Support Care Cancer (2014) 22:479–485
DOI 10.1007/s00520-013-2000-7

ORIGINAL ARTICLE

Predictors of falls among community-dwelling older adults with cancer: results from the health and retirement study

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Received: 13 May 2013 / Accepted: 23 September 2013 / Published online: 10 October 2013

Abstract
Purpose Cancer symptoms and the side effects of its treatment can increase the risk of falling among older adults with cancer. This study aimed to identify predictors of falling and recurrent falls among community-dwelling older adults with cancer over a 2-year period.
Methods Data from the Health and Retirement Study were used (N=1,630) in this study. The sample had a mean age of 75 years and was mostly female (53 %) and white (89 %). Descriptive analyses, correlation analyses, and logistic regressions were used to analyze the data.
Results The results showed that functional limitations (OR=1.13, 95 % CI=1.03–1.24), the full-tandem stance (OR=1.48, 95 % CI=1.01–2.16), and self-reported difficulties with balance (OR=1.50, 95 % CI=1.23–1.83) at time 1 were significant predictors of falling at time 2. Only difficulties with self-reported balance (OR=1.84, 95 % CI=1.44–2.36) at time 1 were found to be a predictor of recurrent falls at time 2.
Conclusions The consequences of falling can complicate the course of cancer treatment. Measures of functional limitations and balance have the potential to be quick and useful clinical tools to detect falling among seniors with cancer living in communities.

Keywords Cancer · Falls · Balance difficulty

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About 30 % of community-dwelling older adults aged 65 years fall every year [1]. Falls often result in physical injuries [2] and impair individuals' gait and postural control [3]. They can also affect older adults' activities of daily living [4], precipitate depression [5], induce anxiety and fear of falling [6], and lead to social isolation and activity restriction [7]. More importantly, falls can reduce older adults' health-related quality of life [8].

Studies have shown that over half of the older adults who fall experience a subsequent fall, and suggest that recurrent falls should be examined separately from single falls [9, 10]. Researchers note that while falls are caused by intrinsic (e.g., poor balance) and extrinsic (e.g., environment) factors [11], recurrent falls are more likely the result of intrinsic factors [10]. Recurrent falls have a stronger correlation with risk factors than single falls making them more predictable [9]. Thus, older adults with recurrent falls might respond better to a falls prevention program [10].

Older adults with cancer might be especially susceptible to falling due to symptoms and side effects of treatment [12]. Research has indicated that about 20 % of older adults aged 65 years and older with newly diagnosed cancer fell one or more times in a 6-month follow-up period [13]; this rate increases to 53 % among older adults with advanced cancer [14]. Older adults with cancer in the hospital reported a higher frequency of falling compared to those without cancer [15]. The number of cancer diagnoses in older adults is expected to increase by 67 % in the next 20 years due to the aging population [16], suggesting an increase in falls incidence among older adults that could consequently influence public health and policy. Therefore, it is critical to study factors related to falls in this population to minimize the impact of falling to these individuals and society overall.

Several studies have identified risk factors of falling among older adults with cancer. In oncological outpatient settings, difficulties in performing activities of daily living (ADL) was

significantly associated with falling after controlling for age, gender, depression, and cognition among older adults aged 70 years and older [17]. Another study identified the significant relationship between the ability to perform ADLs and falling among participants [18]. However, this study noted that participants' performances on ADLs were no longer related to falling after considering adults' ability to perform instrumental activities of daily living (IADL), and concluded that IADLs were significantly associated with falling among older adults with cancer. Another study examined the relationship between falls and physical performance among older adults with cancer and found that increased time used to walk a 3-m course was significantly related to falling among older adults [19]. Tofthagen et al. investigated falling among outpatients aged 18 year and older with neuropathy induced by chemotherapy [20]. They found that the increased risk of falling was significantly associated with the number of chemotherapy treatments received and self-reported impairments in balance.

