Academy of Oncologic Physical Therapy EDGE Task Force: A Systematic Review of Measures of Balance in Adult Cancer Survivors

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Background and Purpose: Balance impairments are prevalent in adult cancer survivors, leading to increased fall risk and reduced quality of life. To identify survivors in need of balance and fall interventions and to track change with intervention, health care providers need measures with sound psychometric properties and high clinical utility. The purpose of this systematic review was to identify reliable, valid, and clinically useful measures of balance impairments in adult cancer survivors. Secondary purposes were to obtain minimal detectable change of identified balance measures and to determine use of measures to evaluate fall risk. **Methods:** A systematic review was conducted to assess psychometric properties and clinical utility of balance measures identified from the literature search. Two reviewers in a team independently extracted data from articles and evaluated cumulative evidence for each balance measure using the Cancer EDGE Task Force Outcome Measure Rating Form. **Results:** The search located 187 articles, with 54 articles retained for quality assessment of balance measures. The Fullerton Advanced Balance Scale and gait speed were highly recommended (rated 4). Balance Evaluation Systems Test, Timed Up and Go, and Five Times Sit to Stand were recommended (rated 3). **Limitations:** Selection bias is possible. Samples and settings across reviewed studies were widely heterogeneous. **Conclusions:** We recommend 5 balance measures for use in adult cancer survivors. Future research with existing balance measures should establish norms, responsiveness, and predictive validity for fall risk, while expanding to focus on imbalance in midlife survivors. Patient-reported outcome measures are needed for cancer-related imbalance. **(Rehab Oncol 2019;37:92–103)** *Key words: neoplasm, outcome measures, postural stability, psychometrics*

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The ability to establish and maintain balance during daily activities, work, and recreation is fundamental to both independent living and injury prevention across the lifespan. For individuals living with a current or prior cancer diagnosis, balance impairments and fall risk elevate beyond those expected for age. This phenomenon is now extensively documented.[1-7] In a US population-based study, the prevalence rates of balance problems after adjusting for age were significantly higher after the diagnosis of non-Hodgkin lymphoma (45% postdiagnosis

vs 26% prediagnosis), breast cancer (41% postdiagnosis vs 32% prediagnosis), prostate cancer (29% postdiagnosis vs 22% prediagnosis), and lung cancer (46% postdiagnosis vs 33% prediagnosis) in adults 65 years or older.[8] Significantly, worse balance performance was observed in cancer survivors undergoing or recently completed chemotherapy in comparison with age-matched noncancer controls.[5,6] Among 244 cancer survivors treated at outpatient settings, nearly 20% reported having difficulty with balance but none received a referral to rehabilitation specialists to address balance deficits.[9] Taken together, balance impairments in adult cancer survivors are prevalent, concerning, and underaddressed. In response, cancer rehabilitation efforts must expand in this direction, toward enhanced balance screening, assessment, and interventions. A critical first step is to identify available outcome measures with good psychometrics, clinical utility, and population-specific validity.[10]

The Academy of Oncologic Physical Therapy of APTA launched the Cancer Evaluation Database to Guide Effectiveness (EDGE) Task Force in 2010 to recommend outcome measures for use in cancer survivors. In 2015, the Cancer EDGE Task Force evaluated balance measurements for breast cancer and could only identify 2 tests with good psychometric properties and clinical utility.[11] The lack of balance measures with high-level evidence in the oncology population is impeding the management of cancer-related imbalance and falls. In 2018-2019, the Cancer EDGE Task Force convened to conduct a systematic review of balance measures for use in adult survivors of all cancer diagnoses. The primary objective of this review was to identify reliable, valid, and clinically useful outcome measures in the adult oncology population and make recommendations on existing balance measures. Secondary objectives were to derive standard error of measure (SEM) and minimal detectable change (MDC) and to identify published evidence of fall risk assessment using balance measures. This systematic study (see PRISMA Checklist, Supplemental Digital Content 1, available at: http://links.lww.com/REHABONC/A19) aimed to answer the following question: What balance measures with good psychometrics and clinical utility are available for use in adult cancer survivors?

METHODS

Data Source and Searches

The primary search was conducted from May 2018 to June 2018 using the following databases: PubMed/Ovid MEDLINE, CINAHL, EMBASE, and SCOPUS. Search terms included ("cancer" or "neoplasm") AND ("balance" or "postural balance") AND ("physical therapy," "occupational therapy," or "rehabilitation") AND ("reliability," "validity," or "psychometrics," "measures," "measurements," "surveys," or "questionnaires"). The search was updated to locate new evidence in August 2018. Additional "hand search" was conducted by reviewing references, relevant balance measures, and other publications by authors of found articles and was completed in November 2018. The research was limited to English, adults older than 18 years, and published between January 1, 2008, and November 1, 2018.

