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History of falls, balance performance, and quality of life in older cancer survivors

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ABSTRACT

Older cancer survivors may be predisposed to falls because of the sequalae associated with cancer and its treatments. This study examined the association between the fall history, balance performance, and health-related quality of life (QoL) in older, community-dwelling cancer survivors who had completed primary cancer treatments. Forty-one cancer survivors (age = 67.9 ± 8.8 years) participated in the study. Balance performance was examined using the Activities-specific Balance Confidence Scale (ABC) and the Balance Evaluation Systems Test (BESTest). Scores from the Physical Component Summary (PCS) and Mental Component Summary (MCS) of the SF-36v2 were obtained to assess the QoL. The demographics and health status were comparable between the fallers and non-fallers. While 54% of the participants had experienced at least one fall in the past 12 months, 30% had experienced two or more falls. Spearman's correlation analysis revealed a significant relationship between the outcomes from the ABC and the PCS ($p < 0.001$), and between the BESTest and the PCS ($p < 0.001$). Only the PCS significantly differentiated fallers from non-fallers ($p < 0.01$). Logistic regression analysis estimated that a one-unit increase in the PCS score significantly reduced the odds of falling by 13% ($p < 0.01$). The results demonstrate that in older cancer survivors, falls are a significant problem and balance control is a determinant of perceived physical function and well-being. Older cancer survivors reporting a poor QoL in the physical health domain may have higher risks of falling. Future studies are needed to examine the risk factor profiles of falls and the interventions to prevent falls in older cancer survivors.

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1. Introduction

Cancer has been recognized as primarily a disease of older adults. Among people with newly diagnosed cancers in 2013, almost 80% are aged 55 years and older [1]. The 5-year survival rate is 69.4% for people aged 55–64 years, and 58.7% for people older than 65 years [1]. By the year 2022, the prevalence of cancer will approach 18 million [2]. As the population ages, the number of older adults with a cancer history, i.e., older cancer survivors, will continue to grow.

Falls are a significant problem in older adults [3]. A cancer diagnosis may be associated with higher risks of falls. In a study that followed postmenopausal women for up to 9 years, the risk of two or more falls in a year was 27% higher in cancer survivors compared to individuals without cancer [4]. The odds ratio for falls in older cancer survivors had been estimated to be 1.16 (95% CI = 1.02–1.33) [5]. Cancer survivors may be predisposed to falls because the disease and its treatments can adversely affect body systems and functions involved in preventing falls [2]. Chemotherapy [6], hormonal therapy [7], muscle weakness [6], difficulty in balance and walking [6–8] have been linked to falls in cancer survivors. In contrast, age [5,6], cancer type/stage [5,6], the time since the cancer diagnosis [5], and the presence of frailty markers [9] are not associated with falls.

Previous studies have also reported impaired balance in cancer survivors. Compared to healthy individuals, breast cancer survivors aged 30–60 years when tested within 30 days after completing chemotherapy demonstrated poorer balance [10]. Among cancer survivors who were less than 70 years, those with a fall history exhibited balance deficits related to vestibular dysfunction [11]. Cancer survivors aged 40–64 years with ongoing or recently finished chemotherapy were found to have increased postural sway and lower fall efficacy compared to healthy individuals [12]. Taken together, cancer survivors are likely to experience balance deficits after receiving their cancer diagnosis. The maintenance of balance involves multiple systems underlying postural control, such as sensory integration, anticipatory and

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reactive responses [13]. To date no study has examined balance in older cancer survivors from this multi-system framework.

Health-related quality of life (QoL) considers the impact of the medical condition and/or therapy on the individual's health and function [14]. A cancer diagnosis has been associated with long-term declines in QoL [15]. Cancer survivors were found to have poorer QoL compared to age-matched individuals without cancer [15]. Problems in balance and walking were reported to cause distress in the physical domain of QoL in older cancer survivors [16]. In older adults, the experience of falls was linked to the subsequent declines in QoL [17]. Studying the impact of falls and balance deficits on QoL may provide insight into the clinical management of older cancer survivors.

The primary purpose of this study was to examine the balance function and QoL in older cancer survivors as related to the fall history. Currently, standardized measures of fall risks for older cancer survivors are limited. Assessing fall risks can identify older cancer survivors who require a referral to a fall prevention program. The outcome of the intervention can also be evaluated using the standardized measures of fall risks. Therefore, a secondary purpose was to develop a model to quantify fall risks in older cancer survivors.

