ORIGINAL RESEARCH

History of falls, gait, balance, and fall risks in older cancer survivors living in the community

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Abstract: Older cancer survivors may be predisposed to falls because cancer-related sequelae affect virtually all body systems. The use of a history of falls, gait speed, and balance tests to assess fall risks remains to be investigated in this population. This study examined the relationship of previous falls, gait, and balance with falls in community-dwelling older cancer survivors. At the baseline, demographics, health information, and the history of falls in the past year were obtained through interviewing. Participants performed tests including gait speed, Balance Evaluation Systems Test, and short-version of Activities-specific Balance Confidence scale. Falls were tracked by mailing of monthly reports for 6 months. A "faller" was a person with ≥ 1 fall during follow-up. Univariate analyses, including independent sample t-tests and Fisher's exact tests, compared baseline demographics, gait speed, and balance between fallers and non-fallers. For univariate analyses, Bonferroni correction was applied for multiple comparisons. Baseline variables with $P<0.15$ were included in a forward logistic regression model to identify factors predictive of falls with age as covariate. Sensitivity and specificity of each predictor of falls in the model were calculated. Significance level for the regression analysis was $P<0.05$. During follow-up, 59% of participants had one or more falls. Baseline demographics, health information, history of falls, gaits speed, and balance tests did not differ significantly between fallers and non-fallers. Forward logistic regression revealed that a history of falls was a significant predictor of falls in the final model (odds ratio =6.81; 95% confidence interval =1.594–29.074) ($P<0.05$). Sensitivity and specificity for correctly identifying a faller using the positive history of falls were 74% and 69%, respectively. Current findings suggested that for community-dwelling older cancer survivors with mixed diagnoses, asking about the history of falls may help detect individuals at risk of falling.

Keywords: balance, falls, risk factor, aging, cancer survivor

Introduction

Cancer is a chronic condition of older adults. Approximately 77% of cancers are diagnosed in adults 55 years and older.[1] The 5-year survival rate is 69.8% for adults 55–64 years, and 58.6% for adults ≥ 65 years.[1] By 2024, the number of cancer survivors will likely reach 19 million with the aging population and improved survival.[2] The need for rehabilitation services to improve function in aging cancer survivors present a significant challenge.

Falls and fall-related injuries are serious problems in older adults.[3] Older cancer survivors may be predisposed to falls because cancer- and treatment-related side effects impact virtually all body systems.[2] Pain, fatigue, muscle weakness, vision and cognitive impairments, difficulty with balance and walking can emerge while a person is receiving cancer treatments or develop years after treatments have completed.[2,4–6] Decline in physical function after the cancer diagnosis is often undetected or untreated.[4] In a sample of Medicare and Medicaid recipients aged

65 years and older, a fall occurred at a significantly higher rate (33%) in cancer survivors than those without cancer (29%).[7] The odds ratios for having one fall in the past 12 months had been estimated to be 1.16–1.17 (95% confidence interval [CI] =1.02–1.33)[7,8] between older cancer survivors and older adults without a history of cancer. A population-based study reported that the risk of two or more falls within 1 year was 27% higher in postmenopausal women with cancer compared to women without cancer.[9] Taken together, fall risks may be increased in older cancer survivors.

Previous studies have investigated risk factors of falls in cancer survivors of various ages.[5,10–14] Chemotherapy and its complications, including weakness, peripheral neuropathy, problems with balance and walking had been linked to falls in survivors aged 28–86 years.[11] Androgen deprivation therapy for prostate cancer causes anemia, osteoporosis, and metabolic syndromes[2] and was found to increase the fall rate in men (age ≥70 years).[6] Winters-Stone et al[5] assessed falls retrospectively in the past year and prospectively for 6 months in breast cancer survivors (age ≤70 years). Compared to women without falls, those with a history of falls at baseline performed worse when the integration of vestibular inputs was critical for maintaining balance.[5] Balance problems at baseline, however, were not predictive of future falls over 6 months.[5] In prostate cancer survivors (age =69±6.7 years), a history of falls but not balance assessed using Timed Up and Go predicted future falls over 12 months.[10] A population-based study of community-dwelling older cancer survivors has identified impaired balance in tandem stance and self-reported difficulties with balance as significant predictors of future falls over 2 years.[12] In contrast, age, sex, education, comorbidity, frailty markers, time since cancer diagnosis, type and stage of cancer were not predictive of falls in community-dwelling older cancer adults.[12,14]

