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Assessment of Gait Speed and Timed Up and Go Measures as Predictors of Falls in Older Breast Cancer Survivors

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Abstract

Background: Older breast cancer survivors are at an increased risk of loss of postural balance and accidental falls, however, the ability of clinical mobility measures to predict falls has not been determined. The purpose of this study was to examine the prognostic ability, sensitivity, and specificity to predict accidental falls in measures of gait speed and functional mobility in older breast cancer survivors. **Methods:** Thirty-four breast cancer survivors 65 years and older performed 3 measures of gait speed (GS) (usual, fast, dual-task) and Timed Up and Go (TUG) (TUG, TUG-Cognitive, TUG-Manual). Follow-up calls were made 3 months after testing to track falls. **Results:** The area under the curve (AUC) was below 0.5 for all GS measures, indicating poor predictive ability and all GS measures had low sensitivity and specificity to predict falls. All TUG measures had AUC values above 0.5. The cutoff score with the best sensitivity/specificity to predict falls was: TUG-Cognitive = 11.32 seconds, Sens = 0.64, Spec = 0.80; TUG-Manual = 9.84 seconds, Sens = 0.71, Spec = 0.65. **Conclusion:** When assessing fall risk in older breast cancer survivors, performance on the TUG and TUG-Cognitive are able to predict falls.

Keywords

postural balance, mobility limitation, accidental falls, breast neoplasms, gait

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Introduction

Falls are a major cause of injury and death in older adults.[1] Older breast cancer survivors are at an increased risk of falls and fall-related injuries due to multiple sequelae of cancer and its treatment.[2-4] Chemotherapy-induced peripheral neuropathy causes sensory deficits in the lower extremities, often leading to impaired balance and altered walking patterns in breast cancer survivors.[5,6] Muscle weakness and fatigue are also common deficits that impair mobility and balance.[2] Due to these balance and mobility impairments and subsequent fall risk, older breast cancer survivors should be assessed for their risk of falling.[2,7] Clinical measures exist to assess mobility and balance in older cancer survivors.[8,9] Several measures also have established sensitivity, specificity, and cutoff scores to predict falls in older adults.[10-12] However, the ability of these measures to predict falls in older breast cancer survivors has not been reported.

Gait speed (GS) is a measure commonly used in clinical settings to assess mobility and ambulation. For community dwelling older adults, GS is significantly associated with overall health, level of independence, and falls risk.[10] In older cancer survivors, slowed GS is a significant predictor of early death.[13] Speeds between 0.6 and 0.8 m/s have been determined as the cut-offs for increased fall risk in community-dwelling older adults.[10] Although some studies in older cancer survivors have reported mean GS above 1.0 m/s,[9,14,15] it is unknown if the cutoff speeds reported in the geriatrics literature for falling should be used for older cancer survivors as they often have sensory or balance impairments that increase their fall risk.[2,5,7] Additionally, GS is measured in a number of different ways including usual or normal walking speed, fast GS, and with the inclusion of a secondary cognitive task, known as dual-task GS. Despite having established validity and reliability in older cancer survivors,[9] the sensitivity and specificity thresholds of the GS

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measures to predict falls needs to be established for this population.

The timed up and go (TUG) test is another measure often used in clinical settings and across multiple populations to assess mobility and dynamic balance. Scores on the TUG have been identified as a significant predictor of falls in community-dwelling older adults.[11,12] Early studies on the TUG reported a time of greater than 13.5 seconds to have 80% sensitivity and 100% specificity to predict falls in community-dwelling older adults.[11] More recent findings have found a faster cutoff time of 12.6 seconds to have 30.5% sensitivity and 89.5% specificity to predict falls in community-dwelling older adults.[12] In cancer survivors longer, or more impaired, TUG completion times are reported as compared to those without history of cancer.[14,16] Two additional versions of the TUG exist which have been used to predict falls, including the TUG-Cognitive where a secondary cognitive task is performed during the measure, and the TUG-Manual. Similar to GS, the validity and reliability of the 3 TUG measures have been established in older cancer survivors,[9] but the prognostic ability to predict falls and the cut-off scores with the highest sensitivity and specificity have not been reported.