2. Method

2.1. Participants

Forty-one cancer survivors living in the community (12 men, 29 women; age = 67.9 ± 8.8 years) volunteered to participate. The inclusion criteria were: age 55 years and over, a new cancer diagnosis (not involving the nervous, integumentary or musculoskeletal systems), completion of the primary cancer treatment (chemotherapy, surgery or radiation) for at least 3 months, and ability to walk 50 ft without assistance. Additional exclusion criteria were: metastases, acute illness, impaired cognition as assessed by the Mini-Cog, low contrast vision (<20/60), unstable cardiopulmonary conditions, severe pain affecting one's ability to stand and walk, and a history of neurologic conditions. The Institutional Review Board of University of Michigan-Flint approved the study.

Table 2
Spearman's correlation coefficients (rho) for Activities-specific Balance Confidence (ABC), the Balance Evaluation Systems Tests (BESTest) Total score, the Physical Component Summary (PCS) measure and Mental Component Summary (MCS) measure of the SF-36v2.

	BESTest total	*p*-value	ABC	*p*-value
PCS	0.540[a]	<0.001	0.551[a]	<0.001
MCS	−0.124	0.446	−0.031	0.851
ABC	0.751[a]	<0.001	–	–

[a] Indicate $p < 0.001$.

2.2. Procedures

After the participants gave their written consent, an investigator utilized a pre-structured form to collect the demographic, health information, walking difficulty as identified by "yes" to the question "do you have difficulty walking on ramps, stairs, or uneven terrain", and the fall history through the face-to-face interview and the review of medical documents provided by participants. An investigator who did not conduct the interview assessed the participants' plantar tactile sensation on 3 sites of each foot using a 5.07/10 g Semmes-Weinstein monofilament [18], gait speed, balance and QoL. Participants took rest breaks during testing that lasted less than 2 h. All investigators followed the standardized protocols to obtain the data.

2.3. Measures

2.3.1. Functional Comorbidity Index (FCI)

The FCI is a self-report measure with 18 questions to assess the impact of comorbidity on physical function [19]. A score of 18 indicates the greatest number of comorbid conditions present while a score of 0 indicates no comorbid condition present.

2.3.2. History of falls

A fall is defined as "unintentionally coming to rest on the ground or at some other lower level, not as a result of a major intrinsic event (e.g., a stroke or syncope) or overwhelming

Table 1
The demographics and health status of the participants with one or more falls (fallers) and with no falls (non-fallers) in the preceding 12 months prior to the enrollment in the study. Values shown are group mean ± 1SD, or the number of participants (*n*).

	Fallers	Non-fallers	*p*-value
Number of participants	22	19	–
Demographics and health status			
Age (year)	68.7 ± 8.27	66.8 ± 9.68	0.51
Body mass index (kg/m^2)	29.6 ± 6.75	28.8 ± 4.65	0.95
Number of prescribed medications	5.3 ± 3.84	5.6 ± 4.32	0.84
Functional Comorbidity Index (FCI)	3.1 ± 1.70	2.4 ± 1.49	0.17
Average year since cancer diagnosis	6.0 ± 3.45	7.4 ± 5.61	0.34
4 Meter gait speed (m/s)	1.02 ± 0.198	0.99 ± 0.214	0.52
Self-report of walking difficulty (*n*)	14	14	0.29
Impaired plantar tactile sensation (*n*)	4	7	0.52
Cancer treatment			
Chemotherapy (*n*)	11	9	0.87
Cancer diagnosis			
Breast (*n*)	14	9	–
Prostate (*n*)	4	4	–
Colon (*n*)	1	0	–
Thyroid (*n*)	0	1	–
Stomach (*n*)	1	1	–
Other (*n*)	6	4	–

*Indicates $p < 0.05$.