In previous prospective studies about falls in cancer survivors, only one employed an operation definition for falls[5] and balance was assessed using single-item tests, Timed Up and Go[10] and tandem stance,[12] which do not reflect the spectrum of balance skills required during daily activities. Maintaining balance is a complex process involving various domains of postural control, including base of support configuration, postural alignment, lower extremity muscle strength, stability limits, anticipatory and reactive responses, sensory integration, stability during walking, and dual-task walking.[15] Currently there is a lack of evidence on the use of gait speed or clinical balance tests to assess fall risks in older cancer survivors. Because of the diverse sequelae

with cancer, clinical tests that examine multiple domains of postural control, such as the Balance Evaluation Systems Test (BESTest), may locate the impairments underlying balance problems and guide the treatments to target the identified deficits to reduce fall risks.[15]

The aim of this prospective pilot study was to investigate the relationship of previous falls, gait, and balance with falls in older cancer survivors living in the community. The objective was to determine whether a history of falls, gait speed, and balance performance assessed using a standardized and multi-domain clinical test at baseline would be associated with falls during a 6-month follow-up period in older cancer survivors. It was hypothesized that a positive history of falls, slower gait speed, and impaired balance would be predictive of future falls in older cancer survivors.

Methods
Participants
A person is considered as a cancer survivor from the time of diagnosis until death.[16] Cancer survivors living in the community were recruited via advertisements, flyers, and presentations at local oncology clinics, support groups, and health fairs. The inclusion criteria included age ≥55 years, first cancer diagnosed ≥1 year prior to enrollment in the study (not involving the nervous, integumentary, or musculoskeletal systems), completion of primary cancer treatments ≥3 months (chemotherapy, surgery or radiation), and ability to walk ≥50 ft without another person's assistance. The exclusion criteria included cancer metastases, acute illness, impaired cognition assessed by the Mini-Cog, 10% low-contrast binocular and corrected vision less than 20/60 on Snellen chart, unstable cardiopulmonary conditions, severe pain affecting standing and walking, and a history of neurologic conditions. The University of Michigan–Flint Institutional Review Board approved the study. All participants gave their consent.

Procedures and measures
An investigator reviewed the medical documents provided by participants and conducted an interview to collect demographics, health information, and history of falls. The impact of comorbidity on physical function was assessed using Functional Comorbidity Index, a self-report measure of 18 medical conditions. A score of 0 is no comorbidity and 18 indicates the highest number of comorbidities.[17] The plantar tactile sensation on three sites of each foot was assessed using a 5.07/10 g Semmes-Weinstein monofilament.[18] Other investigators administered tests of gait speed and balance to minimize bias. After testing, falls were tracked for 6 months

via mailing of monthly fall reports. All investigators followed the same protocols.

Falls

The history of falls in the preceding 12 months prior to study entry was obtained by interviewing. Falls were also assessed prospectively for 6 months via mailing of "daily calendar" every month. A fall was defined as:

> Unintentionally coming to rest on the ground or at some other lower level, not as a result of a major intrinsic event (eg, a stroke or syncope) or overwhelming hazard.[3]

An investigator explained the definition of falls and asked the participants "How many times have you fallen in the past 12 months?" Participants reporting one or more falls were identified as having a history of falls. To assess prospective falls, participants recorded falls daily on a calendar by writing "F" if they had a fall and "N" if they did not fall. The definition of falls was printed on the calendar. Each calendar was mailed to the investigators after completion. A fall report that was not received by the 3rd week of the following month was confirmed verbally by phone. Data from participants who did not return the calendar or phone call were excluded from further analysis. Participants with one or more falls during follow-up were identified as fallers.

Four-meter gait speed

Participants walked at usual pace over an 8-meter path. The intermediate 4-meter was timed. An investigator started and stopped timing using a stopwatch when the participant's leading leg crossed a line at 2 meters and 6 meters of the path. Using a stopwatch to obtain 4-meter gait speed was found to demonstrate excellent test-retest reliability (intraclass correlation coefficient [ICC] =0.96) and concurrent validity with gait speed measured using a wireless automatic timer (ICC =0.99).[19] The average of two trials was obtained.

BESTest

BESTest is a comprehensive, reliable, and valid test with 36 balance and walking tasks.[15] It was designed to locate specific impairments within multiple domains of balance control, including: 1) biomechanical constraints, 2) stability limits, 3) anticipatory postural adjustments, 4) reactive postural responses, 5) sensory orientation, and 6) gait stability. The total score of BESTest and the sub-scores of each domain are expressed as percent scores (%), which are the percentage of maximum points possible within the BESTest and each domain, respectively. Higher scores indicate better balance. The BESTest total score and sub-section scores were obtained.

