensory, and pain impairments. These impairments are common in patients who are undergoing cancer treatment or have a history of cancer.

Hearing and vestibular functions can be affected by tumor growth or by chemotherapy. Although auditory impairments are infrequently targets of physical therapy assessment, vestibular impairments and their relationship to balance dysfunction should be considered. Vestibular schwannoma, a relatively rare benign tumor, can impair vestibular function, usually unilaterally. Cisplatin, a chemotherapy drug used to treat many types of tumors (eg, lung, breast, ovarian) has been associated with both vestibular toxicity and ototoxicity.[74,75] Tests of vestibular function can help physical therapists document change during or after treatment (Tab. 1). It also is important for therapists to use a measure of balance for patients with these impairments (see the "Neuromusculoskeletal and Movement-Related Functions and Structures" section for more information on balance measures).

Treatment-induced peripheral nerve impairments are common. Several chemotherapy drugs (ie, taxanes, platinum agents, vinca alkaloids, and thalidomide) can damage peripheral axons and nerve cell bodies.[76] Chemotherapy-induced peripheral neuropathy (CIPN) is characterized by sensory impairments, including paresthesias, dysesthesias, decreased touch thresholds, decreased vibration thresholds, and reduced deep tendon reflexes.[77–79] As CIPN worsens, muscle weakness and limb movement disorders, such as foot drop, may develop and require the use of an orthosis. Multidimensional tests, such as the modified Total Neuropathy Scale, may be beneficial in fully describing the severity of CIPN (Tab. 1).[77,80,81] Anesthesia or dysesthesias may occur when compression or surgical dissection of a nerve occurs.[82] Radiation plexopathies also may occur but are much less common, as radiation oncologists have developed techniques to shield delicate neural structures.[83]

Many patients with cancer, particularly those with advanced or metastatic disease, have increased levels of pain.[84] Cancer-related pain may arise from the tumor itself or as a side effect of treatment. Some forms of cancer are inherently more painful, specifically any cancer originating in or metastasizing to the bone. Pain can have a large impact on mobility, and some researchers have even established cut-points for moderate and severe pain based on its interference with daily activity.[85] Evaluation of pain in this population is essential and should be multifaceted (Tab. 1, Pain). Although many

Table 1.
Measurement Tools for Body Function and Structure, With *International Classification of Functioning, Disability and Health* (ICF) Code (Alphabetic Chapter and Numeric Second-Level Domains) in Parentheses

Construct	Measurement Tool[a]	Measurement Characteristics	Representative Studies in Populations of Patients With Cancer
Mental functions			
Specific mental functions (b140–b152)	High-sensitivity cognitive screen	An interview-based instrument designed to assess 6 major domains of neuropsychological performance: memory, language, attention/ concentration, visual/motor, spatial, and self-regulation and planning[148]	Prostate cancer[149]
	Mini-Mental State Examination	An 11-item questionnaire that is used to screen for dementia[70]	Brain tumor[150]
	Functional Assessment of Cancer Therapy–Cognitive Function (FACT-COG)	A 38-item questionnaire that addresses cognitive issues related to treatment. This instrument assesses an array of generic and targeted measures and has multiple benefits, including validity, ease of administration and interpretation, and global application.[151]	All populations of patients with cancer; prostate cancer[149]
	Perceived Cognition Questionnaire	A self-report scale that rates an individual's perception of change in cognition since the inception of chemotherapy[152]	Breast cancer[152]
	Profile of Mood States	Measures 6 mood or affective states: tension-anxiety, depression-dejection, anger-hostility, vigor-activity, fatigue-inertia, and confusion-bewilderment[72,73]	Prostate cancer,[153] advanced cancer,[154] breast cancer,[155,156] non–small cell cancer,[157] head and neck cancer[158]
Sensory functions and pain			
Hearing and vestibular functions (b230–b249)	Dizziness Handicap Inventory Questionnaire	A 25-item questionnaire that allows for self-assessment of the impact of disequilibrium on functional activity[159]	Vestibular schwannoma[160,161]
	Computerized gaze stabilization/ visual acuity tests (eg, NeuroCom inVision System)	A mechanical test that assesses patient difficulty in coordinating eye movements with head movements. Deficits may indicate problems with vestibulo-ocular reflex.[162,163]	Vestibular schwannoma[161]
Additional sensory functions (b250–b279)	Modified Total Neuropathy Score	Multidimensional test of peripheral nerve function[79]	Breast cancer[79]
	Semmes-Weinstein monofilaments	Mechanical test that quantifies touch thresholds[164]	Breast cancer[79]
	Biothesiometer	Mechanical test that quantifies vibration thresholds[164,165]	Breast cancer[79]
Pain (b280–b289)	Visual analog scale	Unidimensional measure of pain intensity[166]	Lung cancer[167]
	Numeric rating scale	Unidimensional measure of pain intensity[86]	Pediatric cancers[168,169]; mixed adult population[170]
	Faces Pain Scale–Revised[171]	Intensity measure appropriate for children and patients with cognitive decline[171]	Pediatric cancers[168,169]