Although clinical measures exist to assess mobility and balance in older cancer survivors, studies describing their ability to predict falls are lacking. Establishing cut-off scores along with the sensitivity and specificity of these tools would add to the clinical utility of these measures to identify falls risk and to develop interventions to mitigate risk. Therefore, the purpose of this study was to examine the prognostic ability, sensitivity, and specificity to predict falls of Usual GS, Fast GS, Dual-task GS and 3 versions of the TUG (TUG, TUG-Cognitive, TUG-Manual) in older breast cancer survivors.

Methods

Study Population

Participants in this study were selected from a larger study of mobility, balance, and cognitive measures in community-dwelling older cancer survivors.[9,17] Inclusion criteria for that study included being age of 65 years or more, English speaking, having a medically confirmed diagnosis of breast, lung, prostate or colorectal cancer, primary cancer treatment completion at least 3 months prior to testing, and being able to get up from a chair, stand, and walk 50 ft with or without the use of an assistive device. Only data from breast cancer survivors were used in this analysis as they comprised the majority of the sample population. Exclusion criteria included reporting a cancer recurrence or metastases, a history of chronic neurologic condition, more than one cancer diagnosis (excluding skin cancer), acute illness or having an unstable medical condition. We did not screen for the presence of chemotherapy induced peripheral neuropathy (CIPN) nor include it as inclusion or exclusion criteria. Human subject institutional review board approval was obtained from the University of Michigan (HUM00137566).

Gait Speed Measures

GS was measured using the 10-m walk test, which consisted of a 5-m acceleration and deceleration zone on each end of a 10-m testing zone. Timing began when the participant crossed the line marking the end of the acceleration zone and stopped when they crossed the line marking the beginning of the deceleration zone. Usual GS was measured first, during which the participant was instructed to walk at their normal walking speed. Dual-task GS was measured next. During this test, the participant was instructed to walk at their normal walking speed while reciting the alphabet out loud and skipping every other letter. Fast GS was measured last in this sequence and during which the participant was instructed to walk as fast as possible over the same 10-m distance without becoming unsteady or running. Each GS measure was performed twice and the average speed was calculated in meters/second.

TUG Measures

For the TUG, the participant was required to stand up from a chair, walk 3 m and touch a line on the floor, walk back to the chair and sit down.[9] A demonstration of each TUG measure was completed by the examiner prior to having the participant complete the measure. For all 3 TUG measures, timing began when the tester said "go" and stopped when the participant made contact with the chair as they sat down. Each measure was performed twice and the average time was calculated. TUG was completed first. TUG-Cognitive was completed next and for this test the participant was instructed to count down out loud by subtracting 3 from a random number between 20 and 100 while completing the TUG. They were instructed to continue the test even if they made a subtraction error. TUG-Manual was the last of the 3 TUG measures completed which required the participant to pick up a partially filled cup, carry it as they completed the TUG, and set it back down before sitting.

Prospective Falls Assessment

After gathering baseline data, participants were told that they would receive a follow up phone call from the research team 3 months after the testing session. They were informed to document on a calendar if they experienced a fall. During the follow up call, the research team member asked the participant if she had fallen within the previous 3 months. To improve recall, a date was referenced (eg, "have you fallen since October 1st?") A fall was defined as a loss of balance which resulted in a person coming to rest inadvertently on the ground or floor or other lower level.[18]

Other Measures

Other data gathered at baseline included general demographic information, medical history which was used to create a comorbidity index, cancer related medical history, and anthropometric information to calculate body mass index (BMI). The Functional Comorbidity Index (FCI) was used to represent the number of comorbidities present in the population. FCI is a sum of 18 self-reported comorbid conditions with a score of 0 to 18 with higher scores indicating greater comorbidity.[19]

Data Analysis

Participants who fell at least once during the 3-month follow-up period were defined as fallers and assigned to the Falls Group. Those who did not fall were defined as non-fallers and assigned to the No Falls Group. Mean values for continuous variables were compared between groups using independent t-tests while categorical data was compared using Chi-squared tests.

