Original Article

Beyond balance and mobility, contributions of cognitive function to falls in older adults with cardiovascular disease

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Abstract

Objectives: Older adults with cardiovascular disease (CVD) are at risk for cognitive impairment. Cognitive function is associated with falls in older adults however it is unknown if a relationship exists between cognitive function and falls in CVD. The aim of this study was to examine the contributions of cognitive function on falls in older adults with CVD. **Methods:** A secondary analysis was performed on data from the Health and Retirement Study cohort 2010 (N=3413) of older adults with CVD. Group assignment was based on falls history (yes/no) within the two years prior to the survey. Demographic (age, education, gender, marital status), physical (strength, balance, physical activity, and mobility) and cognitive (immediate and delayed recall, orientation, semantic verbal fluency, numeracy) information was extracted to characterize the sample. Comparisons between groups were completed for all of these variables. Logistic regression was performed to examine associations between each of the cognitive variables and falls while controlling for age, gender, marital status, education, and BMI. **Results:** Demographic (age, gender, marital status, and education), physical (grip strength, tandem stance time, and gait speed), and cognitive (orientation, immediate and delayed recall) variables differed by falls history ($p<0.05$). After controlling for confounding, immediate recall was the only significant predictor of falls (OR=1.09, 95% CI=1.01-1.17) (Nagelkerke $R^2=0.037$, $\chi^2=35.14$, $p<0.05$) with correctly classifying 65.9% of cases. **Conclusions:** In older adults with CVD, cognitive and physical functions are more impaired in those with a falls history. Screening for cognitive function, specifically immediate recall, should be a part of the management of falls in this population.

Keywords: Cardiovascular disease, Cognition, Recall, Falls, Mobility

Introduction

One out of four older adults falls each year, accounting for more than fifty billion dollars in health care costs[1]. Adults with cardiovascular disease (CVD) are reported to have higher odds of falling as compared to those without reported CVD[2]. A link between cognition and falls/falls risk has been reported in the literature. Cognitive function is used in everyday mobility tasks and specifically during goal-directed activities, the initiation of tasks, and while negotiating obstacles within the environment[3-6]. Older adults with impaired cognition have an increased likelihood of falling than cognitively intact peers, and are at an increased risk for an injurious fall, and institutionalization after falling[7-11]. Various cognitive processes have been identified as significant predictors of functional decline and falls in older adults[7-9]. In older adults, impaired cognitive function has been associated with decreased performance in activities of daily living[12] and slower, more impaired gait[4].

Of particular interest is that despite the possibility of cognitive decline occurring throughout the aging process[13], the changes in cognition may be more pervasive in those with CVD[14,15]. The prevalence of cognitive impairments in adults with CVD ranges from 30% to 80% and is dependent on disease type and duration[16-20]. However, decreased performance on cognitive measures has been reported in older adults with CVD regardless of age and education

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indicating that cognitive dysfunction may play a more predominant role in those with CVD[16].

Studies in CVD which address falls risk factors have primarily focused either on mobility related factors such as decreased gait speed, impaired balance or the presence of disease associated side effects (e.g. orthostatic hypotension)[2,21]. Although changes in functional mobility provide sufficient evidence of the concern of falls in CVD, a crucial knowledge gap exists in the additional role that cognitive impairment plays on falls, given the prevalence of cognitive decline in older adults with CVD. Determination of the specific cognitive functions that contribute to falls in older adults with CVD is imperative to incorporate appropriate cognitive screening and interventions in this population for reducing falls risk. Therefore, the aim of this study was to first describe the differences in cognitive function in older adults with CVD by falls history. A secondary aim was to examine the influence of specific cognitive processes on falls (yes/no) in older adults with CVD using logistic regression.

Materials and methods

The sample for this cross-sectional study comes from the 2010 wave of the Health and Retirement Study (HRS). HRS is a longitudinal study which surveys a representative sample of approximately 20,000 community dwelling Americans over age 50 every two years[22]. The 2010 wave included participants from 50- 110 years of age. A detailed description of the study can be found at: http://hrsonline.isr.umich.edu/. This secondary analysis was approved by the institutional review board of the primary investigator.