(Continued)

Table 1.
Continued

Construct	Measurement Tool[a]	Measurement Characteristics	Representative Studies in Populations of Patients With Cancer
Pain (b280-b289) continued	Brief Pain Inventory	Multidimensional measure of pain; includes intensity and impact on function[88]	Adult pain clinic participants,[172] prostate cancer,[173] bone metastases[174]
	Pain Treatment Satisfaction Scale	A 5-item questionnaire that measures patient satisfaction with pain management[89]	None
Neuromusculoskeletal and movement-related functions and structures			
Functions of the joints and bones (b710–b729)	Goniometry	Mechanical measure, with published normal values[175,176]	Breast cancer,[90,91,177] head and neck cancer,[92–94] leukemia,[178] osteosarcoma[179]
	Sit-and-reach	Performance test of generalized flexibility[180]	Lymphoma,[21] breast cancer[181]
Muscle functions (b730–b749)	Manual muscle testing	Standardized performance test that measures the patient's ability to resist against therapist-applied force	Osteosarcoma[101]
	Handheld dynamometry	Mechanical measure of force output, with published normal values[98]	Leukemia[178,182]
	Grip strength	Mechanical measure of force output, with published normal values[97]	Osteosarcoma,[101] breast cancer,[183,184] lymphoma[185]
Structures related to movement–other (b750–b789)	National Cancer Institute's Common Terminology Criteria for Adverse Events, version 3 (Fibrosis Scale)	This scale provides standardized language to describe fibrosis of tissue due to postsurgical scarring or radiation therapy[121]	Uterine cancer[186]
Motor reflex functions (b750)	Deep tendon reflexes	A mechanical test that can be performed in isolation, but often is included in multidimensional peripheral nerve tests such as the Modified Total Neuropathy Score	Breast cancer[104]
Involuntary movement reaction functions (b765)	Computerized posturography (eg, NeuroCom Sensory Organization Test)	Computer-based, quantitative assessment of postural stability under various sensory conditions[187]	Breast cancer,[104] vestibular schwannoma,[188,189] prostate cancer,[190] cerebellar tumor[191]
Gait pattern functions (b770)	Gait speed	Performance measure of gait requiring little equipment	Pediatric sarcoma[101]
	Kinematic gait analysis	Quantitative analysis of joint and limb positions and movement during gait; can require expensive equipment	Pediatric brain tumor,[103] bone tumor[99]
Functions of the cardiovascular, hematologic, immunologic, and respiratory systems			
Cardiovascular system functions (b410–b429)	Heart rate	Standard vital sign, with normal values[192]	Hospice[193]
	Blood pressure	Standard vital sign, with cut-points for hypertension and prehypertension[192]	Survivors of childhood cancer,[194] leukemia,[195] testicular cancer,[196] brain tumor[197]

(Continued)