The ability of the GS and TUG measures to predict falls was first examined using Receiver Operating Characteristic (ROC) curves with the Area Under the Curve (AUC) analyzed. Higher AUC values indicate that a measure is able to predict falls ranging from 0.5 where the test is no better than chance, up to 1.0 indicating that the test has a 100% ability to predict falls. For measures for which AUC values were >0.50, the score with the highest sensitivity and specificity to predict falls was determined and that score was used in regression modeling.

Then, to examine how each of the measures contributes to falls we completed logistic regression analyses for each of the GS and TUG measures. We examined this first using the continuous scores of the measures and then we used the sensitivity/specificity cutoff score from the ROC analysis. Unadjusted logistic regression models were created to calculate the odds ratio (OR) with 95% confidence intervals for the continuous scores of TUG, TUG-Cognitive, and TUG-Manual and for the cutoff scores for each measure. Then, adjusted multivariate logistic regression models were created controlling for comorbidity. Statistical significance was set at $P<.05$ and SPSS version 26 (IBM Corporation, Armonk, NY) was used for all analyses.

Results

A total of 34 older breast cancer survivors participated. Mean age was 72.62 ± 5.66 years with the majority being white (91.2%) and having a college degree (70.6%). Complete demographic information can be found in Table 1.

At the 3-month follow up, 14 participants (41.2%) reporting falling and were allocated to the Falls Group while 20 (58.8%) had not fallen. The number of falls ranged 0 to 3 with a mode of 1. In the falls group, 11 people reported falling once, 1 fell twice, and 2 fell 3 times within the 3-month follow up. Groups did not significantly differ in age, race, level of education, comorbidity, BMI, number of medications, time since cancer diagnosis, cancer stage at diagnosis, or cancer treatment. Members of the No Falls Group had walked faster and had better TUG performance than the Falls Group with significantly faster times on the TUG ($P<.05$) and fast GS ($P<.05$).

ROC Curve

Usual GS and dual-task GS had an AUC of 0.27 ($P=.12$) and 0.34 ($P=.10$), respectively. Fast GS had an AUC of 0.25 (95% CI=0.00-0.57), which was significant ($P=.02$). TUG had the highest AUC (0.76) at a 95% CI of 1.08-2.35; $P=.02$. The AUC was 0.69 for both TUG-Cognitive (95% CI=0.98-1.57, $P=.07$) and TUG-Manual (95% CI=0.96-1.67, $P=.10$).

Sensitivity and Specificity

The sensitivity and specificity of each measure at different cutoffs can be found in their corresponding table (Tables 2 and 3). Measures of GS did not have cutoff scores with appropriate sensitivity and specificity for predicting falls (Table 2). The TUG cutoff score of 9.37 seconds had a sensitivity=71% and specificity 80%. The score on the TUG-Cognitive with the best sensitivity/specificity was 11.32 seconds (Sens=64%, Spec=80%) while a score of 9.84 seconds on the TUG-Manual had a sensitivity=71% and specificity=65% (Table 3).

Prediction of Falls

The regression analysis results to predict falls can be found in Table 4. For the gait speed measures, fast GS was the only significant predictor of falls in both the unadjusted and adjusted models (OR=0.02, 95% CI=0.00-0.71, $P=.03$).

Of the 3 TUG measures, TUG was the only significant predictor of falls in both unadjusted and adjusted models. However, when the 9.37 seconds cutoff time for TUG was used in regression modeling to predict falls, this resulted in greater odds ratios in both the unadjusted (OR=10.00, 95% CI=2.03-49.29, $P=.005$) and adjusted (OR=8.90, 95% CI=1.73-45.70, $P=.009$) models.

The TUG-Cognitive cutoff time of 11.32 seconds was also a significant predictor of falls in both models, and stronger after controlling for covariates (Adjusted: OR=7.95, 95% CI=1.52-41.68, $P=.01$). In unadjusted modeling, the TUG-Manual cutoff time of 9.84 seconds was

Table 1. Demographic Information for Entire Sample, Falls Group, and No Falls Group (N = 34).