Research has also examined falls among adults with cancer who were hospitalized for palliative care. Stone et al. investigated falls among adults with advanced cancer to determine whether falls predominantly occurred in older patients [21]. They found that almost 50 % of the participants aged at least 65 years fell during the study period. They reported that pain, medication, depression, previous fall history, and cancer involving the brain predicted future falls. Pearse et al. investigated the risk factors of falling among inpatients in hospice settings [22]. They found that cognitive impairment and low-lying systolic blood pressure significantly predicted future falls when controlling for other significant covariates. Pautex et al. explored risk factors of falling among adults with advanced cancer staying in hospitals over a 1-year period [23]. While they identified several significant differences between fallers and nonfallers in their analyses, chronic obstructive pulmonary disease was the only significant predictor of falling after considering these factors simultaneously. O'Connell et al. also examined risk factors of falling among adults during admission to inpatient oncology settings [24]. They found that people who fell during their stay had significantly weaker leg strength than those who did not fall.

Although research has identified several predictors of falling among adults with cancer, there are a few limitations in these studies. First, the majority of studies were based on cross-sectional designs. Hence, the causal relationships between risk factors and falls among older adults with cancer have not necessarily been established. Second, falls among older adults are usually associated with multiple risk factors [11]. Although several fall-related factors among adults with cancer have been reported, few studies have examined these factors concomitantly. For example, O'Connell et al. [24] found several significant differences between fallers and nonfallers (i.e., leg strength); however, these factors were not examined together to account for the variance of falling. Third, some of these studies did not specifically focus on an aging population; they included participants aged 18–70 years old. Although Stone et al. aimed to investigate whether older cancer patients fell more than younger patients, they did not examine the risk factors of falling separately by age groups. Given that older adults are generally defined as individuals aged 65 years and older [25], the generalizability of the results from these studies to the older population is limited. Last, as recurrent falls are more predictable, and recurrent fallers are thought to respond better to intervention, targeting older adults that fall frequently may be a more efficient approach to reducing falls. No study to date has examined recurrent falls among older adults with cancer.

The current study included a population of community-dwelling adults with cancer who were at least 65 years old. The purpose of this study was to comprehensively investigate the predictors of falls using longitudinal data in an attempt to address the limitations noted above. This study also aimed to identify predictors of recurrent falls among older adults with cancer.

Methods

Data

The secondary data were retrieved from the Health and Retirement Study (HRS), funded by the National Institute on Aging (NIA U01AG009740) and conducted by the University of Michigan [26]. The HRS is a longitudinal study with nationally representative sample aged 50 years and older. This ongoing longitudinal dataset is publicly available and has collected information on adults biennially since 1992. The original sample collected in 1992 included respondents aged 51–61 years of age and their spouses. The selection of households was based on a multistage probability sample design with oversamples of Blacks, Hispanics, and residents of Florida (see [27] for more details). For the purposes of our study, baseline information (time 1) uses data from the 2006 wave, including data on demographic characteristics, chronic conditions, functional limitation, pain, muscle weakness, balance, and self-reported balance difficulty as potential predictors of falling [1, 9, 10, 20, 28, 29]. Time 2 data is based on the 2008 wave of the HRS, and includes information on the respondents' reports of falling that serve as the dependent variables in this study.

Participants

Community-dwelling adults aged 65 years and older with a diagnosis with cancer of any kind (excluding skin cancer) at time 1 were included in the current study. Individuals must

have provided fall-related information at time 2 to be included in the final sample. Participants whose surveys were completed by proxy were excluded from the sample. The final sample for this study included 1,630 individuals with cancer. The average age of the respondents was 75 years old (SD=7.05), approximately 53 % were female, 89 % were white, and they had an average of 12.58 years (SD=3.06) years of education.

Measures

Falls Individuals were asked whether they had experienced a fall in the past 2 years since the last HRS interview. This response was dichotomized, with individuals who reported a fall coded as 1. Respondents who fell were further asked the total number of falls they experienced over the 2-year period, with individuals who experienced two or more falls being referred to as recurrent fallers and coded as 1.

Demographics Age and education were recorded in years as continuous variables. Gender and race were dichotomized, with female and white coded as 1.

Chronic conditions This measure was created to summarize comorbidities in addition to cancer. It took into account diagnoses of any of the following conditions: high blood pressure, diabetes, lung disease, heart disease, stroke, emotional or psychiatric problems, or arthritis. The total number of diagnoses was summed for each individual (ranging from 0 to 7) with higher scores indicating more chronic conditions.