Study Selection

For this systematic review, balance was defined as a person's ability to "orient the body in space, maintain an upright posture under static and dynamic conditions, and move without falling."[12]

The task force considered the following criteria to include studies: (1) study designs were randomized controlled trials, controlled clinical trials, experimental studies, and observational studies; (2) participants were adults older than 18 years, with confirmed diagnoses of any cancer; and (3) tests or measures were used to assess balance impairments or fall risk, psychometric properties of the measures were reported, or balance or fall risk was the primary outcome of the measures. Exclusion criteria for articles were as follows: (1) studies demonstrated a lack of evidence in psychometric analysis; (2) participants included pediatric or noncancer populations; (3) conference abstracts or unpublished data; (4) case reports, case series, narrative reviews, systematic reviews, or clinical practice guidelines; and (5) measures had a few items evaluating balance or fall risk, but balance was not the primary outcome or purpose of the tool.

Two reviewers in a team independently screened the titles and abstracts of articles found from the search. Subsequently, full-text articles that were included after the initial screening were appraised for eligibility in the qualitative synthesis by the same reviewers independently. For any disagreement in the decision for including articles, the reviewers would first discuss to resolve the discrepancy. If a consensus could not be reached, a third reviewer was assigned.

Data Extraction, Quality Assessment, Data Synthesis, and Analysis

Articles included from the search that reported the same balance measure were grouped together. Two reviewers in a team independently extracted data about a balance measure from relevant articles using the Cancer EDGE Task Force Outcome Measure Rating Form (see Appendix 1, Supplemental Digital Content 2, available at: http://links.lww.com/REHABONC/A18). Additional evidence about psychometric properties of identified balance measures in adult cancer survivors from articles published prior to 2008 was recorded in the form. The form recorded the measure's International Classification of Functioning, Disability and Health (ICF) domain, type of measurement, language, validated populations, instrument psychometric properties, clinical utility, and recommendation for the measure. The collective evidence obtained from the group of articles was appraised for the balance measure.

The Cancer EDGE Task Force assessed the reliability of a measure based on the intraclass correlation coefficient (ICC) or Pearson's coefficient (r) (excellent:

≥0.90; good: 0.76-0.89; moderate: 0.50-0.75; poor: <0.50) or kappa coefficient (κ) (excellent: ≥80%; substantial: 60-79%; moderate: 40-59%; poor-fair: <40%)[13] and appraised the clinical utility based on the following criteria: the measure takes 20 minutes or less to complete, equipment is easily available in the clinic, the measure has no copyright payments or license fees, and scoring schema for the measure is simple. The validity of a measure was evaluated on the basis of the evidence demonstrating construct, concurrent, and predictive validity.[13] The 2 reviewers independently applied the Cancer EDGE Rating Scale (Table 1) to evaluate the quality of cumulative evidence about a balance measure and assigned a rating for the measure (highly recommended = rating of 4; recommended = rating of 3; reasonable to use = rating of 2; and not recommended = rating of 1). A disagreement of the rating was discussed among the 2 reviewers. If there was no consensus following the discussion, a third reviewer was used to provide judgment. Final recommendations and Cancer EDGE ratings for the balance measure were recorded on the Cancer EDGE Task Force Outcome Measure Rating Form.

For recommended measures with a rating of 3 or 4, responsiveness including SEM and MDC values based on 95% confidence interval (MDC_{95}) were obtained directly from the articles, if available, or calculated using the following formula: $MDC = 1.96 \times SEM \times \sqrt{2}$, whereas SEM was calculated on the basis of the standard deviation (SD) obtained from the first test of test-retest data and ICC for test-retest reliability using the following formula: $SEM = SD \times \sqrt{(1 - ICC)}$.[14]

RESULTS

The Figure illustrates the literature search and review process. The search found 178 articles from databases and 53 articles by hand search. After duplicates were removed, titles and abstracts of 187 articles were screened. After applying inclusion and exclusion criteria, 95 articles were removed from initial screening. Among 92 full-text articles that were assessed for eligibility in the quality synthesis, 54 articles were retained to evaluate the evidence of balance measures.

A total of 17 balance measures were identified from included articles. Five are recommended for use. The Fullerton Advanced Balance Scale (FABS) and usual and fast gait speed are highly recommended (rating = 4). Balance Evaluation Systems Test (BESTest), Timed Up and Go (TUG), and Five Times Sit to Stand (5TSTS) are recommended (rating = 3). Validation studies for the recommended balance measures recruited adult survivors with a wide age range and mixed cancer diagnoses from various practice settings (Table 2). While most measures were validated in the community setting, the TUG was used in survivors receiving palliative[15] or presurgical care[16] and 5TSTS was used in those with subacute hematopoietic stem cell transplant.[17]

For recommended measures, clinical utility is presented (Table 3), considering equipment need, cost, ease of administration, burden for scoring and interpretation, and normative reference values. The BESTest requires the most equipment, takes the longest time (20-30 minutes), and is copyrighted. All other recommended measures require minimum equipment and are highly feasible in most clinical settings.