Variable	Entire sample N = 34	Falls group N = 14	No Falls group N = 20	*P*-value
Age, y	72.62 (5.66)	72.86 (4.17)	72.45 (6.61)	.84
Race				
White	31 (91.2%)	12 (85.7%)	19 (95.0%)	.16
Black/African American	2 (5.9%)	2 (14.3%)	—	
Asian	1 (2.9%)	—	1 (5.0%)	
Highest level of education				
High school	3 (8.8%)	2 (14.3%)	1 (5.0%)	.69
Some college	7 (20.6%)	3 (21.4%)	4 (20.0%)	
Associate degree	3 (8.8%)	2 (14.3%)	1 (5.0%)	
Bachelor's degree	7 (20.6%)	2 (14.3%)	5 (25.0%)	
Beyond Bachelor's degree	14 (41.2%)	5 (35.7%)	9 (45.0%)	
Functional comorbidity index	2.59 (1.76)	3.21 (1.48)	2.15 (1.84)	.08
BMI, kg/m^2	28.08 (5.17)	30.08 (6.54)	26.88 (3.91)	.15
Number of medications	6.35 (4.05)	7.50 (4.75)	5.55 (3.38)	.17
Years since diagnosis	12.53 (10.55)	12.79 (12.19)	12.35 (9.57)	.91
Cancer stage at diagnosis				
0	3 (8.8%)	1 (7.1%)	2 (10.0%)	.73
1	18 (52.9%)	7 (50.0%)	11 (55.0%)	
2	9 (26.5%)	2 (35.7%)	4 (20.0%)	
Unknown	4 (11.8%)	1 (7.1%)	3 (15.0%)	
Cancer treatment type				
Chemotherapy	14 (41.2%)	8 (57.1%)	6 (30.0%)	.37
Radiation	11 (32.4%)	4 (28.6%)	7 (35.0%)	
Surgery	8 (23.5%)	5 (14.3%)	6 (30.0%)	
Hormonal therapy	1 (2.9%)	—	1 (5.0%)	
Usual GS, m/s	1.16 (0.20)	1.08 (0.18)	1.21 (0.20)	.06
Fast GS, m/s	1.65 (0.32)	1.48 (0.25)	1.76 (0.32)	.009
Dual task GS, m/s	1.08 (0.26)	0.99 (0.27)	1.14 (0.24)	.99
TUG, s	9.41 (2.27)	10.59 (2.26)	8.58 (1.92)	.009
TUG-Cognitive, s	11.00 (3.32)	12.29 (3.50)	10.11 (2.95)	.06
TUG-Manual, s	10.31 (2.87)	11.34 (2.80)	9.59 (2.77)	.08

Values shown are mean (standard deviation) or number (%).
Abbreviations: BMI: body mass index; GS: gait speed; TUG: timed up and go; s: seconds.

Table 2. Sensitivity and Specificity of Gait Speed Measures.

	Speed (m/s)	Sensitivity	Specificity
Usual Gait Speed	≤0.85	0.93	0.05
	≤1.01	0.57	0.15
	≤1.10	0.36	0.20
	≤1.20	0.21	0.35
	≤1.31	0.07	0.70
Fast Gait Speed	≤1.38	0.79	0.10
	≤1.50	0.50	0.25
	≤1.58	0.36	0.35
	≤1.69	0.21	0.40
	≤1.74	0.14	0.50
Dual-Task Gait Speed	≤0.72	0.86	0.05
	≤0.81	0.79	0.15
	≤0.93	0.57	0.20
	≤1.02	0.50	0.30
	≤1.20	0.21	0.55

Table 3. Sensitivity and Specificity of TUG Measures.