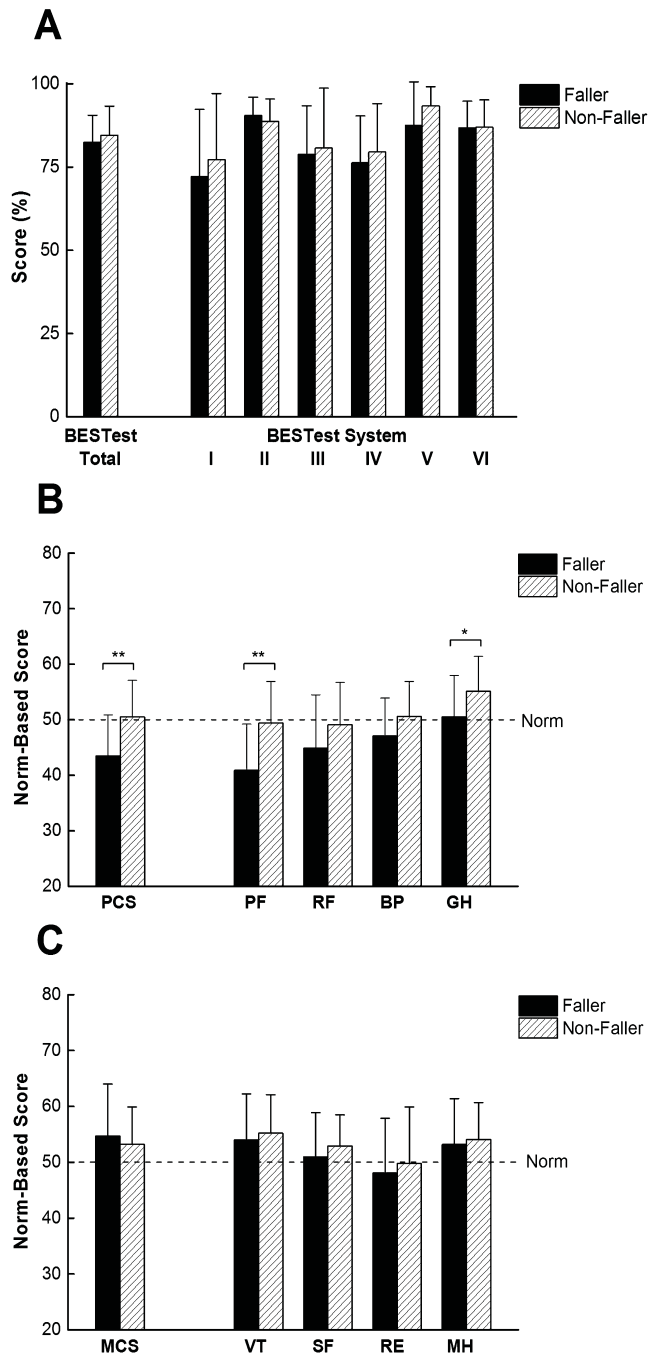

Fig. 1. (A) Mean (±1SD) of the BESTest total score and the scores of the six BESTest systems in the fallers and the non-fallers. BESTest systems: I = biomechanical constraints, II = stability limits. III = anticipatory postural adjustments. IV = reactive postural response. V = sensory orientation. VI = 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 of the system for the BESTest system subscores. (B) Mean (±1SD) scores of the Physical Component Summary (PCS) measure and four subscales in the physical health domain of the SF-36v2 in the fallers and the non-fallers. Abbreviation of the physical health subscales: PF = physical functioning (performance of physical activities such as self-care, walking, and vigorous physical activities). RP = role limitations due to physical health (the degree to which a person performs their typical role activities (e.g., childcare, job) as a result of physical health). BP = bodily pain (intensity, duration, and frequency of bodily pain and limitations in usual activities due to pain). GH = general health perceptions (the beliefs and evaluations of a person's overall health). Scores are normalized based on the U.S. population data. Each summary measure and domain has a mean of 50 (dash line - - -) and a standard deviation of 10. In comparison to the non-fallers, the fallers had significantly lower scores in the PCS, and the subscales of PF and GH. * Indicates $p < 0.05$. ** Indicates $p < 0.01$. (C) Mean (±1SD) scores of the Mental Component Summary (MCS) and four subscales in the mental health domain of the SF-36v2 in the fallers and the non-fallers. Abbreviation for the mental health subscales: VT = vitality (feelings of energy; the absence of fatigue). SF = social functioning (the degree to which a person develops and maintains social relationships, e.g., with family, friends, etc.). RE = role limitations due to emotional problems (the degree to which a person performs their typical role activities (e.g., childcare, job) as a result of mental health). MH = mental health (a person's emotional, cognitive and intellectual status). Scoring is the same as in B. No group differences in the MCS measure and the mental health subscales were found.