Reliability, validity, and MDC_{95} of recommended measures are summarized in Table 4. Only 2 balance measures were used to evaluate fall risk in adult cancer survivors in studies of cross-sectional design.[18,19] In postmenopausal breast cancer survivors, higher gait speed was significantly associated with reduced fall risk (defined by Tinetti Performance-Oriented Mobility Assessment scores).[19] In geriatric oncology, a TUG score of 14 seconds or more was associated with a higher risk of having 1 or more falls in the past 6 months (OR = 1.9; 95% CI, 1.4-2.6).[18]

Balance measures with a Cancer EDGE rating of 1 or 2 are presented in Table 5, with rationale. While most had insufficient psychometric properties in adult cancer survivors, 4 measures were not recommended (Cancer EDGE rating of 1). Center-of-pressure (COP) measures are widely considered the gold standard for analysis of balance control.[3,6] However, these tests require extensive training and equipment, time, and space, so are impractical for a clinical setting. Although the Sensory Organization Test (SOT) had evidence-based psychometric properties in

TABLE 1
Cancer EDGE Rating Scale

4	Highly recommended	The outcome measure has excellent psychometric properties (reliability and validity AND have available data to guide interpretation) in condition of interest and excellent clinical utility (≤20 min, equip in clinic, no copyright payments, easy to score); the measure is free or reasonably accessible to a broad range of providers.
3	Recommended	The outcome measure has good psychometric properties (may lack some info about reliability, validity, responsiveness) in the population of interest and good clinical utility (>20 min, some equip, training, copyright fee); OR has excellent psychometric properties but is not free and may require access to specialized testing equipment that is beyond the means of many clinicians or clinics.
2	Reasonable to use	Limited study in the target group; the outcome measure has good or excellent psychometric properties and clinical utility in a related population, but insufficient study in the target population to support higher recommendation.
1	Not recommended	The outcome measure has poor psychometric properties and/or poor clinical utility.

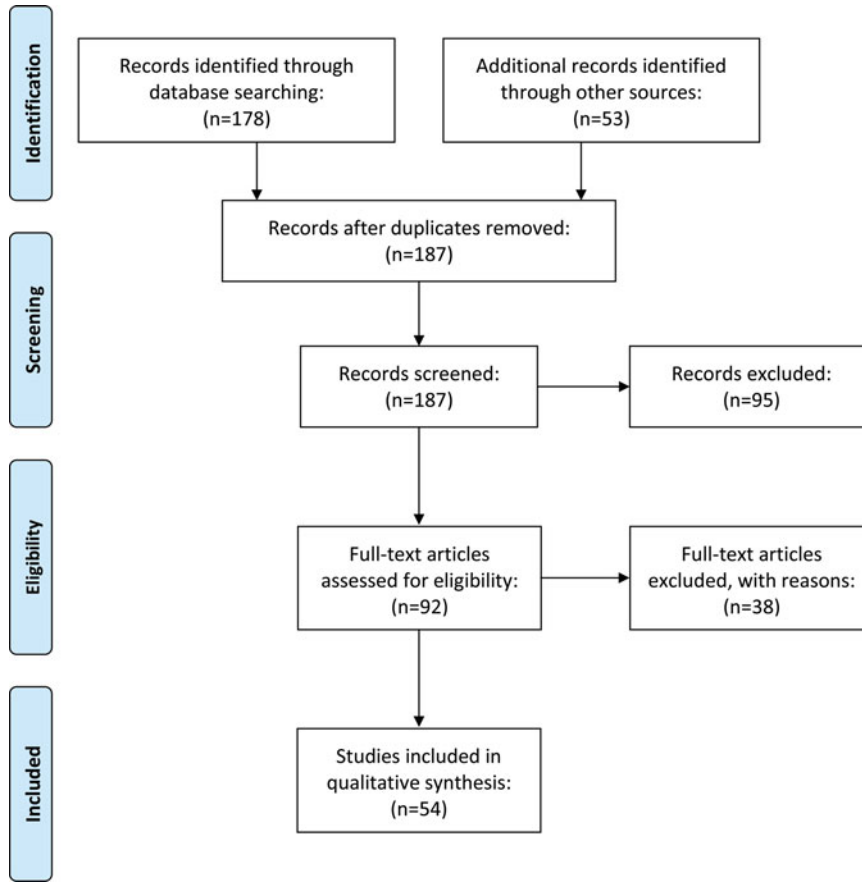

Fig. PRISMA flowchart of literature search.

adult cancer survivors, it requires a computerized system and therefore it was rated 1.

DISCUSSION

Of 18 balance measures identified in this Cancer EDGE review, we recommend 5 for use with adult cancer survivors, 2 of them highly. We found a lack of prospective studies reporting predictive validity of balance measures to evaluate future fall risk and a lack of studies reporting meaningful change thresholds in response to balance interventions. Our results highlight the need for continued research to validate existing balance measures in the adult cancer population, but specifically with attention to age, and the diverse mechanisms behind cancer-related imbalance, few of which are fully understood.

Responsiveness to change, both improvement and decline, is a critical feature of balance measures in cancer rehabilitation. Prospective surveillance focuses on monitoring a survivor from the time of diagnosis through cancer treatment and thereafter. Currently, there is little guidance to follow when judging whether score declines with treatment toxicity are "clinically meaningful" or even large enough to be "real." Likewise, thresholds are lacking to interpret score improvement with cancer rehabilitation. This is especially important in the current value-based care climate; unfortunately, clinicians must resort to MDC and minimal clinical important difference (MCID) values established in samples that are cancer-free, significantly older, or against a very different anchor (return to independent ambulation vs yoga). Here we reported MDC_{95} values of recommended measures. In the absence of higher-level evidence, MDC_{95} may assist clinicians when deciding whether a score change reflects "true" change in balance control beyond measurement error.

