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Prevalence of Falls, Physical Performance, and Dual-Task Cost While Walking in Older Adults at High Risk of Falling with and Without Cognitive Impairment

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Purpose: To compare the prevalence of falls, physical performance, and dual-task cost during walking between cognitively healthy and impaired older adults at high risk of falling.

Methods: A cross-sectional analysis of 670 community-dwelling older adults who were considered at high risk of falling, operationalized as 1) having fallen at least once in the preceding 12 months and having a health-care practitioner's referral indicating that the participant was at risk of falls or 2) having impaired mobility as evidenced by a Timed Up and Go (TUG) result ≥13.5 s. Participants (mean age = 77.7 years, SD = 5.6) were divided into cognitively healthy (n = 461) or cognitively impaired (n = 209) groups using a cutoff score of <23 on the Montreal Cognitive Assessment test. Assessment included self-reported number of falls over the previous 12 months, functional reach, TUG, Short Physical Performance Battery (SPPB), and single- and dual-task walk performance. Data were analyzed using Poisson regression to estimate the prevalence ratios of falls and analysis of variance to examine between-group differences on physical performance and dual-task cost during walking performance.

Results: In the analysis, 82.3% of older adults with cognitive impairment and 69.4% of unimpaired older adults reported 1 or more falls in the previous 12 months. Compared with cognitively healthy participants, those with cognitive impairment were 2.57 (95% confidence interval [CI] = 2.17 to 3.05) times more likely to have any fall and 2.33 (95% CI = 1.95 to 2.78) times more likely to have multiple falls. Older adults with cognitive impairment performed worse on functional reach (mean difference [MD] = −2.33 cm, 95% CI = −3.21 to −1.46), TUG (MD = 3.05 s, 95% CI = 2.22 to 3.88), and SPPB (MD = −1.24 points, 95% CI = −1.55 to −0.92) and showed increase in dual-task costs (MD = 6.59%, 95% CI = 4.19 to 9.03) compared to those without cognitive impairment.

Conclusion: Older adults at high risk for falls and who have cognitive impairment are associated with a greater risk for falls and decrements in physical and dual-task performance.

Keywords: cognitive impairment, dual-task, falls, elderly, physical performance

Introduction

As the proportion of older adults in the population increases, concerns about falls and impaired cognitive and functional abilities and their impact on older adult fallers, their caregivers, and the health-care system raise significant public health issues.[1–3] While falls and injurious falls in older adults have unequivocally been

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recognized as a major public health problem globally,[1,4,5] increasing evidence suggests that those who experience cognitive impairment may be at greater risk.[3,6] Studies have shown that between 30% and 50% of older adults with cognitive impairment have reported falls[7,8] and that they may have 5 times higher risk of falling compared to those who are cognitively unimpaired.[9] In addition, older adults with cognitive impairment perform poorly on balance, gait, and dual-task activities.[8,10,11]

While evidence points to the increased risk for falls and fall-related injury and functional deficits among community-dwelling older adults with cognitive impairment,[3,6,12,13] what remains unclear is whether cognitive impairment elevates fall risks for those who are already at high risk of falling, a subpopulation of older adults who may be further disadvantaged by compromised attentional resources, executive function, control of posture, and gait.[3,14] With the demonstrated increase in morbidity and mortality among individuals with cognitive impairment, including those with Alzheimer's disease and related disorders,[15,16] the lack of knowledge linking cognitive impairment to increased fall risks among high-risk fallers may impede our efforts to develop effective interventions specifically targeting this growing population of older adults. Additionally, clarifying these relationships can help inform clinical guidelines and evidence-based recommendations for improving treatment of motor deficits and fall prevention strategies for individuals at increased risk of cognitive impairment and falls.

Therefore, we examined a sample of community-dwelling older adults who were identified as being at high risk of falling to compare the prevalence of falls and physical and dual-task performance between those who were cognitively healthy and those demonstrating cognitive impairment. On the basis of prior research,[8–11] we hypothesized that, in this high-risk population, older adults with cognitive impairment would have a higher prevalence of falls and an increased risk for multiple falls and worse physical and dual-task performance compared to cognitively healthy older adults.

Methods

Study Design and Population

We employed a cross-sectional design using data ascertained from the baseline of a previously completed randomized controlled trial that examined the effectiveness of a Tai Ji Quan exercise intervention to prevent falls.[17] The sample was drawn from community-dwelling older adult residents aged ≥70 years who lived in three counties (Multnomah, Clackamas, Lane) in the state of Oregon, where there was a high density of older adult populations and high rates of fall-related deaths. Participants were recruited through promotional efforts conducted at local senior or community centers, senior meal sites (ie, Meals on Wheels), medical clinics, and statewide senior falls prevention networks, supplemented by targeted mass mailings and local newspaper advertisements. Of 1147 individuals who responded to the study promotion and screened per study eligibility criteria (see below), 670 were enrolled into the study, representing a 58% response rate.