Table 1.
Continued

Construct	Measurement Tool[a]	Measurement Characteristics	Representative Studies in Populations of Patients With Cancer
Respiratory system functions (b440–b449)	Respiratory rate	Standard vital sign, with normal values[192]	Hospice,[193] general cancer population[198]
	Oxygen saturation	Indirect measure of oxyhemoglobin level	Lung cancer[199]
	Pulmonary function tests	Direct measures of lung volume and flow rates	General cancer population,[198] post-lung irradiation,[200] lung cancer,[199] Hodgkin disease[201]
	Medical Research Council Dyspnea Scale	Self-report rating of shortness of breath[111]	None
Additional functions and sensations of the cardiovascular and respiratory systems–aerobic capacity (b455)	Graded exercise testing	Estimate of maximal oxygen consumption based on exercise performance[192]	Breast cancer[202–204]
	Duke Activity Scales Inventory	Estimate of maximal oxygen consumption based on self-reported activity[205]	None
	2- or 6-minute walk test	Performance-based assessment of exercise tolerance and functional capacity[110]	Osteosarcoma,[101] leukemia,[182] prostate cancer,[190] lung cancer[199]
	9-minute run-walk	Performance-based assessment of exercise tolerance[206]	Osteosarcoma[207]
	Borg Rating Scale of Perceived Exertion	Self-report of physical effort during exercise or activity[112]	None
Additional functions and sensations of the cardiovascular and respiratory systems–fatigue (b455)	Multidimensional Fatigue Inventory	A 20-item questionnaire with 5 subscales that assesses self-reported fatigue[208]	Head and neck cancer[209]
	Functional Assessment of Chronic Illness Therapy–Fatigue	A 13-item questionnaire that assesses fatigue and the impact of fatigue[210]	Patients with cancer and severe pain[115]
	Piper Fatigue Scale	A 26-item multidimensional fatigue assessment instrument[211]	Leukemia,[212] breast cancer[213]
	Brief Fatigue Inventory	A 9-item rapid screening tool for fatigue severity and impact on function[214]	Lung cancer,[136] leukemia,[215] lymphoma,[21,215] rectal cancer[216]
Immunological system functions (lymphatic system) (b435)	Limb volume: water displacement	Direct, mechanical quantitative measurement of limb volume[117–119]	Breast cancer[117–119]
	Limb volume: infrared optoelectric technology	Direct, quantitative measure of limb volume using computer analysis of a scanned image to document the diameter of the extremity along its length[217]	Breast cancer[120]
	Limb volume estimates: limb circumferences using a truncated cone formula	Indirect, quantitative measure of limb volume[117,118]	Breast cancer[117,118]
	National Cancer Institute's Common Terminology Criteria for Adverse Events, version 3 (lymphatic, integument, and phlebolymphatic cording scales)	Numeric scales that use standardized language to describe impairments in the lymphatic, integument, and phlebolymphatic systems[121]	Survivors of cancer[20]

[a] Not intended to be an all-inclusive list of measures, but as examples of measures that have been reported in the oncology literature.

scales, such as visual analog scales and numeric rating scales,[86,87] specifically focus on pain intensity, other scales are multidimensional and include questions on interference with daily activity[88] or acceptability of pain treatments.[89]

Neuromusculoskeletal and Movement-Related Functions and Structures

Table 1 (Neuromusculoskeletal and Movement-Related Functions and Structures) describes useful measures for evaluating potential changes in neuromusculoskeletal and movement-related functions and structures. Patients with cancer or a history of cancer may experience a number of impairments in this subdomain, including loss of ROM, decreased strength (force-generating capacity), gait pattern abnormalities, and balance deficits.

Deficits in ROM may be present in patients who have undergone surgery, chemotherapy, or radiation therapy. Such deficits may result from the formation of scar tissue following surgery, disuse of a joint following chemotherapy or surgery, or fibrosis caused by irradiation. Decreased ROM may occur coincident with treatment or after the completion of treatment. Seemingly less-invasive surgeries (lumpectomy versus mastectomy) can affect ROM as much as more-invasive procedures.[90] Decreased ROM also should be considered if radiation treatment has involved a joint.[91] This loss of ROM may occur after radiation is completed and can extend beyond the immediately irradiated joint. For example, patients who have completed surgery or radiation for a head and neck tumor may have impaired shoulder abduction and flexion in addition to the more obvious loss of cervical ROM. These problems are more severe after surgeries involving radical neck dissections and the removal of the spinal accessory nerve.[92–94]

Muscle strength deficits can arise from tumor-produced inflammatory intermediates that are catabolic, resulting in muscle wasting (cachexia).[95] Surgical interventions also may damage muscle groups and peripheral nerves, leading to loss of strength. Radiation and chemotherapy (especially the vinca alkaloids, taxanes, and platinum agents) can reduce strength by damaging muscle or peripheral nerve tissue.[91] Corticosteroids preferentially damage proximal limb muscles, limiting activities such as sit-to-stand and overhead reaching.[96] Additionally, pain, fear, and fatigue lead to inactivity, which, in turn, causes further loss of muscle strength and aerobic capacity. Although techniques for manual muscle testing are widely used by therapists to measure strength, measures of dynamometry and grip force provide quantitative documentation of strength deficits.[97,98]

Cancer or cancer treatments can alter gait characteristics by adversely affecting the function and structure of the lower extremity or the nervous system. The few studies that have assessed these changes have shown deficits in patients with bone tumor lesions of the lower extremity and tumors of the nervous system.[99–103] Traditional gait evaluation tools, such as kinematic analysis or gait speed measurements, are appropriate for patients with cancer.