Among the highly recommended measures, the FABS is a multidimensional tool evaluating various domains through a series of 10 diverse activities that challenge static and dynamic balance by altering vision and support surface or by testing activities such as reaching or jumping forward. Each item is scored (0- to 4-point scale) and summed for the total score.[20] Test-retest and interrater reliability is excellent, and concurrent validity with the SOT is modest ($r = 0.581$).[6] For construct validity, the FABS significantly differentiated adult cancer survivors with (score $= 33.3 \pm 6.7$) and without chemotherapy-induced peripheral neuropathy (CIPN) (score $= 36.2 \pm 4.8$) ($P < .001$)[21] and breast cancer survivors (score $= 33.90 \pm 3.46$) from healthy controls (score $= 36.69 \pm 0.99$) ($P < .008$).[6] FABS MDC_{95} is 1.36 points for the breast cancer population.

The other highly recommended (Cancer EDGE rating of 4) balance measure is gait speed, a "unidimensional" tool (single task). It requires the least equipment, instruction,

TABLE 2

Recommended Outcome Measures With Cancer EDGE Rating of 3 or 4 and Application to Cancer Diagnosis, Age, and Practice Setting

Measure	EDGE Rating	Features	Participant Characteristics in Validation Studies		
			Cancer Diagnosis	Age Range	Practice Setting
Fullerton Advanced Balance Scale	4	• 10 performance-based activities • Assessing static and dynamic balance under varying sensory conditions	• Breast cancer[6] • Mixed cancer diagnoses[21,45]	• 50.35 ± 9.34 y (range, 30-60 y)[6] • 58.4 ± 12.3 y in survivors with CIPN and 60.9 ± 10.5 y in survivors without CIPN[21] • 60.6 y[45]	• Survivors with CIPN postchemotherapy and radiation therapy[21] • Receiving taxane chemotherapy[6] • Community[45]
Usual and fast gait speed	4	• Variations in walking speeds and distances for testing	• Mixed cancer diagnoses[25,46-48] • Glioblastoma[49] • Breast cancer[1,3,19,27,28] • Head and neck cancer[26]	• 47.8 ± 11.2 y[1] • 58.5 ± 9.7 y[3] • 62.3 ± 10.8 y[46] • 63.1 ± 9.3 y[26] • 65 ± 11 y[49] • 70.2 ± 4.3 y[19] • 77.2 ± 3.3 y[48] • 53-83 y[27] • 65-93 y[50] • 68-83 y[47] • 75-89 y[25]	• Community[3,25-27,46-48,50] • Receiving inpatient cancer treatment[49] • Receiving cancer treatment[26,47,50] • Postsurgical cancer treatment[19,26] • Receiving chemotherapy[1]
Balance Evaluation Systems Test	3	• 36 performance-based activities • Assessing mechanical constraints, limits of stability, anticipatory postural adjustments, postural responses to induced loss of balance, sensory orientation, and gait	• Mixed cancer diagnoses[39,51]	• 66.7 ± 8.6 y[51] • 68.4 ± 8.1 y[39]	• Community[39,51]
Timed Up and Go	3	• A test item in the CDC STEADI and Otago exercise program • Assessing balance and walking at a comfortable and safe pace	• Mixed cancer diagnoses[15,16,18,21,25,31-33,36] • Breast cancer[19,34] • Prostate cancer[35]	• 58.4 ± 12.3 y in survivors with CIPN; 60.9 ± 10.5 y in survivors without CIPN[21] • 69.6 ± 6.7 y in survivors with ADT; 69.7 ± 6.7 y in survivors without ADT[35] • 59.0 ± 12.2 y[33] • 59.7 ± 10.4 y[34] • 67.8 ± 8.9 y[36] • 70.2 ± 4.3 y[19] • ≥65 y[15,18] • 65-89 y[7] • 73-81 y[16] • 70-93 y[31] • 75-89 y[25] • 77-99.4 y[32]	• Community[18,21,25,33-36] • Receiving cancer treatment[7] • Postsurgical cancer treatment[19] • Receiving chemotherapy[31,32] • Palliative care[15] • Presurgical[16]

(*continues*)

TABLE 2

Recommended Outcome Measures With Cancer EDGE Rating of 3 or 4 and Application to Cancer Diagnosis, Age, and Practice Setting (*Continued*)

Measure	EDGE Rating	Features	Participant Characteristics in Validation Studies		
			Cancer Diagnosis	Age Range	Practice Setting
Five Times Sit to Stand	3	• Variations in timing the fifth sit-to-stand repetition • Assessing lower extremity functional strength and balance during postural transition	• Mixed cancer diagnoses[2,5,17,52] • Metastatic colorectal cancer[53] • Prostate cancer[29,37]	• 50.9 ± 7.0 y[5] • 52.3 ± 12.1 y[17] • 62 ± 6.0 y[2] • 63.7-75.8 y[52] • 69.8 ± 7.0 y[29] • ≥50 y[37] • 50-81 y[53]	• Community[2,29,37,52,53] • Receiving or recently finished chemotherapy ≤12 mo[5] • Subacute hematopoietic stem cell transplant[17]