Data for the HRS interview was collected between March 2010 through May 2011 through information provided by the respondent or their proxy. Data was included if respondents were aged 65 years+, had a diagnosis of CVD, and did not have Alzheimer's disease, dementia, diabetes, depression, or history of cancer. Additionally, those with a history of stroke were excluded from the sample to reduce confounding of falls and associated cognitive impairments resulting from cerebrovascular insults. The American Heart Association definition for CVD was used to create the sample population. CVD was defined as any condition affecting the heart and blood vessels and included diagnoses of coronary heart disease, congestive heart failure, hypertension, peripheral artery disease, arrhythmia, or heart valve disorders[23]. Respondents who reported to have a physician diagnosis of heart disease, myocardial infarction, congestive heart failure, arrhythmia, heart valve problems, hypertension, or those who were taking medications for the aforementioned conditions were included in the sample. Respondents who had incomplete demographic, disease, physical function or cognitive information were excluded. The 2010 HRS wave consisted of a total of 22,034 respondents, of which 4051 had CVD and 3413 met inclusion/exclusion criteria for this study.

Demographic data extracted included age, gender, marital status, and education. Other health related variables included the reported frequency of engaging in mild physical activity at least once per week and anthropometric measures for calculation of body mass index (kg/m^2). Falls information required respondents or their proxy to account for any falls which occurred in the two years prior to the survey interview. Falls data extracted included incidence (yes/no), number of falls, and whether an injury (yes/no) had occurred from a fall.

Measures of strength, balance, and mobility were extracted to characterize the sample. Grip strength measurement data (dominant hand) was used as a measure of overall strength. Tandem stance time was used as a measure of balance. Considered to be a necessary component of balance in community dwelling older adults, the ability to perform tandem stance has been associated with fall risk[24]. The total amount of time, in seconds that the respondent was able to stand in heel to toe tandem position without support for up to 60 seconds was recorded. Mobility was assessed via gait speed measurement. Gait speed is associated with cognitive function and falls in older adults[25]. In the HRS, gait speed was measured over two trials as the time (in seconds) required to walk an eight-foot distance on level surfaces. The average speed over two trials was calculated and converted to meters per second for analyses.

Cognitive data extracted included assessments of memory (immediate and delayed), orientation, verbal fluency, and numeracy. Memory was measured via immediate and delayed word recall. For immediate word recall (IWR), the interviewer read a randomly assigned list of 10 nouns to the respondent, and asked the respondent to recall as many words as possible from the list in any order immediately afterwards. The number of correctly recalled words was recorded for this task. Delayed word recall (DWR) required respondents to name as many of those original 10 words after a period of 5 minutes had passed and during which the respondent was engaged in other tasks. DWR was scored in the same fashion as IWR. Orientation was assessed by the respondent being able to correctly recall the week, month, day, and year. Scores ranged from '0' indicating that no correct responses were provided to '4' indicating that all orientation items were correctly answered. A verbal fluency task was used as a measure of executive function as it requires the use of strategic search, set-shifting and semantic memory for task completion[26]. In the semantic verbal fluency test respondents were required to name as many animals as possible in 60 seconds with the total number of named animals to comprise the score. Numeracy was measured with the serial sevens subtraction test (SST) which is a measure of concentration and attention[27,28]. For the SST respondents were required to subtract 7 from 100, then from 93 and so on for a series of 5 sequential subtractions. All numerical responses were recorded and respondents were not corrected during this process[27]. The number of numerically correct subtractions (even after error) are summed to produce the respondent's