Balance can be disrupted in many patients with cancer or a history of cancer and may arise from impairments in multiple body systems. Problems with sensory input, central processing of balance-related information, ROM limitations, orthostatic hypotension, and muscle force production can all contribute to this multifactorial issue. Specific to the neuromuscular system, patients with taxane-induced peripheral neuropathy have limitations in postural stability.[104] It is important for physical therapists to measure postural control in a variety of challenging positions to detect and treat balance limitations in patients, especially after chemotherapy. Because the oncology population often is at risk for falls,[105] screening for balance disorders is very important. We have included measures that are intended to identify balance impairments and their underlying structural problems in Table 1 (Measurement Tools for Body Function and Structure: Involuntary Movement Reaction Functions) and tests that use mobility skills to rate the level of balance dysfunction in Table 3 (Measurement of Activity and Participation: Mobility–Changing and Maintaining Body Positions). In either case, in the ICF model, a balance disorder is classified as a body function and structure impairment.

Functions of the Cardiovascular, Hematologic, Immunologic, and Respiratory Systems

Cardiotoxicity is a well-known late effect of several chemotherapeutic agents, particularly the anthracyclines (Adriamycin*) and trastuzumab (Herceptin†). These compounds may damage cardiac myocytes and ultimately can result in congestive heart failure.[106,107] Similarly, radiation striking the heart can cause cardiac and coronary artery scarring, leading to restrictive cardiac disease and coronary artery disease.[108] In older patients, these cardiovascular changes may be superimposed on already existing cardiovascular disease, further amplifying the impairments associated with this disease. It is important for therapists to ask the patient's physician for the results of cardiac testing, performed

* Pharmacia Inc, Kalamazoo, MI 49001.
† Genentech Inc, 1 DNA Way, South San Francisco, CA 94080-4990.

Table 2.
Physician-Performed Diagnostic Measures of Body Structure and Function Indicating "Red Flags" or "Yellow Flags" for Physical Therapists, With *International Classification of Functioning, Disability and Health* (ICF) Code (Alphabetic Chapter and Numeric Second-Level Domains) in Parentheses

Construct	Measurement Tool	Measurement Characteristics and Importance to Physical Therapy	Representative Studies in Populations of People With Cancer
Structures of the nervous system			
Nervous tissue (s110–s199)	Magnetic resonance imaging[a]	Preferred method to detect compression of neurologic tissue, (ie, spinal cord, nerve roots, or nerve plexus) by tumor or unstable vertebral fractures[123]	Patients with vertebral metastases or spinal cord compression[123,218]
Structures related to movement			
Skeletal system (s710–s770)	Dual-energy x-ray absorptiometry[a]	Diagnostic test for osteopenia and osteoporosis	Leukemia,[182,219] prostate cancer[190]
	Radiography or computed tomography scan[a]	If 25%–50% of the cortex of bone is degraded, then partial weight-bearing precautions should be instituted. If greater than 50% bone degradation, then touch-down or non–weight-bearing precautions are recommended.[220]	Multiple myeloma[220]
Functions of the cardiovascular, hematologic, immunologic, and respiratory systems			
Hematologic system functions (b430)	Complete blood count (ie, hemoglobin, hematocrit, white blood count, platelet count)[a]	Diagnostic test to detect anemia, neutropenia, and thrombocytopenia. These values also are useful in exercise prescription, particularly in choosing safe mode and intensity of exercise.	Patients with stem cell transplant[221]
Cardiovascular system functions (b410–b429)	Echocardiogram[a]	Assesses ventricular function, including ejection fraction, wall movement, and cardiac output	Hodgkin disease,[222] breast cancer[223]

[a] These tests are performed by a physician, but yield important information for the physical therapist.

both before and after treatment with cardiotoxic agents (Tab. 2).

Primary tumors of the lung are frequent, with 215,020 new cases estimated for 2008 in the United States.[1] These space-occupying tumors cause respiratory impairments by limiting the expansion of the thoracic cavity, compressing the airways, and reducing the surface area of the lungs available for gas exchange. As these tumors grow and impinge on other mediastinal structures, they can decrease cardiac function secondary to cardiac and vascular compression and cause upper-extremity musculoskeletal injury secondary to brachial plexus compression and infiltration.

The respiratory system also can be adversely affected by chemotherapy and radiation treatment for cancers not involving the lung. Chemotherapeutic agents such as bleomycin, methotrexate, and docetaxel can damage pneumocytes and the pulmonary parenchema.[109] Such damage can lead to obliteration of alveoli and dilation of air spaces. Likewise, chest wall irradiation can damage the lining of the alveoli, leading to toxicities such as pneumonitis and fibrosis,[109] as well as causing fibrosis of integumentary and musculoskeletal structures that contribute to ventilation.