	Score (s)	Sensitivity	Specificity
TUG	≤6.71	1.00	0.15
	≤7.80	0.93	0.35
	≤9.37	0.71	0.80
	≤10.04	0.57	0.85
	≤11.35	0.50	0.95
TUG-Cognitive	≤7.39	1.00	1.00
	≤9.99	0.79	0.50
	≤11.32	0.64	0.80
	≤12.93	0.50	0.90
	≤16.51	0.14	0.95
TUG-Manual	≤7.02	1.00	0.15
	≤8.11	0.93	0.40
	≤9.84	0.71	0.65
	≤11.41	0.50	0.80
	≤12.01	0.36	0.85

Table 4. Unadjusted and Adjusted Logistic Regression Analysis of Gait Speed and Timed Up and Go Measures to Predict Falls in Older Breast Cancer Survivors.

	Unadjusted analysis				Adjusted analysis			
Variable	*B*	OR	95% CI	*P*-value	*B*	OR	95% CI	*P*-value
Usual GS	−3.77	0.02	0.00–1.41	.07	−3.35	0.04	0.00–2.42	.12
Fast GS	−3.66	0.03	0.00–0.57	.02	−3.81	0.02	0.00–0.71	.03
Dual-Task GS	−2.41	0.09	0.01–1.65	.10	−2.04	0.13	0.01–2.82	.19
TUG	0.47	1.60	1.08–2.35	.02	0.45	1.57	1.05–2.35	.03
TUG, 9.37 s cutoff time	2.30	10.00	2.03–49.29	.005	2.19	8.90	1.73–45.70	.009
TUG-Cognitive	0.22	1.24	0.98–1.57	.07	0.19	1.21	0.94–1.55	.14
TUG-Cognitive, 11.32 s cutoff time	1.97	7.20	1.53–33.84	.01	2.07	7.95	1.52–41.68	.01
TUG-Manual	0.24	1.27	0.96–1.67	.10	0.22	1.24	0.93–1.66	.15
TUG-Manual, 9.84 s cutoff time	1.54	4.64	1.06–20.39	.04	1.51	4.55	0.96–21.45	.06

Abbreviations: *B*: unstandardized beta; OR: odds ratio; CI: confidence interval; GS: gait speed; TUG: timed up and go; s: seconds.

able to significantly predict falls (OR = 4.64, 95% CI = 1.06-20.39, *P* = .04), however its ability to predict falls was no longer significant after controlling for covariates.

Discussion

Clinical measures of mobility are used to predict fall risk in older adults. Due to the unique medical history and physical impairments of older breast cancer survivors, establishing cutoff scores of these measures to predict falls is needed in this population. This study adds to the literature describing the sensitivity and specificity of measures of GS and TUG to predict falls in older breast cancer survivors.

In unadjusted and adjusted multivariate regression modeling, fast GS was the only gait measure identified as a significant predictor of falls, yet the OR values were quite low indicating limited ability to predict falls. Further, the AUC of the ROC curve analysis of 0.25 indicated that this measure had limited ability to predict falls and a cutoff score with high sensitivity/specificity was not able to be determined. Likely this was the result of having mean usual walking speeds of the population >1.16 m/s which is suggested to be faster than normative speeds reported in geriatrics literature.[10] This suggests that fast, usual or DT GS measure performance may not be able to predict falls in older breast cancer survivors and that other measures with better predictive ability should be considered.

The AUC for the TUG in this study (0.76) was greater than previous AUC values for the TUG reported in community-dwelling older adults (AUC = 0.58; *P* = .165) which indicated that TUG scores were unable to predict falls at 12-months after baseline measures.[20] These results suggest that TUG may better predict falls in older breast cancer survivors, and perhaps more so within a shorter time frame. The AUC for TUG-Cognitive was higher in our sample of breast cancer survivors, yet it was not a significant predictor of falls, whereas, TUG-Cognitive scores were able to significantly predict falls 12-months after baseline measures.[20] The AUC values of this study demonstrate moderate accuracy for predicting falls, with the highest accuracy for the TUG.