Variable	Total Sample N= 3413		Falls Group N= 1164		No Falls Group N= 2249		*p*-value
	Mean (SD) or Percentage	Range	Mean (SD) or Percentage	Range	Mean (SD) or Percentage	Range	
Age, years	76.14 (7.56)	65-109	77.86 (8.13)	65-109	75.25 (7.08)	65-102	0.00*
Education, years	12.42 (3.15)	1-17	12.21 (3.20)	1-17	12.52 (3.12)	1-17	0.01*
Gender, % Female	58.6	-	61.8	-	57.0	-	0.00*
Marital Status, % Married	57.3	-	52.4	-	59.9	-	0.00*
Number Times Fallen	3.21 (5.09)	0-50	3.21 (5.09)	0-50	-	-	-
Injury Due to Fall, %	28.8	-	28.8	-	-	-	-
Mild Intensity Physical Activity Once/week, %	29.0	-	29.4	-	28.9	-	0.75
Physical Measures							
Body Mass Index, kg/m^2	29.69 (5.69)	16.05-55.44	29.29 (5.55)	16.05-49.35	29.89 (5.73)	16.64- 55.44	0.07
Grip Strength, kg	27.76 (10.22)	0.0-56.50	25.53 (9.82)	0.0- 56.50	28.98 (10.23)	7.25- 56.50	0.00*
Gait Speed, m/s	0.75 (0.24)	0.16-1.50	0.73 (0.23)	0.16-1.43	0.77 (0.24)	0.18-1.50	0.00*
Tandem Stance Time, s	31.14 (17.39)	0.01- 60.00	28.25 (17.78)	0.01- 60.00	32.47 (17.02)	0.001- 60.00	0.00*
Cognitive Measures							
Immediate Word Recall	5.00 (1.79)	0-10	4.82 (1.78)	0-10	5.08 (1.71)	0-10	0.00*
Delayed Word Recall	3.92 (2.05)	0-10	3.75 (2.02)	0-10	4.01 (2.06)	0-10	0.00*
Orientation	3.68 (0.69)	0-4	3.62 (0.75)	0-4	3.71 (0.65)	0-4	0.00*
Numeracy	3.04 (1.96)	0-5	2.93 (1.97)	0-5	3.09 (1.96)	0-5	0.05
Semantic Verbal Fluency	14.98 (6.47)	0-42	14.96 (6.42)	0-42	14.99 (6.49)	0-38	0.89

*s: seconds; *p<0.05*

Table 1. Demographic, mobility, and cognitive data of the CVD sample and by group assignment.

total score with a maximal score of 5.

To detect differences in cognitive and physical function of the CVD sample by falls history, two groups were created based on reporting a history of falls (yes/no) within the two years prior to the survey (Falls Group; No Falls Group). Demographics were first described for the whole sample and then for each group. Characteristics were then compared by group using ANOVA for continuous variables and χ^2 for dichotomous variables. Multivariable logistic regression analyses were performed to examine the odds ratio (OR) with a 95% confidence interval (95% CI) for falling in older adults with CVD by cognitive performance. An OR greater than 1 is indicative of an increased likelihood of falling. The cognitive predictor variables included: semantic verbal fluency, IWR, DWR, numeracy, and orientation. The outcome variable was falls (coded as yes=1 or no= 0). Baseline characteristics and cognitive variables that differed between groups at $p<0.15$ were included as independent variables in the model and included age, marital status, gender, body mass index, and education. A p-value cutoff point of 0.15 has been suggested for selection of variables in logistic regression as the traditional *p*-value of 0.05 can fail to detect important variables[31]. All data was analyzed using SPSS 24.0 (IBM Corp., Armonk, NY, USA) and a significance level was set at $p<0.05$.

Results

Characteristics of participants

Overall, 3413 individuals met inclusion criteria and comprised the study population. The mean age was 76.14 years (SD=7.56; range=65-109), 57.3% were married, and 58.6% were female.

Within the sample, 34.10 % (N=1164) reported falling and were assigned to the Falls group. An average of 3.21 (SD=5.09) falls were reported of which 28.8% were injurious falls. Significant differences existed between groups across multiple demographic variables including age, gender, marital status, and education. Groups did not differ in their BMI or physical activity levels. Falls group participants had lower overall strength (grip strength 25.53 kg/m^2 vs 28.98 kg/m^2), slower gait speed (0.73 m/s vs 0.77 m/s), and more impaired balance (tandem stance time: 28.25s vs 32.47s) as compared to those in the No Falls group.