Table 3
Logistic regression model with the fall history as the dependent variable. PCS = Physical Component Summary measure of the SF-36v2.

Predictor	Model coefficient (SE)	Model constance (SE)	Odds ratio (95% CI)
PCS[a]	−0.134 (0.050)	6.491 (2.407)	0.870 (0.793, 0.965)

[a] Indicates $p < 0.01$.

hazard" [20]. During the interview, participants were asked whether he/she had fallen in the previous 12 months and if yes, how often. People who reported having one or more falls were identified as fallers [3].

2.3.3. Four-meter gait speed (4MGS)

The participants were instructed to walk without assistance at a normal and comfortable speed over an 8 m path. The intermediate 4 m was timed. Two meters for acceleration/deceleration were provided at the beginning and end of the timed 4 m walk. The same tester started and stopped timing using a stopwatch when the participant's leading leg crossed the line at 2 m and 6 m, respectively. The average of two trials was obtained. Measurement of 4MGS by a stopwatch was found to have excellent test-retest reliability (ICC = 0.96) and validity [21]. The 4MGS obtained by a stopwatch and the wireless automatic timer was highly correlated (ICC = 0.99) [21].

2.3.4. Balance Evaluation Systems Test (BESTest)

The BESTest [13] assesses the impairments within the postural control systems that cause balance problems. It has 36 items and 108 points total in 6 systems: I. Biomechanical constraints, II. Stability limits, III. Anticipatory postural adjustments, IV. Reactive postural responses, V. Sensory orientation, and VI. Gait stability. To obtain the BESTest total score, the scores of all items were summed and converted into a percent score (0–100%), i.e., as a percentage of the maximum points of 108. The item scores within each system were summed and divided by the maximum point possible within the system to calculate the system subscores (0–100%). Higher scores indicate better balance. The BESTest total score and system subscores were obtained.

2.3.5. Activities-specific Balance Confidence Scale (ABC)

The ABC is a self-report measure of balance confidence during 16 indoor and outdoor daily activities [22]. Participants rated their balance confidence for each activity on a scale from 0% (no confidence) to 100% (complete confidence). The average of the item scores was the score of ABC.

2.3.6. Medical Outcomes Study short form-36 version 2.0 (SF-36v2)

The SF-36v2 is a generic, self-report measure for QoL [14]. It does not target a specific age or disease. There are 36 questions in eight subscales: physical functioning, role limitations due to physical health, bodily pain, general health, vitality, social functioning, role limitations due to emotional problems, and mental health. Participants rated their response to each question on a Likert scale while referring back to the past 4 weeks. The item

Table 4
Sensitivity and specificity for the PCS at each cutoff score based on the results of the regression model in Table 3. PCS = Physical Component Summary measure of the SF-36v2.

Probability of falling with a PCS score ≤ cutoff value	Cutoff score	Sensitivity (95% CI)	Specificity (95% CI)	Accuracy (%)
0.4	≤51.5	0.82 (0.59–0.94)	0.50 (0.27–0.73)	67.5%
0.5	≤48.3	0.77 (0.57–0.90)	0.67 (0.44–0.84)	72.5%
0.6	≤45.4	0.79 (0.57–0.91)	0.67 (0.45–0.83)	72.5%
0.7	≤42.0	0.59 (0.38–0.76)	0.83 (0.61–0.94)	70.0%

scores were combined to calculate the scores for the Physical Component Summary (PCS) and Mental Component Summary (MCS). Based on the U.S. population data, the PCS and MCS scores were then transformed into norm-based scoring in standardized units (average = 50; SD = 10). A score of 100 indicates best health. A score of 0 indicates the worst. The scores of the PCS, MCS, and eight subscales were obtained.