Main study eligibility criteria included 1) being 70 years of age and older and 2) being at high risk of falling, defined as having a history of falls in the preceding year and having a health-care practitioner's referral indicating that the participant was at risk of falls or having demonstrated impaired mobility (a score of 13.5 s or greater on the Timed Up and Go [TUG] test[18]). Individuals with severe cognitive impairment (a score ≤20 on the Mini-Mental State Examination (MMSE))[19] or with major limiting physical conditions (as determined by their providers) were excluded. Data used from this study were collected between February 2015 and August 2017. The study was approved by the institutional review board of the Oregon Research Institute, Eugene, Oregon, and written informed consent was obtained from all participants.

Classification of Cognitive Impairment

For the purpose of this study, participants were divided into cognitively healthy (n = 461) or impaired (n = 209) on the basis of a cutoff score of <23 on the Montreal Cognitive Assessment (MoCA) test.[20] MoCA is a clinically valid and reliable measure of cognitive function that involves multiple domains, including attention, executive functions, memory, language, conceptual thinking, calculations, visuospatial abilities, and orientation, with scores ranging from 0 to 30, where higher scores indicate better cognitive functioning. The raw MoCA scores were corrected for level of education, that is, 1 point was added to the participant's score if he or she has 12 years or less of formal education. The decision to use a cutoff score of <23 was based on a meta-analysis indicating that this cutoff score provided the best diagnostic accuracy for differentiating those with healthy cognitive function from those with cognitive impairment.[21]

Outcome Measures

Outcome measures included number of falls in the past 12 months and performance-based measures of functional reach,[22] TUG,[18] Short Physical Performance Battery (SPPB),[23] and walk performance under single- and dual-task conditions.[24] Participant falls data over the previous 12 months were obtained via their recall of fall events, which were defined as "when you land on the floor or the ground, or fall and hit objects like stairs or pieces of furniture, by accident."[17] At an in-person interview, participants were asked, "Have you fallen in the last three (six, nine) months?" and "Have you fallen in the last year?" At each question, we also asked how many falls they had. We sought to determine as accurate an estimate of the timing of any fall(s) and the number of falls as possible. To overcome the limitations related to recall,[25] we also sought corroboration of participant self-reports with a proxy informant (78%).

Functional reach assessed the maximal distance (in cm) participants could reach forward, beyond arm's length, while maintaining a fixed based of support in the standing position, with higher scores indicating better balance. The TUG measure assessed the time (in sec) taken to stand up from a standard armchair (approximate seat height, 46 cm; arm height, 65 cm), walk a distance of 3 m, turn, walk back to the chair, and sit down, with higher scores indicating more difficulty with the task. The SPPB included measures of 1) increasingly challenging standing balance tasks, 2) a 4-m walk (walk velocity), and 3) chair stands (leg strength). A single summary measure of SPPB was used, with the score ranging from 0 points (worst physical function) to 12 points (best physical function).

Participant walk performance was assessed via an Instrumental Timed Up and Go (ITUG) test (APDM, Inc.). Following an explanation of the walking procedures, participants were asked to stand up from an armless chair, walk for a distance of 14 m with no cognitive task (single-task walking), and then walk 14 m with a concurrent cognitive (arithmetic) assignment (dual-task walking) (ie, walking while performing a serial subtraction of 5 from a prior-determined number).[24] The verbal instructions for these tasks included the following: "Walk at normal pace" (during both single- and double-task walking) and "perform as many subtractions as accurately as you can" (during dual-task walking).

The total walking duration (in seconds) during each walk trial was recorded. Two trials were administered under both the single-task condition and the dual-task condition (starting with the number 95 in trial 1 and 65 on trial 2). For the dual-task walk trials, the serial subtractions of 5 were not performed at random and no specific instructions were given regarding task prioritization. The order of the walking conditions was counterbalanced across participants. Scores (in seconds) from each of the walk conditions were averaged to represent single-task walk and dual-task walk. Using the average score ascertained from each walk, a dual-task cost measure was estimated as dual-task cost = ((dual-task – single-task) /single-task) x 100, with positive values (in percentage) indicating deteriorated walking performance in the dual-task condition (ie, dual-task cost) with respect to the single-task condition.

Covariates

As part of the study assessment, each participant completed a health survey that contained demographic and clinical information regarding age, race/ethnicity, gender (1 = men; 2 = women), level of education (elementary/middle/high school, community college, university degree or higher), health status (1 = very poor, 2 = poor, 3 = fair, 4 = good, 5 = very good, 6 = excellent), level of depression (with higher scores indicative of higher levels of depression),[26] number of chronic diseases diagnosed (eg, arthritis, heart disease, high blood pressure, diabetes, etc.), and number of medication used (prescriptions). These measures were included as covariates in the data analysis.