Abbreviations: ADT, androgen deprivation therapy; CDC, Centers for Disease Control and Prevention; CIPN, chemotherapy-induced peripheral neuropathy; STEADI, Stopping Elderly Accidents, Deaths, & Injuries.

and time of all recommended tools, yet is well-validated and powerful in other populations, especially geriatrics. Coined the "sixth vital sign," gait speed is reliable, valid, and predictive of falls, function, and mortality in older adults[22] and neurologic populations.[23,24] Gait speed is gaining popularity in the adult cancer setting. As evidence of construct validity, gait speed distinguishes older women with (1.3 ± 0.4 m/s) and without cancer (1.5 ± 0.3 m/s)[25] and cancer survivors with (1.1 ± 0.2 m/s) and without CIPN symptoms (1.2 ± 0.2 m/s).[2] Longitudinally, gait speed in early-stage breast cancer survivors differs from prechemotherapy baseline (1.5 ± 0.3 m/s) to the fourth taxane cycle (1.4 ± 0.3 m/s).[1] The MDC_{95} for 10-m walk at usual pace was 0.22 m/s in head and neck cancer

TABLE 3

Clinical Utility of Recommended Measures With Cancer EDGE Rating of 3 or 4

Measure	Equipment Needed	Cost	Ease of Use	Scoring/ Interpretation	Time to Administer	Normative Data
Fullerton Advanced Balance Scale	• 6-in step • Foam pad	Free	High	Easy	10-15 min	• Community-dwelling older adults[60,55]
Usual and fast gait speed	• Stopwatch • Walkway	Free	High	Easy	<5 min	• Adults[56] • Stroke[57] • Female breast cancer survivors aged 65-79 y[19]
Balance Evaluation Systems Test	• Stopwatch • Measuring tape • Masking tape • Foam pad • 10° incline ramp • 6-in step • 2 shoe boxes • Standard chair with arms	Free but copyrighted	Moderate	Easy	20-30 min	• Subacute stroke[58] • Adults aged 50-89 y[59]
Timed Up and Go	• Stopwatch • Standard chair with arms • Masking tape	Free	High	Easy	<5 min	• Community-dwelling older adults[60] • Parkinson disease[61] • Spinal cord injury[62] • Vestibular hypofunction[63]
Five Times Sit to Stand	• Stopwatch • Standard chair with arms	Free	High	Easy	<5 min	• Parkinson disease[64] • Adults aged 60-89 y[65]

survivors.[26] Gait speed protocols vary across cancer studies reviewed, in task goal (usual pace[2,26-29] vs fast pace[1,25,29]) and walking distance (4 m,[2,27,28] 6 m,[29] 10 m,[1,26] and 11 m[25]). Most importantly, no study described whether timing began when participants were already walking or standing. The latter method captures the gait acceleration phase and therefore may result in a slower walking speed. Caution is warranted when comparing gait speeds measured using different testing protocols.[30]

Like gait speed, 2 recommended tools (rating of 3), TUG and 5TSTS, require minimum equipment, training, time, and space to administer. They can be easily

TABLE 4

Psychometric Properties of Recommended Measures With Cancer EDGE Rating of 3 or 4

Measure	Reliability	Validity	MDC_{95}
Fullerton Advanced Balance Scale	*Internal consistency* • Cronbach $\alpha = 0.736$[45] *Test-retest/intrarater reliability* • ICC = 0.98[6] *Interrater reliability* • ICC = 0.98[6] • ICC ≥ 0.8[21]	*Concurrent validity* • Correlated with SOT: $r = 0.581$[6] • Correlated with COP velocity[6] – Eyes open/head straight: $r = -0.581$ – Eyes open/head back: $r = -0.541$ – Eyes closed/head straight: $r = -0.523$ • Eyes closed/head back: $r = -0.496$ *Construct validity* • *Cancer survivors with (33.3 ± 6.7) vs without CIPN (36.2 ± 4.8)* ($P < .001$)[21] • *Breast cancer survivors (33.90 ± 3.46) vs healthy controls (36.69 ± 0.99)* ($P < .008$)[6]	*Breast cancer* • 1.36 (ICC = 0.98; SEM = 0.49)[6]
Usual and fast gait speed	*Coefficient of variation* • CV = 3.1% (4MWT at usual speed)[27,28] • CV = 5.6% (6MWT at usual speed)[29] • CV = 6.7% (6MWT at fast speed)[29] *Test-retest reliability* • ICC = 0.941 (10MWT at usual speed)[26]	*Construct validity* • Community-dwelling women with cancer (1.3 ± 0.4 m/s) vs without cancer ≥75 y (1.5 ± 0.3 m/s) (11MWT at fast speed) ($P < .05$)[25] • Reduced gait speed with cumulative taxane exposure from baseline to the fourth taxane cycle (10MWT at fast speed) in early-stage breast cancer: 5% ± 9% ($p = 0.003$)[1] • Correlated with 30-s sit to stand in head and neck cancer (10MWT at usual speed): $r = 0.322$ ($P = .038$)[26] • Female cancer survivors with (1.1 ± 0.2 m/s) vs without CIPN symptoms (1.2 ± 0.2 m/s) (4MWT at usual speed) ($P < .001$)[2] • Postmenopausal breast cancer survivors with higher (median = 0.29 m/s) vs lower fall risk (median = 0.61 m/s) ($P < .001$)[21] *Predictive validity* Higher gait speed significantly reduces fall risk in postmenopausal breast cancer survivors ($P < .05$)[21]	*Head and neck cancer* • 0.22 m/s (ICC = 0.94; SEM = 0.08) (10MWT at usual speed)[26]
Balance Evaluation Systems Test	*Test-retest/intrarater reliability* • ICC = 0.92[39] *Interrater reliability* • ICC = 0.96[39] *Internal consistency* Cronbach $\alpha = 0.64$-0.78 for each of the 6 categories[51]	*Concurrent validity* Correlated with ABC: $\rho = 0.73$ ($P < .001$)[39]	*Community-dwelling mixed cancer diagnoses* 6.86 (ICC = 0.92; SEM = 2.47)[39]