Functional limitations Individuals were asked if they had difficulties completing the following physical activities: walking one block and several blocks, climbing stairs, getting up from a chair, reaching their arms, stooping, pulling and pushing objects, lifting weights, and picking up dime. The total number of functional limitations was computed (ranging from 0 to 9) with higher scores indicating more limitations.

Pain Individuals were asked to rate the intensity of pain they experienced most of the time on a scale of 0 (no pain) to 3 (severe pain).

Muscle strength The Smedley spring-type hand dynamometer was used to measure grip strength [30]. Individuals completed the grip strength test twice for each hand. The interval between each trial was 30 s. Strength was measured in kilograms, and the average strength of the four trials at time 1 was used in the analyses.

Balance This assessment included the side-by-side, semi-tandem, and full-tandem stances [30]. Individuals were asked first to hold the semi-tandem stance for 10 s. If they failed to do so, they were then asked to maintain the side-by-side stance for 10 s. If an individual successfully completed the semi-tandem stance, they were asked to perform the full-tandem stance for 30 s. An *uncompleted* stance was coded as 1; if the participant was able to successfully complete the stance, the variable was coded as 0. The side-by-side stance was not included in the analyses because only 5 % of the respondents were asked to complete this balance test.

Balance difficulty Perceived difficulty with balance was assessed with the question, "How often do you have difficulty with balance?" and was rated on a scale of 1 (never) to 4 (often).

Analytical procedures

First descriptive analyses were used to explore characteristics of the sample. Because falls and recurrent falls were dichotomized, phi and point biserial correlation coefficients were used to examine the relationships between potential predictors at time 1 and falls status (i.e., falling and recurrent falls) at time 2. The significant correlates were then included in the logistic regressions to investigate the predictors of falling and recurrent falls.

Results

At time 1, approximately 30 % of the individuals reported a fall and 16 % experienced recurrent falls. At time 2, the rates increased to 40 % of older adults reporting a fall and 24 % experiencing recurrent falls. Characteristics of the fallers and recurrent fallers are displayed in Table 1.

The significant relationships from the correlation analyses were included in logistic regression analyses to predict the incidence of falling and recurrent falls (see Table 2 for the results from the correlation analyses). Functional limitations (OR=1.13, 95 % CI=1.03–1.24), the full-tandem stance (OR=1.48, 95 % CI=1.01–2.16), and self-reported balance difficulty (OR=1.50, 95 % CI=1.23–1.83) at time 1 were significant predictors of falling at time 2. Specifically, older adults with cancer who reported one additional functional limitation at time 1 were 13 % more likely to report falling at time 2. Those who were unable to complete the full-tandem stance at time 1 were 48 % more likely to fall at time 2. Respondents who reported one unit greater perceived balance difficulty at time 1 were 50 % more likely to report falling at time 2.

For recurrent falls, self-reported balance difficulty (OR=1.84, 95 % CI=1.44–2.36) was the only significant predictor after considering all other possible risk factors. Specifically, older adults who reported one unit higher in perceived balance difficulty at time 1 were 84 % more likely to experience

Table 1 Sample characteristics at time 1

Variable	Overall (N=1,630) M (SD) or %	Fallers (n=495) M (SD) or %	Recurrent fallers (n=268) M (SD) or %
Age	75.41 (7.05)	76.77 (7.36)	76.79 (7.11)
Female (%)	53 %	60 %	58 %
White (%)	89 %	90 %	88 %
Education (years)	12.58 (3.06)	12.42 (3.13)	12.28 (3.13)
Chronic Conditions	2.29 (1.33)	2.64 (1.44)	2.84 (1.43)
Functional Limitations	2.78 (2.42)	3.78 (2.56)	4.12 (2.51)
Pain (%)			
No pain	68 %	56 %	52 %
Mild	8 %	8 %	8 %
Moderate	19 %	27 %	29 %
Severe	5 %	9 %	11 %
Muscle strength (kg)	27.38 (9.81)	25.97 (10.32)	26.37 (10.78)
Balance: uncompleted (%)			
Semi-tandem	7 %	11 %	7 %
Full-tandem	40 %	50 %	54 %
Balance difficulty (%)			
Never	30 %	16 %	13 %
Rarely	33 %	25 %	27 %
Sometimes	26 %	37 %	34 %
Often	11 %	22 %	26 %

recurrent falls at time 2. Table 3 displays the results of the logistic regression analyses.