Data Analyses

We conducted descriptive analyses, using analysis of variance for continuous variables and the chi-square (or Fisher's Exact) test for categorical variables, to examine the demographic characteristics of the study population by cognitive status, with outcomes presented as means or percentages. Using the GENLIN procedure in SPSS, we performed Poisson regression analyses on falls count data to estimate falls prevalence and its 95% confidence interval (CI) between the impaired and unimpaired groups and univariate logistic regression to assess the association between cognitive impairment and the odds of having multiple falls (defined as having 2 or more falls). Given that there were multiple dependent variables, we performed MANOVA to examine whether there was a between-group difference (main effect) on any of the three physical performance measures (functional reach, TUG, SPPB) and dual-task cost during walking performance. In the presence of a main effect, follow-up univariate ANOVAs were performed. Between-group differences in means and their 95% CIs are presented. We performed all analyses with and without adjusting for age, gender, health status, chronic conditions, and medication use. For all statistical tests, two-sided P values of <0.05 were considered significant. There were no missing data in the study, and all analyses were conducted using SPSS version 26 (IBM Corp).

Results

A total of 670 older adults participated in the study. Descriptive information on participant demographic and clinical characteristics is shown in Table 1. Participants (mean age = 77.7 years, SD = ±5.6) were primarily white (92.1%) and female (65.1%). There were statistical differences between groups in the variables of age, gender, health status, and fall counts.

Prevalence of Falls

The overall prevalence of falls during the previous year in the study population was 73.4% (95% CI, 70.08% to 76.78%; n = 492). There was a statistical difference in any falls and multiple falls between the two groups (Table 2), with a higher number of falls observed among those in the cognitively impaired group. Comparing participants with cognitive impairment to cognitively healthy participants, the prevalence of any fall was 82.3% (172/209 = 0.823) and 69.4% (320/461 = 0.694), respectively (p = 0.001). The fall prevalence ratio, derived from the unadjusted Poisson regression model, was 2.57 (unadjusted odds ratio [uOR]; 95% CI: 2.17 to 3.05), indicating a statistically significant difference in prevalence between the two groups, with those having a cognitive impairment being 2.6 times more likely to have fallen in the previous 12 months. The prevalence ratio remained unchanged after controlling for the a priori specified set of covariates, with the adjusted OR (aOR) = 2.51 (95% CI: 2.09 to 3.01).

When the odds of falling and multiple falls were examined, the uOR from the unadjusted logistic regression model showed that those with impairment were 1.19 (95% CI, 1.09 to 1.29) times more likely to experience falling compared to the cognitively healthy older adults, and the estimate was relatively unchanged after adjustment with the covariates (aOR = 1.61, 95% CI, 1.06 to 1.28). For multiple falls, the uOR estimate showed that those with impairment were 2.33 (95% CI, 1.95 to 2.78) times more likely to experience multiple falls compared to the cognitively healthy older adults. The adjusted model estimate (aOR) was 2.23 (95% CI, 1.83 to 2.70).

Physical Performance and Dual-Task Cost During Walking

There was a statistically significant difference in physical and dual-task performance scores from MANOVA, $F(4, 655) = 23.76$, $p < .0001$; Wilk's $\Lambda = 0.88$. Descriptive statistics for the outcome measures for each group are presented in Table 3. Compared with cognitively healthy participants, those with impairment showed worse performance on functional reach (mean difference [MD] = −2.33 cm, 95% CI: −3.21 to −1.46) (the negative value indicates shorter distance reached), TUG (MD = 3.05 s, 95% CI: 2.22 to 3.88) (the positive value indicates slower time), SPPB (MD = −1.24 points, 95% CI: −1.55 to −0.92) (the negative value indicates worse performance), and increase in dual-task cost (MD = 6.59%, 95% CI: 4.19 to 9.03) (the positive value indicates slower time).

Discussion

Findings from this cross-sectional study showed that community-dwelling older adults at high risk of falling with cognitive impairment were 2.6 times more likely to report a fall and more than twice as likely to experience multiple falls in the previous 12 months compared to their cognitively healthy peers. In addition, older adults with cognitive impairment also showed poorer physical performance and exhibited lower dual-task ability (as evidenced by high dual-task cost) during walking performance compared to cognitively unimpaired older adults.