Short-version of Activities-specific Balance Confidence scale (ABC-6)

ABC-6 is a self-report measure to assess balance confidence and fear of falling during six daily activities.[20] It is a patient-centered outcome measure reflective of balance skills required in one's environment.[20] Participants rated their level of balance confidence and fear of falling in doing each activity from 0% (no confidence, highest fear of falling) to 100% (complete confidence, no fear of falling). The average of all item scores was obtained.

Statistical analysis

SPSS version 21 (IBM Corporation, Armonk, NY, USA) was used for statistical analysis. In univariate analyses, baseline differences in demographics, health information, a history of falls, gait speed, BESTest total score and sub-scores, and ABC-6 were compared between fallers and non-fallers using independent sample t-test for continuous variables and chi-square test for dichotomous variables. Bonferroni correction was used for multiple comparisons between fallers and non-fallers, with $P<0.0056$ being statistically significant for the demographics and health information and $P<0.005$ for a history of falls, gait speed, BESTest, BESTest sub-sections, and ABC-6. Subsequently, baseline variables that differed between fallers and non-fallers at $P<0.15$ were included as independent variables in a forward logistic regression model to identify factors independently associated with falls. Age was entered as the covariate in the model. Coding for falls as the dependent variable in the model was 1 for fallers and 0 for non-fallers. The P-value cut-off point of 0.15 has been recommended for selection of variables in logistic regression analyses because a traditional P-value such as 0.05 can fail to identify important variables.[21] The significance level was $P<0.05$ for the regression analysis. Sensitivity and specificity of significant predictors of falls in the regression model were calculated.

Results

Characteristics and health information of participants

Of 44 participants enrolled at baseline, five did not return fall calendars or return phone calls about falls during follow-up. Data from the remaining 39 participants were analyzed. At baseline, participants were on average 67.9 years old (standard deviation =8.8 years; range =55–88 years). The majority were women (72%) and had breast cancer (54%). As shown in Table 1, baseline demographics and health information, including age, body mass index, number of medications, Functional Comorbidity Index, time since cancer diagnosis, percentage of participants with chemotherapy, and

Table 1 Baseline demographic variables between participants who had one or more falls (fallers) and no falls (non-fallers) during the 6-month follow-up period

Characteristic	Fallers	Non-fallers	P-value
Number of participants (n)	23	16	–
Female sex (n)	15	13	0.47
Age (year)	68.8±9.71	67.4±8.46	0.66
Body mass index (Kg/m²)	29.1±4.43	29.6±6.66	0.81
Number of prescribed medications (n)	6.7±4.40	4.8±3.68	0.14
Functional Comorbidity Index	2.8±2.00	2.5±1.59	0.57
Time since cancer diagnosis (year)	7.0±5.44	6.11±3.52	0.54
Impaired plantar tactile sensation (n)	5	3	1.00
Cancer treated with chemotherapy (n)	14	6	0.20
Time since completion of chemotherapy (year)	6.2±6.25	5.8±3.84	0.84
Cancer diagnosis (n)			
Breast	11	10	–
Prostate	6	1	–
Colon	1	0	–
Thyroid	0	1	–
Stomach	1	1	–
Other	4	3	–

Notes: Values shown are mean ± 1 standard deviation or the number (n) of participants.

time since completion of chemotherapy were not significantly different between fallers and non-fallers. Approximately 21% of participants had impaired plantar sensation but the proportion of participants with sensory impairments was similar between fallers and non-fallers (Table 1).

In the preceding 12 months prior to enrolling in the study, 56% of participants had at least one fall. At the end of 6-month follow-up, 23 participants had fallen at least once, of whom ten participants (10/23=44%) had two or more falls. Seventeen (74%) of the fallers had a history of falls in the preceding 12 months prior to study entry. Only five of the non-fallers (31%) had a history of falls. The proportion of participants with a history of falls was not significantly different between fallers and non-fallers (*P*=0.008).