Cognitive performance differed between groups. More

Predictor in final logistic regression model	Coefficient (SE)	Constant (SE)	Odds Ratio (95% CI)	p-value
Immediate Word Recall	-0.084 (0.038)	3.205 (0.762)	1.09 (1.01, 1.17)	0.026*
*Note: * p< 0.05; CI=confidence interval; SE=standard error.*				

Table 2. Logistic regression analysis for cognitive variables associated with falls in older adults with CVD (N= 3413).

impaired recall was found in the Falls group in both IWR (4.82 words; SD=1.78; $p<0.05$) and DWR (3.75 words; SD=2.02; $p<0.05$) as compared to the No Falls group (IWR=5.08, SD=1.71; DWR=4.01, SD=2.06). Falls group members were, on average, less oriented to week, month, day, and year (mean: 3.62, SD=0.75; $p<0.05$) as compared to the No Falls group (mean: 3.71, SD=0.65; $p<0.05$). Numeracy was more impaired in the Falls group with the SST score of 2.93 (SD=1.97) versus 3.09 (SD=1.96) in the No Falls group, but the difference did not reach statistical significance (p=0.05). Groups were not significantly different in their semantic verbal fluency in the Falls group (14.96 animals named, SD= 6.42, $p>0.05$) versus the No Falls group (14.99, SD=6.49). Full demographic, mobility and cognitive data can be found in Table 1.

Predictors of falls

Associations between cognition and falls from logistic regression analyses of the whole sample revealed that immediate recall was associated with falls (OR= 1.09, 95% CI=1.01-1.17, p=0.026) after adjusting for age, gender, marital status, education, and body mass index. The final logistic regression model was significant with immediate recall as a predictor of falls (Nagelkerke R^2= 0.037, χ^2=35.14, $p<0.05$) with correctly classifying 65.9% of cases (Table 2). None of the other cognitive predictor variables were significantly associated with falls after controlling for covariates.

Discussion

This study describes differences in physical and cognitive function based on falls history in a national sample of older adults with CVD. Of all the cognitive processes examined, immediate recall was the only significant predictor of falls indicating that older adults with CVD with impaired immediate recall are at an increased likelihood for falls. Explicitly, as immediate recall declines, the risk of falls increases by 9% in older adults with CVD regardless of age, gender, marital status, education, and body mass index. Evidence suggests that the decline in cognitive function with aging does not affect all memory functions equally[29]. Specifically, deficits in episodic recall or immediate memory tasks are typically noted in older adults[30]. This may explain why immediate recall stood out as the only predictor of falls in this sample of older adults. This study adds to the body of literature by describing the specific cognitive processes which contribute to falls in those with CVD. Although a more comprehensive assessment of cognitive function is warranted, the simple cognitive screening measures used in this study have exposed the predictive ability of cognitive function, specifically immediate recall, on falls in older adults with CVD. Results of this study direct clinicians and researchers to consider these relationships when managing falls risk in older adults with CVD.

In the sample, those who reported falling were older, had more impaired balance, slower gait speed, and decreased overall general body strength than those without a falls history. Differences in these characteristics between fallers and non-fallers may be considered typical as they have been reported to contribute to falls in older adults[21]. When comparing immediate recall performance in the Falls group versus what has been previously reported in a national sample of older adults, IWR in CVD fallers was more impaired (4.82 versus 5.1 words recalled) indicating that this cognitive construct may be more impaired in CVD fallers[26]. Additionally, other areas of cognitive function (delayed recall, orientation, and numeracy) were more impaired in CVD fallers. Collectively, these data suggest that the profile of a faller with CVD may be comprised of more than just impaired physical function, and that consideration should be given to the potential underlying cognitive dysfunction that may contribute to falls.

The sample in this study reported more falls (34.10 %) than what was previously reported in older adults with CVD[2,31]. In the Cardiovascular Health study, 13.2% of older adults with CVD related risk factors reported falling[31]. Another large epidemiological study similar to the HRS reported a 19.2% falls incidence in CVD with an increased risk with advanced age and a greater degree of CVD comorbidity[2]. A strong link has been established between comorbidities and falls in the elderly in previous literature due to direct effects of individual conditions such as depression, visual field defects[32-34], orthostatic hypotension[35], cerebral hypoperfusion[36], arrythmias[37], low bone density[38], muscle weakness, gait deficit[38], peripheral neuropathy[39] and postural imbalance. Subsequently, the risk of falls is compounded as the number of comorbidities increase[40]. In order to describe the cognitive function of the sample without the potential confounding of CVD associated diagnoses on cognition and falls, this study did not include older adults with comorbidities including a history of depression, diabetes, or stroke[41]. These diagnoses may have been present in other studies which reported falls in CVD and therefore the fall rates in this study reflect those of older adults with CVD who do not have those additional diagnoses. Lastly, the sample included adults whose ages ranged from 65-109 and despite controlling for the effect of age on falls in regression modeling, a review of falls rates by age range was not performed. It is possible that falls incidence would be different when age groupings are considered, and therefore more study is necessary.