(*continues*)

TABLE 4

Psychometric Properties of Recommended Measures With Cancer EDGE Rating of 3 or 4 (*Continued*)

Measure	Reliability	Validity	MDC_{95}
Timed Up and Go	*Test-retest/intrarater reliability* ICC = 0.88[6]	*Concurrent validity* • Correlated with ABC-6: $r = -0.54$ ($P < .001$)[36] • Correlated with SOT: $r = -0.48$[6] • Correlated with COP velocity[6] – Eyes open/head back: $r = 0.549$ – Eyes closed/head straight: $r = 0.498$ – Eyes closed/head back: $r = 0.474$ *Construct validity* • Breast cancer survivors (6.69 ± 0.99 s) vs health controls (5.85 ± 0.86 s) ($P = .02$)[6] • Older women with cancer (8.6 ± 4.0 s) vs without cancer (7.4 ± 2.5 s) ($P < .05$)[25] • Cancer survivors with (7.8 ± 2.5 s) vs without CIPN (6.6 ± 1.5 s) ($P < .001$)[21] • Correlated with FACT-NTX: $r = -0.663$ ($P < .01$)[7] • Correlated with Fall Risk Questionnaire: $r = 0.479$ ($P = .028$)[7] *Predictive validity* • OR for falls (TUG ≥14 s vs TUG <14 s) = 1.9 (95% CI, 1.4-2.6) ($P \leq .0001$)[18] • OR for adverse postoperative outcome (TUG >20 s vs TUG ≤20 s) = 3.43 (95% CI, 1.13-10.36) ($P = .03$)[16] – Sensitivity = 42% – Specificity = 89.8% – AUC = 0.66 ($P < .001$) • OR for early deaths (within 6 mo) (TUG >20 s vs TUG ≤20 s) = 2.55 (95% CI, 1.32-4.94) ($P = .006$)[32] • OR for functional decline measured by 6 ADL score from baseline to the second chemotherapy cycle (TUG ≥20 s vs TUG <20 s) = 2.56 ($P = .005$)[31]	*Breast cancer* • 0.95 (ICC = 0.88; SEM = 0.34)[6]
Five Times Sit to Stand	*Coefficient of variation* • CV = 5.9%[28]	*Construct validity* • Women with (12.8 ± 3.7 s) vs without CIPN symptoms (11.6 ± 2.7 s) ($P < .001$)[2] • Prostate cancer survivors on ADT ≥6 mo (16.2 ± 3.9 s) vs on ADT <6 mo (13.5 ± 2.8 s) ($P = .035$)[37]	

Abbreviations: ABC, Activities-specific Balance Confidence Scale; ABC-6, short version of the Activities-specific Balance Confidence Scale; ADL, activities of daily living; ADT, androgen deprivation therapy; AUC, area under curve; CIPN, chemotherapy-induced peripheral neuropathy; CV, coefficient of variation; FACT-NTX, Functional Assessment of Cancer Therapy–Gynecologic Oncology Group–Neurotoxicity; ICC, intraclass correlation coefficient; MCID, minimal clinical important difference; MDC, minimal detectable change; MWT, meter walk test; OR, odds ratio; *r*, Pearson's correlation coefficient; SEM, standard error of measurement; SOT, Sensory Organization Test; TUG, Timed Up and Go.