Gait speed, BESTest, and ABC-6

At baseline, fallers (1.00±0.241 m/s) and non-fallers (1.02±0.168 m/s) did not differ significantly in gait speeds. BESTest total scores did not differ between fallers (83.3%±7.65%) and non-fallers (82.6%±9.35%) (Figure 1). The sub-score of the sensory orientation domain of BESTest
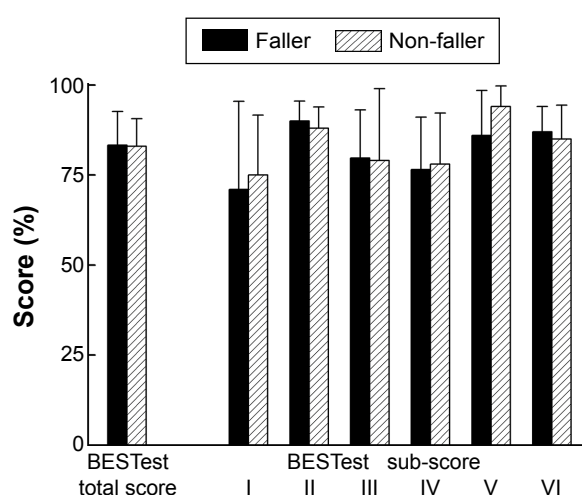

Figure 1 Mean (± 1 standard deviation) of the Balance Evaluation Systems Test (BESTest) total score and the sub-scores of the six domains of BESTest in fallers and non-fallers.
Notes: BESTest domains: I, biomechanical constraints; II, stability limits; III, anticipatory postural adjustments; IV, reactive postural response; V, sensory orientation; VI, stability in gait. Scores are as percentages (0%–100%) of the maximum points possible within the entire BESTest for the BESTest total score and within each domain for the BESTest sub-scores.

was not significantly different between fallers (86.9%±12.47%) and non-fallers (93.8%±5.69%) (*P*=0.02). No significant differences between groups were found in other BESTest domains (Figure 1). Fallers (73.7%±15.90%) and non-fallers (74.1%±20.66%) did not differ significantly in scores of ABC-6.

Predictors of future falls

Based on the results of univariate analysis, the number of medications, history of falls, and sub-score of the sensory orientation section of BESTest were included as independent variables in the forward logistic regression model. The final model was significant with the history of falls as a predictor of falls (pseudo R^2 by Cox and Snell =0.181; χ^2=7.78, *P*<0.05) (Table 2). The odds ratio for the history of falls as a predictor of future falls was 6.81 (95% CI =1.594–29.074) (*P*=0.01). For an older cancer survivor with at least one fall in the preceding 12 months, the odds of having one or more falls in the next 6 months were 1.91. In this sample, sensitivity and specificity for correctly identifying a faller using a positive history of falls were 74% and 69%, respectively.

Discussion

This pilot study examined the association of a history of falls, gait speed, and clinical balance tests with falls in community-dwelling older cancer survivors. Our hypothesis was that a positive history of falls, slower gait speed, and

Table 2 Forward logistic regression model with the outcome of falls during the follow-up as the dependent variable

Predictor in final logistic regression model	Coefficient (SE)	Constant (SE)	Odds ratio (95% CI)	P-value
History of falls in the previous 12 months	1.860 (0.821)	1.918 (0.741)	6.41 (1.28, 32.04)	0.01*

Note: *P<0.05.
Abbreviations: CI, confidence interval; SE, standard error.

impaired balance would predict future falls in older cancer survivors. Univariate analyses showed that a history of falls, gait speed, and balance performance at baseline did not differ significantly between fallers and non-fallers. Logistic regression analysis revealed that a history of one or more falls in the preceding 12 months significantly predicted falls over 6 months. Taken together, these findings partially supported the hypothesis.

Falls occur in 30%–60% of older adults aged ≥65 years each year.[22] Among current participants, the retrospective fall rate in 12 months was 56% and the prospective fall rate in 6 months was 59%. Winters-Stone et al[5] used a method similar to the procedure described in this study by mailing of monthly fall reports to assess falls and employing an operational definition for falls. They reported 58% fall rates retrospectively in the past 12 months and 53% prospectively in the next 6 months in breast cancer survivors (age =58.5±9.7 years).[5] Other prospective studies of older cancer survivors in which falls were assessed by interviewing at the end of follow-up reported fall rates of 18.7%–34.5% over 6 months to 2 years.[7,10,12,14] Lower fall rates in these studies could result from participants' recall problems and their interpretation of a fall.[23] Older adults with better memory are more likely be classified as fallers.[24] Self-reported recall of falls through interviewing can lead to underreporting.[25] Providing an operation definition of falls as in this study increases the validity of the method for assessing falls.[25]

While this study focused on commonly used physical therapy assessment for fall risks, including past falls, gait speed, and balance, it should be noted that falls are multifactorial in older adults.[26] A recent systematic review has indicated that risk factors of falls are unique in older cancer survivors.[27] Factors indicative of falls in the general population, including age, polypharmacy, and opioid use, were not predictive of falls in older cancer survivors.[27] Cancer- and treatment-related factors, including pain, chemotherapy, and cancer stage are significantly associated with falls.[27] In this pilot study of community-dwelling older cancer survivors with mixed diagnoses, an interesting finding is that a history

of falls was predictive of falls. This finding is consistent with those from a study of 88 men receiving androgen deprivation therapy for prostate cancer at an outpatient setting.[10] A prior history of falls in the past 12 months, being unmarried, and arthritis were independent predictors of falls.[10] On the contrary, age, education, comorbidity, 6-minute walk, activities of daily living, and androgen deprivation therapy were not associated with falls.[10] While multiple factors can contribute to falls in an individual,[26] current results indicate that screening fall risks using a simple question about falls is an important step in fall prevention. It can be easily implemented in clinical oncology practice.