Discussions

This study investigated predictors of falling and recurrent falls among community-dwelling older adults with cancer. After considering all of the correlated risk factors, functional limitations, the full-tandem stance, and self-reported balance difficulty at time 1 were significant predictors of falling. Self-reported balance difficulty at time 1 was a significant predictor of recurrent falls.

Kane and Kane [31] indicated that measuring functional abilities provides an understanding of older adults' abilities and limitations and informs the development of care plans. Previous research shows that when IADL scores are accounted for in models as a factor of falls, the effect of ADL scores on falls among older adults with cancer is no longer significant [18]. In this study, self-reported difficulty in performing nine physical activities was significantly associated with falling and recurrent falls at time 2 and was an independent prospective predictor of falling. Measures of functional abilities can generally be categorized into ADLs, IADLs, and mobility [31]. ADL scales have ceiling effects among community-dwelling older adults, and IADL scales are likely to be confounded by gender roles [31]. Moreover, most older adults diagnosed with cancer are functionally independent [32]. Thus, measures of physical activities may be a better way to examine functional abilities among community-dwelling older adults with cancer.

Extermann et al. suggested that comorbidity should be examined separately from functional status among older adults with cancer because it often hinders treatments [33]. The number of chronic conditions at time 1, excluding cancer, the individuals reported was used to assess comorbidity in this study, and did not significantly predict falls status at time 2 after accounting other risk factors of falling. Older adults with less mobility are less likely to fall because they have a reduced exposure to fall hazards [34]. Therefore, it is possible that older adults with more chronic conditions had become more sedentary, making them less likely to fall in this study. More research is needed to clarify the role of comorbidity in the relationship between falls and cancer.

Pain can increase the risk of falling among older adults [35]. Despite the fact that pain is a common symptom among cancer patients [36], it was not a predictor of falling in the current study. The majority of pain is caused by advanced cancer [37]; thus, one possible explanation for this findings is that pain is more tolerable among adults with cancer still dwelling in the community. It is also possible that the single-item used in this study was not an appropriate assessment for cancer pain, and hence failed to detect the severity of pain. Researchers have found that the Edmonton Classification System for Cancer Pain (ECS-CP) significantly predicts falls among older adults with advanced cancer [21]. Using a specific measure for cancer pain, such as the ECS-CP, is recommended in future studies.

Although cancer patients often experience muscle loss [38] which may lead to balance problems [39], muscle strength measured by grip strength was not a significant predictor of falling in this sample. One study using a self-reported measure of muscle weakness found that seniors with cancer who fell perceived greater severity in muscle weakness compared to who did not fall [20]. Hence, muscle strength might be associated with falls among community-dwelling older adults with cancer, but whether it is a predictor of falling is unknown. This relationship requires further examination.

Self-reported balance difficulty was a significant predictor of falling and recurrent falls. This finding was also reported by Tofthagen et al. [20]. Although objective measures such as the Timed Up and Go test provide more accurate information related to gait, postural control, and falls [40], a measure of self-reported balance difficulty might be a useful falls screening tool among individuals with cancer in clinical practice.

There are a few limitations in the current study. First, falling was not clearly defined in the HRS. How falls are defined can potentially bias the outcomes [41]. Future studies should employ a clear definition of falling. Second, the HRS

Table 2 Correlation matrix among potential risk factors of falling at time 1 and falls and recurrent falls at time 2