implemented in clinical practice. Indeed, their use is published across the spectrum of cancer survivorship from presurgical,[16] postsurgical,[19] active cancer treatment,[7] chemotherapy,[31,32] subacute hematopoietic stem cell transplant,[17] community-based,[18,21,25,33,35,36] and palliative care settings.[15] The TUG distinguishes between breast cancer survivors (6.69 ± 0.99 seconds) and healthy controls (5.85 ± 0.86 seconds),[6] between older women with (8.6 ± 4.0 seconds) and without cancer (7.4 ± 2.5 seconds),[25] and between cancer survivors with (7.8 ± 2.5 seconds) and without CIPN (6.6 ± 1.5 seconds).[21] The TUG correlates moderately with the Functional Assessment of Cancer Therapy–Gynecologic Oncology Group–Neurotoxicity (FACT-NTX)[7] and the Fall Risk Questionnaire in older survivors receiving cancer treatments,[7] the short version of the Activities-specific Balance Confidence Scale in older survivors of mixed cancer diagnoses,[36] and the SOT in breast cancer survivors.[6] Standard TUG

TABLE 5
Outcome Measures With Cancer EDGE Rating of 1 or 2

Measure	EDGE Rating	Features	Rationale for EDGE Rating
30-Second Sit to Stand[19,21,25,33,34,46,66]	2	• A test item in the Senior Fitness Test	• Only one study demonstrated excellent test-retest reliability and poor-moderate concurrent validity with gait speed in head and neck cancer survivors[26]
Activities-specific Balance Confidence Scale[39,51]	2	• Patient-reported outcome measure • Assessing balance confidence during 16 daily activities	• Only one study demonstrated good-excellent concurrent validity with the BESTest in community-dwelling older cancer survivors[39]
Berg Balance Scale[49,67-69]	2	• 14 performance-based items primary testing static balance and postural transition	• Insufficient evidence of psychometric properties in adult cancer survivors • One study reported a cutoff score of 45 in the BBS for predicting loss of walking ability 4-8 mo in glioblastoma survivors[49]
Dizziness Handicap Inventory[70]	2	• Patient-reported outcome measures • 25 items about perceived handicap from dizziness	• Insufficient evidence of psychometric properties in adult cancer survivors
Functional Reach Test[33,34,66,71]	2	• Assessing stability limits and verticality	• One study reported effect size, MDC_{90}, and MCID in women with breast cancer[34]
Modified Clinical Test of Sensory Interaction on Balance[67]	2	• Assessing balance under various sensory conditions	• Insufficient evidence of psychometric properties in adult cancer survivors
Short Physical Performance Battery[28,37,72,73]	2	• Multidimensional tool • Assessing lower extremity functioning	• Insufficient evidence of psychometric properties in adult cancer survivors
Single leg stance[46]	2	• Assessing static balance	• One study reported effect size, MDC_{90}, and MCID in women with breast cancer[34]
Tinetti Performance-Oriented Mobility Assessment[19]	2	• Multidimensional tool • Assessing balance and gait	• One study reported gait speed with relation to high and low fall risks as defined by Tinetti POMA scores in women with breast cancer[19]
Balance Efficacy Scale[45]	1	• Patient-reported outcome measures • Assessing balance confidence during 18 daily activities	• Insufficient evidence of psychometric properties in adult cancer survivors and other populations
Center-of-pressure measures[1,4,5,25,67]	1	• Various variables available • Assessing static balance	• Insufficient evidence of psychometric properties in adult cancer survivors • Require equipment, setup, training, time, and space for using a force plate
Sensory Organization Test[3,6]	1	• Assessing balance under various sensory conditions	• Require equipment, setup, training, time, and space for using the device • ICC of test-retest reliability for total SOT = 0.86.[6]
Sharpened Romberg[70]	1	• Assessing static balance under an altered sensory condition • Commonly used in neurologic examination	• Insufficient evidence of psychometric properties in adult cancer survivors and other populations

Abbreviations: BBS, Berg Balance Scale; BESTest, Balance Evaluation Systems Test; ICC, intraclass correlation coefficient; MCID, minimal clinical important difference; MDC_{90}, minimal detectable change based on 90% confidence interval; SOT, Sensory Organization Test; Tinetti POMA, Tinetti Performance-Oriented Mobility Assessment.

requires the patient to walk 3 m (9.8 ft) before turning around, but one study used 8 ft.[19] Most TUG publications are in geriatric oncology populations, as the TUG is a part of the Comprehensive Geriatric Assessment, so its application to younger survivors may be limited, and ceiling effects are published in older cancer cohorts.[35]

5TSTS distinguishes cancer survivors with (12.8 ± 3.7 seconds) and without CIPN symptoms (11.6 ± 2.7 seconds)[2] and between prostate cancer survivors on androgen deprivation therapy for 6 months or more (16.2 ± 3.9 seconds) and less than 6 months (13.5 ± 2.8 seconds).[37] Two different 5TSTS administration protocols were identified among the studies reviewed.[2,28,37] In both, timing started when the patient began to rise from the chair but the endpoint differed. In traditional 5TSTS, timing stopped when the patient sat down against the back of the chair

for the fifth time.[37] In the Short Physical Performance Battery version, timing stopped with upright posture on the fifth stand.[2,28] As with all measures, clinicians must note methodologic differences when comparing an individual score against published values.