When scores were examined as a continuous variable, only TUG scores were able to predict falls in both the unadjusted and adjusted models. Continuous scores on the TUG-Cognitive and the TUG-Manual were not significant predictors of falls in regression modeling. However, the cutoff scores for each of the TUG measures with the best sensitivity and specificity were identified as significant predictors of falls and had odds ratios that were much greater. The TUG cutoff of 9.37 seconds had a 9× higher risk for falling, which is a lower time than the 12.7 seconds cutoff score that has been reported to predict falls in community-dwelling older women without a cancer history (Specificity = 80%, CI = 1.73-45.70).[21] TUG-Cognitive scores greater than 11.32 seconds had a 8× higher risk for falling, which is also faster than the 15 seconds time that has been found to predict falls in community-dwelling older adults.[11] Therefore, clinicians should consider using these cutoff scores as a benchmark to performance on the measures when assessing falls in older breast cancer survivors.

Our regression models were not able to account for the presence of CIPN in the sample, which may have contributed to more postural instability,[22,23] decreased balance resulting in impaired TUG scores and changes in gait including slowed GS. As such, we cannot rule out the possibility that some participants' mobility and balance performance may have been influenced by peripheral neuropathies and we suggest future studies be completed to examine the role that CIPN presence and severity may play on TUG performance, gait speed, and falls risk in older breast cancer survivors.[6]

Although slow GS has been identified as a significant predictor of falls in older adults and more impaired usual and fast GS have been reported in cancer survivors,[24] results from this study suggest that in older breast cancer survivors falls may be better predicted by using a different measure. The TUG measures demonstrated better predictive ability than GS measures, suggesting that falls in this population may be influenced by more than just walking speed. The TUG includes walking as well as lower extremity strength and dynamic balance, providing a more thorough test of mobility and balance. Furthermore, the TUG-Cognitive includes a mental component which examines the ability to dual-task, another skill where decreased performance is associated with falls.[25] Therefore, when choosing a measure to assess fall-risk in older breast cancer survivors, clinicians should consider the TUG or TUG-Cognitive rather than GS measures.

This study was limited in that it included a small sample of breast cancer survivors, limiting its diversity of age, race, and cancer type. The participants in this study were community-dwelling cancer survivors who performed well on the mobility measures and whose mean time since last treatment was 12.53 years. Therefore, they may not accurately represent all older breast cancer survivors and especially those in the more acute stage of the disease or treatment. Additionally, they had limited fall history and those who did fall had variability as some fell more than one time during the follow-up period. Lastly, we did not screen for the presence of CIPN within the recruitment or baseline testing phases which, if present, may translate into having a population with more impaired balance and decreased mobility. However, despite this limitation, we suggest using the cutoff values reported as a minimum threshold for fall prediction in older breast cancer survivors with impaired balance, especially in those a history of CIPN where balance impairments are more pronounced and fall risk increased.

Results of this study indicate that scores on simple measures of mobility are able to predict falls, however, mechanisms of balance which comprise the body's ability to prevent falling are complex and perhaps understudied in cancer survivors. Research using more advanced technologies like force plates or motion capture data may be useful to describe how components of postural control translate into risk of falls in older breast cancer survivors, and specifically when assessing outcomes of fall prevention interventions.[26]

This study adds to the literature in that it describes tools that assess falls risk in breast cancer survivors, however if scores on the included measures in this study are impaired (longer TUG times or slower GS) follow up interventions are suggested. Promising evidence describing improved balance outcomes from task-specific fall prevention exercise programs is emerging in cancer survivors. Multimodal exercise programs that include aerobic and resistance exercises along with balance training have been reported to improve balance in cancer survivors.[26-28] This multimodal approach aligns with the American College of Sports Medicine recommendations that older adults perform regular aerobic, resistance and balance training for optimal physical function.[29] However, we urge caution in employing one type of modality (eg, resistance training alone) to address fall prevention in older breast cancer survivors,[30] as a comprehensive systematic review of the geriatrics literature suggests using a multifactorial intervention to address falls.[31] Nevertheless, additional research should be completed to determine specific types and parameters of exercise to improve balance and decrease fall risk in older breast cancer survivors.

Conclusions

When assessing fall risk in older breast cancer survivors, measures of GS may not accurately predict falls. Clinicians should consider using TUG measures, specifically the TUG and TUG-Cognitive, when assessing falls risk in older breast cancer survivors.