Measurements of vital signs (heart rate, blood pressure, respiratory rate, and oxygen saturation) provide insight into the cardiorespiratory status of patients with cancer. The presence of hemodynamic instability at rest (altered blood pressure, tachy-

cardia, light-headedness, cyanosis) suggests that action should be taken to protect the patient. Impairments in cardiorespiratory status may manifest themselves only with increased exertion. For this reason, assessment involving testing under conditions of increased exertional demand (Tab. 1) is preferred and may involve formal exercise testing, self-report of activity levels, or results from a 6-minute walk test or similar aerobic capacity test.[110] Failure to meet normal range values for these assessment tools suggests impaired cardiovascular and respiratory function. Patient report of breathing difficulties (Dyspnea Scale[111]) and of exertional demand (Borg Rating of Perceived Exertion[112]) during a 6-minute walk test provide further insight into these impairments.

Fatigue is a well-documented, multisystem impairment commonly reported in a wide variety of cancers, both acutely and long after cancer treatments have ended.[113] Exercise is an effective intervention for cancer-related fatigue, and it is recommended that a multidimentional measure be used to capture the physical, emotional, and mental aspects of fatigue.[114] One such measure is the fatigue subscale of the Functional Assessment of Chronic Illness Therapy (FACIT-F), which initially was developed for the oncology population and has been used in patients with a variety of cancer types[115] and in survivors of cancer.[116]

In the ICF, the function of the lymphatic vessels and nodes are classified under immunologic function. Defects may involve tumor obstruction of lymphatic vessels, but they more likely occur secondary to surgical resection of lymph nodes or radiation-induced fibrotic changes that affect lymphatic vessels. In any case, regional lymphatic drainage is reduced, leading to lymphatic fluid accumulation and regional swelling. Such swelling compromises the integument by increasing the likelihood of inflammation, infection, skin breakdown, limits in joint ROM, and decreased ability to move the affected limb. Lymphedema may be most associated with surgical resection of the breast and surrounding lymph nodes; however, surgical resection of a variety of tumors, including head and neck, genitourinary, and reproductive tumors, can result in lymphedema. Localized swelling is the most common impairment of lymphedema; therefore, measures of this impairment focus on quantifying limb volume (Tab. 1, Immunological Systems Functions). The water displacement method is a highly reliable method for determining the volume of an extremity with lymphedema.[117–119] However, this method requires specific equipment and precise methods to obtain reliable measurements. Methods using light-emitting diodes to calculate limb volume have shown early evidence in detecting subclinical lymphedema, allowing for early intervention and prevention of symptomatic lymphedema.[120] Volume estimates made by a truncated cone formula using several limb circumference measures correlate highly with those determined by water displacement.[117,118] Limb circumference measurements may be more practical for some clinicians, given its simplicity and minimal equipment requirements. An important component to early detection is the timing of volume measurements. It has been shown that preoperative measurements assist with early detection and successful treatment of lymphedema.[120]

Volume measures are only one method used to describe the severity of lymphatic impairments. The National Cancer Institute's Common Terminology Criteria for Adverse Events, version 3,[121] has expanded the number of scales to grade the severity of lymphatic and integumentary toxicity (ICF subdomain "skin and related structures"). There are separate scales for volume of lymphedema in extremities, trunk and genital region, head and neck, and viscera. In addition, there are scales to grade the severity of skin color changes, lymph leakage, lymphocele, fibrosis, and phlebolymphatic cording.[121] A weakness of these scales is that the categories are broad and, therefore, not sensitive to small differences that may be clinically important. However, they do provide standardization of language to describe changes to lymphatic tissues and integumentary that may be clinically useful, particularly for long-term goals and clear communication among colleagues.

Diagnostic Measures of Body Function and Structure Indicating "Red Flags" or "Yellow Flags" for Physical Therapists

Body function and structure impairments identified through diagnostic tests performed by a physician may have significant implications for the examination by a physical therapist and the physical therapy plan of care (Tab. 2). Conversely, the therapist may identify concerning "red flags" or "yellow flags" during the examination that would warrant recommending that the patient return to his or her physician for further diagnostic testing. Both situations affect patient safety and, therefore, are described below and in Table 2.

Some tumors cause neural impairment by compressing or infiltrating a peripheral nerve, nerve plexus, or a nerve tract or nucleus within the central nervous system. The impairment may be sensory, motor, or autonomic, depending on the location, size, and structure of the tumor. Physical therapists must consider common neurological sites at increased risk for tumor compression.