Impaired immediate recall has previously been identified as a significant predictor of falls in community dwelling and in hospitalized older adults, but not specifically in older adults with CVD[42,43]. Results of this study are consistent with previous findings indicating the odds of falling increases when immediate recall is impaired, however the odds ratio in this study exceeded those previously reported. Anstay and colleagues found that falls increased by 5% when immediate recall was impaired in community dwelling older adults, however, when they adjusted their regression model for CVD and lifestyle factors, immediate recall was no longer a significant predictor of falls[42]. Whereas in this study, the odds ratio for falling increased by 9% when immediate recall was impaired.

Orientation has been identified as the cognitive area most often screened within a falls risk assessment[44]. Although orientation was significantly different in fallers, it was not a significant predictor of falls. Conversely, the cognitive domain of executive function which is considered a key contributor to falls and of which is suggested to be included within a falls risk assessment was not significantly different between groups[45]. The nature of performing a large epidemiological survey, like HRS, might not be conducive to having surveyors perform complex cognitive assessments which require advanced training and education during data collection. Therefore, it may be possible that the cognitive measures used were not robust enough to detect differences in cognitive processes reported to influence falls and further study should be completed.

Strengths of the study include the use of a large national sample of older adults with CVD and the use of cognitive and physical mobility screening measures which can be replicated in clinical settings. However, limitations exist. First, CVD data was gathered by HRS surveyors through a 'yes'/'no' response by the respondent or a proxy and verification of medical history was not performed. Group assignment was completed by falls history recall over a period of two years and falls may have been missed or not reported. Although falls risk might differ by CVD diagnosis, secondary analysis revealed that the majority of the sample (88%) had underlying hypertension and that the relationship with falls was irrespective of the presence of advanced cardiac disease. Future studies comparing the relationship of falls with individuals having hypertension alone, and those with hypertension along with added cardiac comorbidities would be valuable. Other factors contributing to falls such as postural hypotension were unable to be incorporated into analyses due to the nature of the data, and warrants further research. Lastly, as this was a cross-sectional study, causality between cognitive performance and falls in CVD cannot be established.

Data from this study underlies the importance for using a structured cognitive assessment as a part of a falls risk assessment in older adults with CVD. As CVD pathology and disease treatment are likely to contribute to the presence of impaired cognition and/or mobility, cognitive function should be screened within a falls risk assessment with specific screening of immediate recall especially in those with a history of falling.

References

1. Centers for Disease Control and Prevention. Falls Among Older Adults: An Overview. In: 2014.
2. Bhangu J, King-Kallimanis BL, Donoghue OA, Carroll L, Kenny RA. Falls, non-accidental falls and syncope in community-dwelling adults aged 50 years and older: Implications for cardiovascular assessment. PloS one 2017;12(7):e0180997.
3. Fasano A, Plotnik M. Neurologic aspects and falls. Clinical cases in mineral and bone metabolism 2012;9(1):17.
4. Killane I, Donoghue OA, Savva GM, Cronin H, Kenny RA, Reilly RB. Relative association of processing speed, short-term memory and sustained attention with task on gait speed: a study of community-dwelling people 50 years and older. The journals of gerontology Series A, Biological sciences and medical sciences 2014;69(11):1407-1414.
5. Muir SW, Gopaul K, Montero Odasso MM. The role of cognitive impairment in fall risk among older adults: a systematic review and meta-analysis. Age and ageing 2012;41(3):299-308.
6. Royall DR, Lauterbach EC, Cummings JL, et al. Executive control function: a review of its promise and challenges for clinical research. A report from the Committee on Research of the American Neuropsychiatric Association. The Journal of neuropsychiatry and clinical neurosciences 2002;14(4):377-405.
7. Ble A, Volpato S, Zuliani G, et al. Executive Function Correlates with Walking Speed in Older Persons: The InCHIANTI Study. Journal of the American Geriatrics Society 2005;53(3):410-415.
8. Herman T, Mirelman A, Giladi N, Schweiger A, Hausdorff JM. Executive Control Deficits as a Prodrome to Falls in Healthy Older Adults: A Prospective Study Linking Thinking, Walking, and Falling. Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences 2010;65A(10):1086-1092.
9. Segev-Jacubovski O, Herman T, Yogev-Seligmann G, Mirelman A, Giladi N, Hausdorff JM. The interplay between gait, falls and cognition: can cognitive therapy reduce fall risk? Expert Review of Neurotherapeutics 2011;11(7):1057-1075.
10. Sheridan PL, Hausdorff JM. The role of higher-level cognitive function in gait: executive dysfunction contributes to fall risk in Alzheimer's disease. Dementia and geriatric cognitive disorders. 2007;24(2):125.
11. Yogev-Seligmann G, Hausdorff JM, Giladi N. The role of executive function and attention in gait. Movement Disorders 2008;23(3):329-342.
12. Boyle PA. Assessing and predicting functional impairment in