	Falls	R-Falls	Age	Female (%)	White (%)	Education (years)	CC	FL	Pain (%)	MS (kg)	S-T	F-T	BD
Falls	–												
R-Falls	0.69***	–											
Age	0.12***	0.17***	–										
Female (%)	0.02	0.02	−0.04	–									
White (%)	−0.01	0.01	0.06*	0.01	–								
Education (years)	0.01	−0.01	−0.01	−0.07**	0.16***	–							
CC	0.12***	0.17***	0.04	0.05*	−0.10***	−0.13***	–						
FL	0.23***	0.25***	0.12***	0.17***	−0.12***	−0.18***	0.43***	–					
Pain	0.12***	0.19***	−0.03	0.09***	−0.03	−0.10***	0.30***	0.46***	–				
MS (kg)	−0.10**	−0.13**	−0.27***	−0.76***	−0.02	0.15***	−0.14***	−0.34***	−0.14***	–			
S-T (uncompleted)	0.07	0.06	0.18***	0.09*	0.01	−0.04	0.15***	0.16***	0.11**	−0.18***	–		
F-T (uncompleted)	0.18***	0.14***	0.35***	0.20***	−0.03	−0.12*	0.16***	0.29***	0.11**	−0.32***	0.38***	–	
BD	0.28***	0.30***	0.26***	0.12***	−0.09**	−0.05	0.22***	0.44***	0.20***	−0.25***	0.20***	0.29***	–

Significant correlates of falling at time 1 were included as potential predictors of falls and recurrent falls at time 2 in the logistic regressions

R-Falls recurrent falls, *CC* chronic conditions, *FL* functional limitations, *MS* muscle strength, *S-T* semi-tandem, *F-T* full-tandem, *BD* balance difficulty

*$p<0.05$; **$p<0.01$; ***$p<0.001$

used a retrospective manner to record falls and the recall interval for falls extended over a 2-year period. It has been noted that the retrospective manner of recording falls might not be accurate as prospective method, especially when recalling falls events beyond 12 months [42]. Future studies should use a shorter recall interval to obtain more accurate information about falls. Third, information regarding the circumstances and outcomes of falls (e.g., timing, location, and injuries sustained) was not captured in this dataset and might influence future findings. Fourth, the measurements of pain and balance were categorical, limiting the ability to determine the magnitude of these critical factors. Fifth, information about the respondents' stage of cancer was not available in the HRS. The relationship between cancer stages and falls might not be linear. Older adults in stage 1 might still have good physical capabilities and therefore are able to avoid falling, while those in the final stage are more likely to be bedridden and thus exposed to fewer falls hazards. In contrast, individuals with cancer at stages 2 through 4 might remain active, but have more health problems and be more prone to falling. This information might be useful to predict falls among older adults with cancer in future research. Finally, the current study failed to take into account the impact of neuropathy on falls, a common symptom in cancer patients. Neuropathy often affects sensation and proprioception, can cause muscle weakness [43], and contributes to falling [20]. Future studies should incorporate this factor when examining falls among older adults with cancer.

Functional limitations and balance are two significant predictors of falling among older adults with cancer as well as with the general population [11, 28]. However, gender, socioeconomic status, chronic conditions, pain, and muscle strength did not seem to be important factors in predicting falls status among community-dwelling older adults with cancer. Previous studies have noted that older adults with cancer are heterogeneous [32] and noted gender and racial differences in cancer treatment [44, 45]. In addition, older adults with specific types of cancer might

Table 3 Logistic regression analyses investigating predictors of falls and recurrent falls

Variables	Falls Odds ratio (95 % CI)	Recurrent falls Odds ratio (95 % CI)
Age	1.02 (0.99–1.05)	1.00 (0.97–1.04)
Chronic conditions	0.93 (0.81–1.07)	1.03 (0.88–1.21)
Functional limitations	1.13 (1.03–1.24)*	1.05 (0.94–1.17)
Pain	0.90 (0.74–1.10)	1.04 (0.83–1.30)
Muscle strength (kg)	1.00 (0.98–1.02)	0.99 (0.97–1.01)
Full-tandem (uncompleted)	1.48 (1.01–2.16)*	1.16 (0.74–1.86)
Balance difficulty	1.50 (1.23–1.83)**	1.84 (1.44–2.36)**

*$p<0.05$; **$p<0.001$

be more prone to falling. Therefore, future studies are recommended to investigate falls within subgroups of cancer patients (e.g., lung cancer).

The consequences of falling can complicate cancer treatment among older adults. This study addressed limitations of previous studies, finding that greater functional limitations, inability to complete the full-tandem stance, and perceived balance difficulty are significant predictors of falling. Perceived balance difficulty was the only predictor of recurrent falls. These findings have implications for clinical practice as they might be useful tools in detecting falls among community-dwelling older adults with cancer. This information could be utilized by public health practitioners and when referring adults to falls prevention programs.

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