2.4. Statistical analysis

IBM-SPSS version 21 was used for statistical analysis. To compare the demographics and health status variables between fallers and non-fallers, independent sample *t*-tests and Fisher's exact tests were used for continuous and categorical data, respectively. The normality of data for balance and QoL measures was examined using the Shapiro–Wilk test. Only the scores of the BESTest, the PCS, MCS and subscales of SF-36v2 were normally distributed. Therefore, Spearman correlation was used to examine the association between the scores of the BESTest, the ABC, the PCS and MCS. For the comparisons between fallers and non-fallers, independent sample *t*-tests was used for the BESTest total scores and the BESTest system subscores, the scores of the PCS, MCS and subscales of SF-36v2, and Mann–Whitney *U* test was used for the scores of the ABC. These comparisons allowed for the identification of variables associated with falls. Subsequently a logistic regression model was constructed with the fall history as the dependent variable, and the variables associated with falls as the independent variables. Sensitivity and specificity of the independent variable were calculated. The significance level was a p-value < 0.05.

3. Results

3.1. Characteristics of participants

No statistically significant differences between the fallers and the non-fallers were found in the demographic and health status variables (Table 1). Gait speed was comparable in the fallers and non-fallers. Twenty-two participants (54%) had sustained at least one fall in the preceding 12 months while twelve participants (30%) reported two or more falls. Approximately 26% of our participants had impaired plantar tactile sensation. The proportion of individuals with sensory impairment was comparable between groups. Participants with a breast cancer history constituted the largest proportion of the fallers (64%) and the non-fallers (47%), followed by those with prostate cancer.

3.2. Association between balance and QoL measures

There was a significant correlation between the BESTest and the PCS ($p < 0.001$), and between the ABC and the PCS ($p < 0.001$) (Table 2). Poorer performance on the BESTest and the ABC was associated with lower QoL in the physical health domain. The MCS was not significantly correlated with balance measures.

3.3. Balance and QoL measures between fallers and non-fallers

The ABC score was lower in fallers ($83\% \pm 3.8\%$) than the non-fallers ($88\% \pm 10.6\%$) but this difference was not statistically significant. The BESTest total score and systems subscores were comparable between groups (Fig. 1A). The PCS score was significantly lower in the fallers (43.4 ± 7.47) than the non-fallers (50.5 ± 6.61) ($p < 0.01$), particularly in the subscales of physical function ($p < 0.01$) and perceived general health ($p < 0.05$) (Fig. 1B). The MCS scores and the subscales in the mental health domain were comparable between groups (Fig. 1C).

Because the PCS significantly differentiated the fallers and non-fallers, it was entered into the logistic regression model with the fall history as the dependent variable. The effect of PCS was significant with an odds ratio of falling at 0.870 (95% CI = 0.793–0.965) ($p < 0.01$). For a one-unit increase in the PCS score, the odds of being a faller decreased by 13%. Based on the regression model (Table 3), the predicted probability of falling was estimated by the equation: probability = $100\% \times \exp(6.491 - 0.134 \times \text{PCS score}) / (1 + \exp(6.491 - 0.134 \times \text{PCS score}))$. For the non-fallers with an average PCS score of 50.5, the probability of falling would be 43%. For the fallers with an average PCS score of 43.4, the probability for falling would increase to 66%. The cutoff score for the PCS to identify fallers was 45.4 (sensitivity = 0.79, specificity = 0.67) (Table 4).

4. Discussion

This study is the first to report an association between the fall history, balance, and QoL in older cancer survivors who were living in the community and had completed the primary cancer treatments. The balance performance and the PCS were significantly correlated, suggesting that balance function is a determinant of the perception of physical health in older cancer survivors. While the balance tests could not detect fallers, the PCS was significantly worse in the fallers than the non-fallers. The self-report limitations in activities and participation as related to physical health may provide valuable information about fall risks in older cancer survivors.

In this study, the usual gait speed of the fallers (1.02 ± 0.198) and non-fallers (0.99 ± 0.214 m/s) was below the norms for women (1.07–1.30 m/s) and men (1.21–1.41 m/s) aged 60–80 years [23]. Usual gait speed at 1.0 m/s had been identified as the cut-off value for higher risks of functional declines, hospitalization and mortality [24]. Our participants were likely at the transitioning point for adverse health outcomes. Older adults with faster (>1.3 m/s) and slower (<0.6 m/s) usual gait speeds were found to have higher fall risks compared to those with a speed of 1.0–1.3 m/s [25]. We also confirm that in older cancer survivors, a usual gait speed at about 1.0 m/s was not associated with falls.