Alzheimer's disease: the emerging role of frontal system dysfunction. Current psychiatry reports 2004;6(1):20.
13. Salthouse TA. The Processing-Speed Theory of Adult Age Differences in Cognition. Psychological Review 1996;103(3):403-428.
14. Bellew KM, Pigeon JG, Stang PE, Fleischman W, Gardner RM, Baker WW. Hypertension and the rate of cognitive decline in patients with dementia of the Alzheimer type. Alzheimer disease and associated disorders 2004;18(4):208.
15. Carlo A, Baldereschi M, Amaducci L, et al. Cognitive Impairment Without Dementia in Older People: Prevalence, Vascular Risk Factors, Impact on Disability. The Italian Longitudinal Study on Aging. Journal of the American Geriatrics Society 2000;48(7):775-782.
16. Breteler MMB, Claus JJ, Grobbee DE, Hofman A. Cardiovascular disease and distribution of cognitive function in elderly people: the Rotterdam study. BMJ 1994;308(6944):1604-1608.
17. Kerola T, Kettunen R, Nieminen T. The complex interplay of cardiovascular system and cognition: How to predict dementia in the elderly? International Journal of Cardiology 2010; 150(2):123-129.
18. Kilander L, Andrén B, Nyman Hk, Lind L, Boberg M, Lithell H. Atrial Fibrillation Is an Independent Determinant of Low Cognitive Function: A Cross-Sectional Study in Elderly Men. Stroke 1998; 29(9):1816-1820.
19. Malik ASMD, Giamouzis GMDP, Georgiopoulou VVMD, et al. Patient Perception Versus Medical Record Entry of Health-Related Conditions Among Patients With Heart Failure. American Journal of Cardiology, The 2011;107(4):569-572.
20. Vogels RLC, Oosterman JM, Van Harten B, et al. Profile of Cognitive Impairment in Chronic Heart Failure. Journal of the American Geriatrics Society 2007;55(11):1764-1770.
21. Tinetti ME, Speechley M, Ginter SF. Risk Factors for Falls among Elderly Persons Living in the Community. The New England Journal of Medicine 1988;319(26):1701-1707.
22. Health and Retirement Study. http://hrsonline.isr.umich.edu. Updated 2017. Accessed November 14, 2017.
23. Heidenreich PA, Trogdon JG, Khavjou OA, et al. Forecasting the future of cardiovascular disease in the United States: a policy statement from the American Heart Association. Circulation 2011;123(8):933-944.
24. Pajala S, Era P, Koskenvuo M, Kaprio J, Törmäkangas T, Rantanen T. Force platform balance measures as predictors of indoor and outdoor falls in community-dwelling women aged 63-76 years. The journals of gerontology Series A, Biological sciences and medical sciences 2008;63(2):171-178.
25. Blackwood J, Shubert T, Forgarty K, Chase C. Relationships Between Performance on Assessments of Executive Function and Fall Risk Screening Measures in Community-Dwelling Older Adults. Journal of geriatric physical therapy 2016;39(2):89-96.
26. Savva GM, Maty SC, Setti A, Feeney J. Cognitive and Physical Health of the Older Populations of England, the United States, and Ireland: International Comparability of The Irish Longitudinal Study on Ageing. Journal of the American Geriatrics Society 2013;61(s2):S291-S298.
27. Karzmark P. Validity of the serial seven procedure. International journal of geriatric psychiatry 2000;15(8):677-679.
28. Peters E, Västfjäll D, Slovic P, et al. Numeracy and Decision Making. Psychological Science 2006;17(5):407-413.
29. Craik FIM, Salthouse TA. The handbook of aging and cognition. 3rd ed. New York, NY: Psychology Press; 2007.