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Author Contributions

Jennifer Blackwood was involved in the study conception and design. Material preparation was performed by Kateri Rybicki. Data collection was performed by both authors with assistance from 2 additional research team members, non-authors on this publication. Both authors contributed to data analysis and writing the manuscript.

Declaration of Conflicting Interests

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References

1. Kruschke C, Butcher HK. Evidence-based practice guideline: fall prevention for older adults. *J Gerontol Nurs*. 2017;43:15-21. doi:10.3928/00989134-20171016-01
2. Schwartz AL, de Heer HD, Bea JW. Initiating exercise interventions to promote wellness in cancer patients and survivors. *Oncology (Williston Park)*. 2017;31:711-717.
3. Sattar S, Haase K, Kuster S, et al. Falls in older adults with cancer: an updated systematic review of prevalence, injurious falls, and impact on cancer treatment. *Support Care Cancer*. Jul 2021;29:21-33. doi:10.1007/s00520-020-05619-2
4. Huang MH, Blackwood J, Godoshian M, Pfalzer L. Predictors of falls in older survivors of breast and prostate cancer: a retrospective cohort study of surveillance, epidemiology and end results–medicare health outcomes survey linkage. *J Geriatr Oncol*. 2019;10:89-97. doi:10.1016/j.jgo.2018.04.009
5. McCrary JM, Goldstein D, Trinh T, et al. Balance deficits and functional disability in cancer survivors exposed to neurotoxic cancer treatments. *J Natl Compr Canc Netw*. 2019;17:949-955. doi:10.6004/jnccn.2019.7290
6. Bao T, Basal C, Seluzicki C, Li SQ, Seidman AD, Mao JJ. Long-term chemotherapy-induced peripheral neuropathy among breast cancer survivors: prevalence, risk factors, and fall risk. *Breast Cancer Res Treat*. 2016;159:327-333. doi:10.1007/s10549-016-3939-0
7. Huang MH, Miller K, Smith K, Fredrickson K, Shilling T. Reliability, validity, and minimal detectable change of balance evaluation systems test and its short versions in older cancer survivors: a pilot study. *J Geriatr Phys Ther*. 2016;39:58-63. doi:10.1519/JPT.0000000000000047
8. Huang M, Hile E, Coarkin E, et al. Academy of oncologic physical therapy EDGE task force: a systematic review of measures of balance in adult cancer survivors. *Rehabil Oncol*. 2019;37:92-103.
9. Blackwood J, Rybicki K, Huang M. Mobility measures in older cancer survivors: an examination of reliability and minimal detectable change. *Rehabil Oncol*. Published online December 18, 2020. doi:10.1097/01.reo.0000000000000216
10. Middleton A, Fritz SL, Lusardi M. Walking speed: the functional vital sign. *J Aging Phys Act*. 2015;23:314-322. doi:10.1123/japa.2013-0236
11. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test. *Phys Ther*. 2000;80:896-903.
12. Kojima G, Masud T, Kendrick D, et al. Does the timed up and go test predict future falls among British community-dwelling older people? Prospective cohort study nested within a randomised controlled trial. *BMC Geriatr*. 2015;15:38. doi:10.1186/s12877-015-0039-7
13. Pamoukdjian F, Lévy V, Sebbane G, et al. Slow gait speed is an independent predictor of early death in older cancer outpatients: results from a prospective cohort study. *J Nutr Health Aging*. 2017;21:202-206. doi:10.1007/s12603-016-0734-x
14. Ihira H, Mizumoto A, Makino K, et al. Physical functions, health-related outcomes, nutritional status, and blood markers in community-dwelling cancer survivors aged 75 years and older. *Asian Pac J Cancer Prev*. 2014;15:3305-3310. doi:10.7314/apjcp.2014.15.7.3305
15. Winters-Stone KM, Medysky ME, Savin MA. Patient-reported and objectively measured physical function in older breast cancer survivors and cancer-free controls. *J Geriatr Oncol*. 2019;10:311-316. doi:10.1016/j.jgo.2018.10.006
16. Morishita S, Mitobe Y, Tsubaki A, et al. Differences in balance function between cancer survivors and healthy subjects: a pilot study. *Integr Cancer Ther*. 2018;17:1144-1149. doi:10.1177/1534735418790387
17. Blackwood J, Rybicki K, Huang M. Cognitive measures in older cancer survivors: an examination of validity, reliability, and minimal detectable change. *J Geriatr Oncol*. 2021;12:146-151.
18. Kennedy TE. The prevention of falls in later life: a report of theKellogg International Work Group on the prevention of falls by the elderly. *Dan Med Bull*. 1987;34:1-24.
19. Groll DL, To T, Bombardier C, Wright JG. The development of a comorbidity index with physical function as the outcome. *J Clin Epidemiol*. 2005;58:595-602. doi:10.1016/j.jclinepi.2004.10.018
20. Hofheinz M, Mibs M. The prognostic validity of the timed up and go test with a dual task for predicting the risk of falls in the