For example, breast and lung tumors can compress the brachial plexus, and the lumbosacral plexus is sometimes affected by colorectal tumors, gynecologic tumors, sarcomas, and lymphomas.[122] Regardless of the site, the cardinal sign of neural compression is unrelenting pain, particularly at night and later focal sensory disturbances or weakness in the distribution of the plexus or spinal cord segment involved.[122,123] These signs and symptoms are particularly important to consider in patients with a history of cancer who may enter the clinic with a seemingly unrelated musculoskeletal problem. If neural compression from a tumor is suspected, the therapist needs to refer the patient back to the primary physician so that further medical tests, such as magnetic resonance imaging, and appropriate treatment may be performed.

Skeletal impairments often accompany a cancer diagnosis and reflect a disease-associated loss of bony material (lytic tumor) or invasion of bone (sclerotic tumor) by a primary or secondary tumor. Communication with the medical team can help therapists navigate through the many risks associated with tumor invasion of skeletal structures. It is advantageous for therapists to be familiar with common patterns of cancer-related skeletal system involvement (eg, prostate, breast, lung, and colon cancer often metastasize to the spine; sarcomas commonly present in the femur). As the tumor invades the normal structure of bone, there is reduced bone strength and increased risk of pathological fracture.[124] Although there are no definitive guidelines to predict pathologic fracture risk, it is helpful to monitor the amount of cortex that has been disrupted by tumor growth in long bones used for functional tasks (eg, the femur for gait, the humerus if an assistive device is being used). This can be calculated by a radiologist, using advanced imaging techniques. Table 2 summarizes specific weight-bearing guidelines. Tumor invasion of the vertebrae also can affect the physical therapy plan of care. If the tumor invades the vertebral arch, the segment may become unstable and possibly compress the spinal cord or adjacent nerve roots, creating a medical emergency. Unrelenting back pain often is the primary or presenting symptom of these lesions, and if a therapist suspects neurologic involvement, a segmental motor, sensory, and autonomic examination should be performed.[123] If neural impingement is suspected, the medical team should be notified immediately.[125]

Osteonecrosis and reduced bone mineral density are common among patients with cancer. Both cancer and cancer treatments increase the risk for developing osteonecrosis in a variety of locations, including proximal or distal femur, proximal humerus, jaw, and metatarsals.[126,127] New-onset pain and decreased weight-bearing ability should alert therapists to the possibility of osteonecrosis; however, this condition is not always symptomatic.[128] Pharmaceutical therapies (eg, corticosteroids, hormonal therapies, androgen therapy) and radiation are associated with reduced bone mineral density.[68–70] Therefore, dual-energy x-ray absorptiometry or computed tomography test results can alert therapists to this problem and allow for appropriate intervention planning.

Tests such as a complete blood count can help physical therapists determine safe exercise guidelines, particularly for patients who are undergoing or have just completed chemotherapy, radiation therapy, or bone marrow transplant.[129,130] Each medical center or rehabilitation department has its own criteria for exercise prescription. These values often are the same as those used for the general acute care population, as—to our best knowledge—there are no evidence-based recommendations specific for patients with cancer.[129,130] In addition to checking for anemia, patients not tolerating aerobic exercise should be screened for current or past use of cardiotoxic or pneumotoxic chemotherapy medications and referred as appropriate for further testing (see cardiovascular and respiratory discussion above). Patients should avoid exposure to infectious pathogens while neutropenic (eg, avoid public gyms, health caregivers should avoid patient contact if they are ill). If the patient is thrombocytopenic, high-impact activities or contact sports should be avoided to prevent excessive bleeding.

Measurement of Activity and Participation

The activity and participation domains encompass the ability to execute tasks, such as walking or bathing (activity), and the ability to participate in life situations, such as regularly attending work or school and conducting interpersonal relationships (participation). The subdomains for activity and participation (such as mobility and domestic life) are given in a single list in the Figure, with each component being able to denote activity, participation, or both.[24] This flexibility allows for individual tailoring and operational differentiation of activity and participation.[28,131,132] The ICF beginners guide suggests that clinicians, researchers, and policymakers may use this single list for their needs and purposes to "A) designate some domains as Activities and others as Participation and *not allow overlap*; B) make this designation but *allow overlap* in particular cases; C) designate *detailed* (third- or fourth-level) categories within a domain as Activities and *broad* (second-level) categories in the domain as Participation; or D) *designate all domains*

as potentially both Activity and Participation."[24(p127)] Impairments in body function and structure discussed in the previous sections can result in changes at both the activity and participation levels. Therefore, assessing change in these constructs is important.