30. Naveh-Benjamin M, Cowan N, Kilb A, Chen Z. Age-related differences in immediate serial recall: Dissociating chunk formation and capacity. Memory & Cognition 2007;35(4):724-737.
31. Welmerink DB, Longstreth WT, Lyles MF, Fitzpatrick AL. Cognition and the Risk of Hospitalization for Serious Falls in the Elderly: Results From the Cardiovascular Health Study. Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences 2010;65A(11):1242-1249.
32. de Boer MR, Pluijm SMF, Lips P, et al. Different aspects of visual impairment as risk factors for falls and fractures in older men and women. Journal of Bone and Mineral Research 2004;19(9):1539-1547.
33. Freeman EE, Muñoz B, Rubin G, West SK. Visual field loss increases the risk of falls in older adults: the Salisbury eye evaluation. Investigative ophthalmology & visual science 2007;48(10):4445.
34. Klein BE, Klein R, Lee KE, Cruickshanks KJ. Performance-based and self-assessed measures of visual function as related to history of falls, hip fractures, and measured gait time. The Beaver Dam Eye Study. Ophthalmology 1998;105(1):160-164.
35. McDonald C, Pearce M, Kerr SR, Newton J. A prospective study of the association between orthostatic hypotension and falls: definition matters. Age and ageing 2017;46(3):439-445.
36. Bhangu J, McMahon CG, Hall P, et al. Long-term cardiac monitoring in older adults with unexplained falls and syncope. Heart 2016; 102(9):681-686.
37. Jansen S, Kenny RA, de Rooij SE, van der Velde N. Self-reported cardiovascular conditions are associated with falls and syncope in community-dwelling older adults. Age and ageing 2015; 44(3):525-529.
38. Bijani A, Ghadimi R, Mikaniki E, et al. Cohort Profile Update: The Amirkola Health and Ageing Project (AHAP). Caspian journal of internal medicine 2017;8(3):205-212.
39. Kolb NA, Smith AG, Singleton JR, et al. The Association of Chemotherapy-Induced Peripheral Neuropathy Symptoms and the Risk of Falling. JAMA Neurology 2016;73(7):860-866.
40. Wenhua Bao, Dapeng Hu, Xiaohong Shi , et al. Comorbidity increased the fall risk in Chinese elderly: a cross-sectional study. Int J Clin Exp Med 2017;10(7):10753-10763.
41. Okura T, Plassman BL, Steffens DC, Langa KM. Prevalence of neuropsychiatric symptoms among older adults in the united states: The aging, demographics, and memory study. Alzheimer's & Dementia: The Journal of the Alzheimer's Association 2009; 5(4):P374-P374.
42. Anstey KJ, Von Sanden C, Luszcz MA. An 8-Year Prospective Study of the Relationship Between Cognitive Performance and Falling in Very Old Adults. Journal of the American Geriatrics Society 2006;54(8):1169-1176.
43. Chen X, Van Nguyen H, Shen Q, Chan DKY. Characteristics associated with recurrent falls among the elderly within aged-care wards in a tertiary hospital: The effect of cognitive impairment. Archives of Gerontology and Geriatrics 2010;53(2):e183-e186.
44. Blackwood J, Martin A. Screening for Cognitive Impairment as a Part of Falls Risk Assessment in Physical Therapist Practice. Journal of geriatric physical therapy 2017;40(4):197-203.
45. Hsu CL, Nagamatsu LS, Davis JC, Liu-Ambrose T. Examining the relationship between specific cognitive processes and falls risk in older adults: a systematic review. Osteoporosis International 2012;23(10):2409-2424.