elderly. *Gerontol Geriatr Med*. 2016;2:2333721416637798. doi:10.1177/2333721416637798
21. Bischoff HA, Stähelin HB, Monsch AU, et al. Identifying a cut-off point for normal mobility: a comparison of the timed 'up and go' test in community-dwelling and institutionalised elderly women. *Age Ageing*. 2003;32:315-320. doi:10.1093/ageing/32.3.315
22. Wampler MA, Topp KS, Miaskowski C, Byl NN, Rugo HS, Hamel K. Quantitative and clinical description of postural instability in women with breast cancer treated with taxane chemotherapy. *Arch Phys Med Rehabil*. 2007;88:1002-1008. doi:10.1016/j.apmr.2007.05.007
23. Monfort SM, Pan X, Patrick R, et al. Gait, balance, and patient-reported outcomes during taxane-based chemotherapy in early-stage breast cancer patients. *Breast Cancer Res Treat*. 2017;164:69-77. doi:10.1007/s10549-017-4230-8
24. Hsieh KL, Wood TA, An R, Trinh L, Sosnoff JJ. Gait and balance impairments in breast cancer survivors: a systematic review and meta-analysis of observational studies. *Arch Rehabil Res Clin Transl*. 2019;1:100001. doi:10.1016/j.arrct.2018.12.001
25. Menant JC, Schoene D, Sarofim M, Lord SR. Single and dual task tests of gait speed are equivalent in the prediction of falls in older people: a systematic review and meta-analysis. *Ageing Res Rev*. 2014;16:83-104. doi:10.1016/j.arr.2014.06.001
26. Almstedt HC, Grote S, Perez SE, Shoepe TC, Strand SL, Tarleton HP. Training-related improvements in musculoskeletal health and balance: a 13-week pilot study of female cancer survivors. *Eur J Cancer Care (Engl)*. 2017;26:e12442. doi:10.1111/ecc.12442
27. Foley MP, Hasson SM. Effects of a community-based multimodal exercise program on health-related physical fitness and physical function in breast cancer survivors: a pilot study. *Integr Cancer Ther*. 2016;15:446-454. doi:10.1177/1534735416639716
28. Zimmer P, Trebing S, Timmers-Trebing U, et al. Eight-week, multimodal exercise counteracts a progress of chemotherapy-induced peripheral neuropathy and improves balance and strength in metastasized colorectal cancer patients: a randomized controlled trial. *Support Care Cancer*. 2018;26:615-624. doi:10.1007/s00520-017-3875-5
29. Nelson ME, Rejeski WJ, Blair SN, et al. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Circulation*. 2007;116:1094-1105. doi:10.1161/circulationaha.107.185650
30. Simonavice E, Liu PY, Ilich JZ, Kim JS, Arjmandi BH, Panton LB. The effects of resistance training on physical function and quality of life in breast cancer survivors. *Healthcare (Basel)*. 2015;3:695-709. doi:10.3390/healthcare3030695
31. Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in older people living in the community. *Cochrane Database Syst Rev*. 2012;9:CD007146. doi:10.1002/14651858.CD007146.pub3