The final recommended tool (rating of 3) is multidimensional. The BESTest includes 36 activities in 6 categories: musculoskeletal constraints, stability limits, sensory orientation, anticipatory and reactive postural control, and gait with and without dual-tasking. Each item is scored on a 0- to 3-point scale, summed for a possible score of 108.[38] The BESTest has excellent test-retest and interrater reliability and moderate concurrent validity with the Activities-specific Balance Confidence Scale in community-dwelling cancer survivors.[39] BESTest MDC_{95} is 6.86 points for older adults with mixed cancer diagnoses in the community setting.[39]

To identify balance impairments and quantify fall risk, balance measures must have not only sound psychometric properties but also high clinical utility for the unique needs of an adult cancer population. As prospective surveillance and prehabilitation models grow, survivors are increasingly evaluated in their cancer clinics, with limited space and time. For this reason, COP measures, accepted as the balance "gold standard," are not recommended for clinical use in adult cancer survivors.

We do recommend 2 tools, FABS and BESTest, which require equipment (most is portable) and more time (at least 20 minutes). A benefit of these more comprehensive "multidimensional" tests is the potential to better localize a patient's balance deficits during testing by comparing balance performance across the different tasks within the tool. Results then guide the intervention; a patient who "fails" only tasks with absent or conflicted vision may be prescribed exercises to decrease visual reliance while promoting plasticity of deficient systems. Such multidimensional tools may assist in better defining the nature of cancer-related balance impairments, given the many postural control systems and functions potentially damaged by cancer, and the toxicities of diverse therapies. Because the FABS is shorter and requires less equipment, it may be more practical than the BESTest in a busy cancer clinical environment. Shorter versions of the BESTest, mini-BESTest and brief-BESTest,[40] have fewer test items and are highly applicable in clinical practice, although their psychometrics remain to be examined further in adult cancer survivors. Translating outcome measures into clinical practice is challenging. Knowledge and familiarity with the measures, time required to search for and carry out the assessment, and facility culture are important factors influencing physical therapists' adoption of outcome measures.[41,42] Providing facilitators, workshops, practice sessions, and online and hard copy resources may improve physical therapists' frequency in use of outcome measures.[10] The previous Cancer EDGE Task Force for balance measures, completed in 2015, was restricted to breast cancer and could only recommend the FABS and the TUG.[39] A lack of outcome measures is a barrier to timely identification and management of cancer-related balance impairments.[43] With this systematic review of balance measures, extended to include adult survivors of all cancers, we begin to address this barrier. By expanding the clinical knowledge base of balance measures, the Cancer EDGE Task Force aims to promote practice changes, specifically more frequent screening, assessment, and interventions of balance impairments in adult cancer survivors and not limited to those older than 65 years.

We identified several knowledge gaps and future research opportunities through this review. First, prospective cohort studies are necessary in adult cancer survivors to quantify predictive validity of balance measures for assessing fall risk. In addition, diagnostic validity of balance measures must be established for detecting cancer survivors at risk of falling and extending into younger adult survivor groups in their 30s and 40s. Critical to prospective surveillance and prehabilitation, MDC and MCID values are not established for the majority of balance measures. Another important finding was the lack of diagnosis (eg, cancer type), treatment (eg, postsurgical, radiological, or chemotherapy), or symptom (eg, CIPN)-specific and patient-reported outcome (PRO) measures for balance in adult cancer survivors. PROs enhance the quality of care by facilitating communication between clinicians, patients, caregivers, and other stakeholders, and some even inform clinicians about the effect of balance impairments in the context of the patient's daily activities, societal roles, and participation.[44] We suspect that no single balance measure will meet every rehabilitation need (screening, assessment, and outcome measurement after interventions) for all cancer populations, in adult survivors of all ages and baseline functional statuses, and with exposure to all cancer therapies. Surgery, radiation therapy, traditional chemotherapies, hormonal therapy, and immunotherapies likely impact different postural control systems. Alternatively, they may impact the same systems but by different injury mechanisms. Thus, the problem of imbalance and falls in cancer survivors may be even more multifactorial than in the general aging population. Certain measures may be optimal for subgroups of survivors (eg, those with CIPN vs fatigue) and may even function only for one need (screening fall risk vs quantifying response to intervention).

This systematic review has several limitations. Only peer-reviewed journal articles published in English were included in the search, and selection bias is possible. Balance measures rated were limited to those reported in studies related to the practice of rehabilitation, specifically physical and occupational therapy. Tools used by other disciplines to assess balance may have been excluded from this review. Heterogeneity of studies reviewed was significant even among studies of the same balance measure. Participants varied widely in age, functional status, cancer site and stage, cancer treatments and balance interventions received, and clinical settings. In some cases, administration protocols varied for a single balance measure. Clinicians must consider the individual characteristics of their

patient when using the information in this review to select and apply a balance measure.

In conclusion, for clinical measurement of balance in adult cancer survivors, the Cancer EDGE Task Force highly recommends the FABS and gait speed and recommends the BESTest, TUG, and 5TSTS. Future research should address knowledge gaps in age-based reference values for adult cancer populations, with specific attention to cancer site, stage, treatments, or symptoms. In addition, establishing meaningful change and responsiveness of balance measures is a priority, while defining cutoff scores for prediction of adverse outcomes such as falls and injury is warranted. Finally, patient-reported balance outcomes specific to cancer treatments and symptoms are needed to facilitate communication and care coordination.

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