One in three adults over 65 years old was reported to have at least one fall each year [3]. In this study, 54% of the participants had experienced at least one fall in the preceding 12 months. A wide range of fall rates have been reported in cancer survivors living in the community. In postmenopausal breast cancer survivors who had completed chemotherapy within 2 years, 58% of the women reported having one or more falls over a period of 12 months [11]. Among Medicare beneficiaries, the fall rate was 33% for cancer survivors and 29% in those without cancer [5]. A prospective study showed that 18.7% of older cancer survivors had fallen once or more within the first 6 months after their cancer diagnosis [9]. Various fall rates in previous reports may be related to age, cancer diagnoses and treatments, methods for recording falls, or other risk factors in the samples. Nevertheless, clinicians should not overlook the problems of falls in older cancer survivors.

The significant correlation between the balance tests and the PCS suggests that balance deficits affect the ability of older cancer survivors to carry out daily activities and participate at work or life. Indeed, balance control is essential to the performance of many items in the PCS, including lifting/carrying groceries, climbing stairs, and walking a mile. About 64% of older cancer survivors undergoing treatments in an outpatient setting reported that problems in balance and walking were the leading cause of distress in the physical domain of QoL [16]. A survey study of older cancer survivors receiving care at an oncology outpatient clinic also found that balance and walking difficulty were the most frequent functional problems [26]. However, no clinicians initiated any referral to address these issues [26]. Current findings further underscore the need for rehabilitation professionals to evaluate and treat balance problems in older cancer survivors.

Although balance deficits have been linked to falls in cancer survivors [8,11], neither the BESTest nor the ABC could distinguish the fallers and the non-fallers. The mean ABC scores in the fallers (83% ± 13.8%) and the non-fallers (88% ± 10.6%) were higher than the cut-off score of 80% for highly functioning and physically active older adults [22]. While our participants were on average 67.9 years old, the mean BESTest total scores of the fallers (82% ± 8.1) and the non-fallers (85% ± 8.7%) were within 95% CI of the mean of normative data for people aged 70–79 years (82.5–88.2%) [27]. The psychometric properties of the BESTest have not been established in older adults. A cut-off score of 77% (95% CI = 66–87%) with adequate sensitivity (86%) and specificity (95%) to detect fallers was reported in individuals with and without multiple sclerosis [28]. In this study, the mean BESTest total scores of the fallers and non-fallers were above 77%, indicating that the BESTest would unlikely detect the fallers.

The average MCS score in our participants were slightly above the population average of 50 [14]. The negative effects of cancer and its treatment on the mental health domain of QoL were found to decline over time [15] and with increasing age [29]. Our findings of the significantly poorer QoL in the physical domain in the fallers than the non-fallers are significant. In older adults, falls can lead to fear of falling, avoidance of activities, future falls in 1 year, and spiraling declines of physical function [30]. Although age and comorbidity affect the QoL in cancer survivors [15,29], the fallers and non-fallers showed similar demographics, comorbidity, and health status. A recent population-based study has shown that in older cancer survivors, self-reported difficulty in balance and physical activities, including walking several blocks, climbing stairs or stooping, was a significant predictor of falls over a 2-year period [8].

Our analysis of the regression model demonstrated that a cut-off score of 45.4 on the PCS resulted in the best sensitivity and specific to detect fallers. The model predicted that a one-point increase in the score of PCS significantly reduced fall risks by 13%. This model can quantify fall risks from a gradient of 0 (low risk) to 100 (high risk), rather than classify the individual as a faller versus non-faller. The quantification of fall risks across the whole range of scores is important because it can detect a small but clinically relevant change.

There are limitations in this study. The fall history obtained through the interview could be subject to recall bias. The causes of falls in older cancer survivors may be complex but only balance and QoL measures were examined. Most cancer survivors experience one or more complications of cancer and its treatments, which may emerge months or even years after the treatments ended [2]. Reduced bone density [4] and muscle strength [7], cardiovascular diseases [2], chemotherapy-induced neuropathy [2,6], cognitive declines [2,5], psychological distress, fatigue, and pain [2] are common in cancer survivors. Future studies need to investigate the causes of falls while considering the diverse complications associated with various cancer diagnoses and treatments.

5. Conclusion

Falls are a significant problem in older cancer survivors. Clinical balance tests did not differentiate between fallers and non-fallers. Self-report measures of physical function and health may be a useful indicator of fall risks in older cancer survivors.

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Conflict of interest

The authors have no conflicts of interest to disclose.

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