Physical therapists typically select primary outcome measures at the activity and participation levels when their intervention plan as a whole is directed toward improving a person's physical capacity or performance. Individually tailored rehabilitation goals, commonly seen in physical therapy, take into account personal and environmental factors unique to the patient; however, the use of standardized measures allows for the comparison of individual activity and participation performance to what might be expected from control or population-specific values. The ability to make such comparisons may assist the therapist in gauging patient progress during the course of rehabilitation.

Important activity and participation domains typically addressed by physical therapy interventions include: (1) mobility, for example changing and maintaining a body position, carrying objects, or walking and moving around; (2) self-care, such as dressing, bathing, and toileting; (3) domestic life (eg, carrying a child, doing dishes); and (4) major life areas such as the ability of a child to access a classroom or the ability of an adult to perform specific tasks related to paid employment (Tab. 3). Currently available measures of activity and participation are rarely limited to a specific subdomain, and most instruments include portions of multiple constructs (eg, mobility and self-care).[131]

Measuring activity limitations and participation restrictions can be done by timed or clinician-observed evaluation or by patient self-report. For example, the Functional Mobility Assessment requires patients to physically perform specific tasks and to answer questions, quantifying their level of function.[133] In contrast, the Toronto Extremity Salvage Score, lower-extremity version, is a self-administered questionnaire that asks patients to indicate the level of difficulty they experience in dressing, grooming, mobility, work, sports, and leisure.[134,135] Both methods of measurement have different positive attributes. In using quantitative measurement of limitations or restrictions, a therapist removes some of the potential influences of symptom distress or cognitive changes.[136] However, the therapist must take into account that performance-based measures are effort dependent and require that the activity be done in a standard way. Severe cognitive problems may make a performance-based measure difficult or impossible to do. Qualitative measures also are important, as patient-reported outcomes reflect the patient's own perspective on his or her limitations and restrictions. Additionally, some symptoms, such as pain, can be measured only by self-report. By adding the patient's perspective, we can better document the perceived burden of cancer and meaningful impact of interventions.[137]

Mobility

The mobility subdomain includes the following constructs: changing and maintaining body positions; carrying, moving, and handling objects; walking and moving; and moving around using transportation. We will discuss the changing and maintaining body positions and walking and moving constructs, as they are assessed most commonly by physical therapists.

Changing and maintaining body positions incorporates both the concepts of maintaining balance and transferring between surfaces. Because the balance deficits discussed in the body function and structure section lead to impaired ability to change and maintain body positions, this is a critical area to explore in this population. Several appropriate activity-based measures of maintaining and changing body positions, including those that relate to balance impairments, are described in Table 3.

The concepts of transferring between surfaces and walking and moving often are combined in rehabilitation outcome measures, although they are separate categories in the ICF model. A few examples of combined transfer and mobility status measures include the Timed "Up & Go" Test and the L Test of Functional Mobility (Tab. 3).

Self-care

The ability to care for one's self is a construct often measured in rehabilitation settings. A few commonly reported measures are listed in Table 3 (Self-care). The Karnofsky Performance Scale[138] has been a "gold standard" measure of overall performance status in cancer treatment trials. In its mid-range values, scores indicate the ability of a person to perform self-care. Because of its limited scope, some authors[139,140] have reported that it is potentially limited in its responsiveness, a factor that may make it less useful for measuring rehabilitation outcomes. Other measures, such as the Barthel Index,[141] have multiple components, including large representations of self-care activities in their content, and are likely to be more responsive to changes seen with rehabilitation. Although these scales are used often in inpatient rehabilitation research, they have relevance for oncology populations that may or may not be seen in such a setting.

Table 3.
Measurement of Activity and Participation, With *International Classification of Functioning, Disability and Health* (ICF) Code (Alphabetic Chapter and Numeric Second-Level Domains) in Parentheses