A population-based study has shown that in older adults, falls were an independent predictor for the onset of fear of falling whereas fear of falling was predictive of future falls. These findings provided the evidence of a spiraling effect of increasing falls and fear of falling.[28] In this study, baseline scores of ABC-6 did not differ between fallers and non-fallers, suggesting that the level of balance confidence and fear of falling was not associated with future falls in current participants. Cancer survivors aged 40–64 years undergoing or having completed chemotherapy within 20 months were found to have higher fear of falling compared to non-cancer controls.[29] Older adults who have fallen are likely to develop fear of falling and vice versa, escalating the risk of falls, fear of falling, and functional limitations.[28] The interplay of falls, fear of falling, and function among older cancer survivors remains to be investigated.

Gait speed, recognized as the sixth vital sign, is a reliable and valid measure.[30] Gait speed reflects health and functional status of multiple body systems, including the cardiopulmonary, nervous, and musculoskeletal systems.[31] Slow gait speed is predictive of future health status,[30] functional decline,[30] falls,[30] and mortality.[31] In this study, usual gait speed was not associated with future falls. Gait speeds for fallers (1.00±0.241 m/s) and non-fallers (1.02±0.168 m/s) were below normal gait speed (1.2–1.4 m/s).[30] The relationship between gait speed and falls is likely U-shape. Quach et al[32] reported that older adults with faster (>1.3 m/s) and slower (<0.6 m/s) gait speed were at higher risk of

falling. Future studies are necessary to examine the relationships between faster and slower gait speeds with falls and other health outcomes in older cancer survivors.

This study chose a comprehensive balance test, BESTest,[15] to identify specific impairments in various domains of balance control in older cancer survivors. Current findings did not support the use of BESTest and BESTest sub-sections to detect fall risks in community-dwelling older cancer survivors of mixed diagnoses. The criterion values of BESTest for detecting fallers among older adults have not been established. In persons with Parkinson's disease, the cut-off scores of BESTest to detect fallers was 69%,[33] which was lower than the average BESTest scores in this study (82.6% for non-fallers and 83.3 for fallers). Difficulty in integrating vestibular inputs in fallers has been reported in a study of breast cancer survivors.[5] Compared to non-fallers, fallers showed increased postural sway measured by a force plate when standing on a moving surface with eyes closed or looking at a moving visual surround.[5] Commonly used chemotherapy agents for treating cancers, such as taxane, vinca alkaloid, and taxane, are known to cause neuropathy and vestibular dysfunction.[2,34] In this study, fallers and non-fallers did not differ in the sensory orientation sub-section of BESTest. We did not find any association of impaired plantar sensation or chemotherapy with falls. Different chemotherapy regimens and cancer diagnoses were not analyzed separately in current participants. Future research needs to investigate the influence of chemotherapy and other treatments as well as cancer diagnoses on balance, particularly sensory integration for balance control.

This study has limitations. Current participants had a wide age range. The rates of falls increase steadily with age and older adults aged >75 years are twice as likely to fall compared to those aged 65–75 years.[22] The causes of falls in cancer survivors may be complex because of the diverse sequelae, cancer diagnoses, and treatments. Studies of larger sample sizes are necessary to elucidate cancer- and non-cancer related factors associated with falls in older cancer survivors in comparison with the general population. Analyses focusing on fall risks related to a specific cancer diagnosis and treatments, such as neurotoxic chemotherapy, are imperative. This study followed-up participants' falls over 6 months although 2–4 participants were recruited monthly throughout the study period. Prospective tracking of falls for 12 months may unravel the long-term impact of cancer in survivors and counter the potential confounding factors during follow-up, such as reduced activities or slipping on the ice during winter.

Conclusion

Current findings have important clinical implications in oncology rehabilitation, particularly for physical therapists at outpatient settings and treating older cancer survivors living in the community. Asking about the history of falls may detect older cancer survivors at risk of falling.

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Disclosure

The authors have no conflicts of interest to disclose.

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