Construct	Measurement Tool[a]	Measurement Characteristics	Representative Studies in Populations of Patients With Cancer
Mobility—changing and maintaining body positions (d410–d429)	5-time sit-to-stand	Performance-based assessment of transitional movement ability[224]	None
	Functional reach	Performance-based measure of balance during voluntary movement in standing[225]	Palliative care[226]
	Berg Balance Scale	Performance-based, standardized measure of static and dynamic balance[227,228]	None
	Dynamic Gait Index	Standardized performance-based assessment of gait characteristics[229,230]	Vestibular schwannoma[102]
	Standard Romberg Test and Tandem Romberg Test	Standardized performance-based assessment of static balance in various positions[229]	Breast cancer[104]
Mobility—walking and moving (d450–d469)	Tinetti Balance and Gait Scale	Simple and easily administered performance test that quantifies gait and balance characteristics. Scored on patient performance of gait- and balance-specific tasks.[231]	Lymphoma[185]
	Timed "Up & Go" Test	A timed measure of balance and mobility[232]	Leukemia,[178,182,233] lymphoma,[185] sarcoma,[207,234] breast cancer[79]
	L Test of Functional Mobility	A performance-based assessment of basic mobility skills, including walking, transferring, and turning[234]	Lower-extremity solid tumor[234]
	Functional Mobility Assessment	An instrument that combines assessment of a patient's physical performance with self-report assessment of pain, function, supports, satisfaction, participation, and endurance[133]	Lower-extremity sarcoma[133]
	Toronto Extremity Salvage Scale	A questionnaire that measures the level of difficulty experienced by patients with upper- and lower-extremity sarcoma in performing everyday activities[135]	Sarcoma[134,235,236]
	Fullerton Advanced Balance Scale	Standardized performance-based clinical test of gait and balance characteristics[237]	Breast cancer[104]
Mobility—developmental (d410–d469)	Bruininks-Oseretsky Test of Motor Proficiency	A performance-based measure of gross and fine motor skills in children 4½–14 years of age (second edition: 4½–21 years of age)[238]	Leukemia[239]
	Gross Motor Function Measure	Performance/observation-based measure of movement in children[240]	Leukemia[239]
	Peabody Developmental Motor Scale	Performance-based measure of motor development in children aged 0–38 months with gross and fine motor scales[241]	Leukemia,[242] children with cancer[243]

(Continued)

Table 3.
Continued

Construct	Measurement Tool[a]	Measurement Characteristics	Representative Studies in Populations of Patients With Cancer
Self-care (d510–d599)	Barthel Index	Performance or self-report measure of independence in basic activities of daily living[141]	Prostate cancer,[244] hospice,[245,246] brain tumor[247]
	Physical Performance Test	A 9-item timed test that simulates daily activities[248]	None
	Functional Independence Measure	Provides estimate of burden of care based on level of dependence in performing basic activities of daily living[52]	Solid tumor,[249] brain tumor[250]
	Karnofsky Performance Scale	A standard measure of the ability of adult patients with cancer to perform ordinary tasks. The Karnofsky Performance Scale scores range from 0 to 100. A higher score means the patient is better able to carry out daily activities.[251]	Most drug clinical trials for all types of cancers
Domestic life, interpersonal relations, and major life areas (d710–d799)	General Sickness Impact Profile	A 136-item questionnaire that measures the effect of sickness on everyday activities and behaviors in adults[252]	General[253]
	Reintegration to Normal Living Index	An 11-item questionnaire covering mobility, self-care, family roles, family roles and personal relationships, presentation of self, coping skills, work, housework, and recreational and social activities for adults[145]	Sarcoma[146,235]

[a] Not intended to be an all inclusive list of measures, but as examples of measures that have been used in the oncology literature.

Domestic Life, Interpersonal Relations, and Major Life Areas

Few measures typically used by physical therapists attempt to quantify the capacity of a person to live as a family member and as a member of society (Tab. 3). Restrictions in the ability of an individual to interact with the environment or participate fully in life situations increase the disease burden on the individual, the family, and society. Indeed, people with participation restrictions are more likely to report poor health[142] and bouts of depression.[143] It is generally recognized that patients and survivors of cancer have restrictions in these domains,[144] yet there is a paucity of outcome measures targeted here.

A measurement tool that is focused specifically on the return to lifes roles after a major health change is the Reintegration to Normal Living Index.[145] This tool measures adults' perception of their ability to resume their life roles after a serious illness or trauma. It has been used sparingly in populations of people with cancer.[146,147] Because performance of activities and participation in life roles often are the main goals of rehabilitation, measurement of pertinent activity and participation subdomains provides useful information regarding the need for and effectiveness of oncology rehabilitation.

Conclusion

This article uses the ICF model to describe outcome measures that allow for broad quantification of global function and methods to document progression in patients with cancer and survivors of cancer. Understanding and documenting how these structural or anatomic deficits restrict activities (grooming, dressing, child care) and participation (attending community activities, reduced job expectations) provide a broader view of the patient's abilities. Therapists need to be adept at understanding the intended focus of their therapeutic interventions and using the most appropriate tools to assess the effectiveness of those interventions.

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