The finding on falls is congruent with past studies. Cross-sectional studies have shown that older adults with mild cognitive impairment (MCI) were associated with a higher rate of falls.[10,11] In a prospective study, Gleason et al[27] showed that community-living older adults who scored worse incrementally on the global MMSE scale (ranging from 22 to 30 points, with higher scores indicating better cognitive function) significantly increased risk for falling over 12 months by about 20%, while a prospective study by Ansai et al[7] found that more than 50% of older adults with MCI and mild Alzheimer's disease reported falls over 6 months. A meta-analysis of cognitive impairment in fall risk showed that older adults with impairment on global cognitive measures were at greater risk for falls and serious fall-related injuries.[13] The current study, however, is the first showing that

Table 1 Demographic and Clinical Characteristics of the Study Population by Cognitive Status

	Cognitively Impaired (n = 209)	Cognitively Unimpaired (n = 461)	P value
Age, mean (SD), years	79.23 (5.89)	77.05 (5.36)	<0.001
Gender, n (%)			<0.001
Male	95 (45)	139 (30)	
Female	114 (55)	322 (70)	
Race, n (%)			0.53
White	189 (90)	428 (93)	
African American	13 (6)	18 (4)	
Other	7 (3)	15 (3)	
Education, n (%)			0.05
High school diploma or lower	102 (48)	186 (40)	
College degree or higher	107 (52)	275 (60)	
Resting blood pressure, mean (SD), mmHg			
Systolic	133.45 (21.15)	134.55 (18.51)	0.49
Diastolic	74.09 (11.63)	75.61 (10.80)	0.10
Body mass index, mean (SD), kg/m^2	29.00 (6.58)	29.74 (6.14)	0.16
Self-reported falls in previous 12 months, n (%)			<0.001
None	37 (17.7)	141 (30.6)	
1	37 (17.7)	192 (41.6)	
2	53 (25.4)	97 (21.0)	
≥3	82 (39.2)	31 (6.7)	
Depression (GDS-15)	3.55 (1.78)	3.64 (1.80)	0.14
Self-reported health status, n (%)			0.001
Poor/very poor	58 (27)	72 (17)	
Good/fair	97 (46)	239 (51)	
Very good/excellent	54 (27)	150 (32)	
Self-reported chronic conditions, n (%)			0.42
None	10 (5)	22 (5)	
1	31 (15)	74 (16)	
2	47 (22)	128 (28)	
≥3	121 (58)	237 (51)	
Self-reported medication use, n (%)			0.07
None	35 (17)	104 (22)	
1	55 (26)	131 (29)	
2	58 (28)	126 (27)	
≥3 medications	61 (29)	100 (22)	

Abbreviation: GDS-15, Geriatric Depression Scale (15 items).

among community-dwelling older adults at high risk of falls, those with cognitive impairment have an elevated rate of falls, suggesting that even among high-risk fallers, having a concomitant impairment in cognition elevates the fall risk.

In addition to increased risk of falling, current evidence indicates that older adults with cognitive impairment, including MCI, also exhibit functional deficits in the domains of balance and dual-task walking performance.[3,13,28,29] Corroborating existing evidence, we showed that among those with high fall risk, those with cognitive impairment performed more poorly on mobility-related daily tasks involving upper and lower extremity functioning (eg, reaching, sit-to-stand, balance, and gait).

Table 2 Prevalence of Falls by Cognitive Status

Total Falls	1041		
	Cognitively Impaired (n = 209)	**Cognitively Unimpaired (n = 461)**	**P value**
Any falls	560 (n = 172)	481 (n = 320)	<0.001
2 or more falls	523 (n = 135)	289 (n = 128)	<0.001

These participants also showed higher dual-task costs in their performance of simultaneous motor and cognitive interference tasks during walking, suggesting greater cognitive deficits among high-risk fallers that may be attributed to impairment in attention allocation and executive function.[30,31]

Although the mechanisms precipitating falls among older adults with cognitive impairment, especially in those with high risk of falling, have not been clearly delineated, the literature on older adults with neurological deficits generally suggests that factors such as impaired attentional resource allocation and deficiencies in executive function and working memory may contribute to the increased propensity for falling.[3] Other studies have indicated that gait abnormalities among older adults with cognitive impairment may also contribute to multiple falls and poorer performance of dual-task activities.[29]

Results of this study indicate the need for allocation of intervention resources directed toward this vulnerable population at high risk of falling. Currently, relatively few evidence-based interventions exist for community-dwelling older adults at high risk of falling and with cognitive impairment. Exercise prevents falls in older adults,[32–34] and some emerging findings, albeit from a limited number of unpowered and small sample studies, suggest the potential of exercise to prevent falls in older adults with cognitive impairment.[33,35] However, compelling evidence is lacking, and more targeted trials are needed to clarify this relationship. In addition, interventions may need to be specifically tailored to the functional cognition level of those older adults with cognitive impairment to achieve the desired results. Similarly, given the diminished multitask ability among this population, exercise interventions such as Tai Ji Quan,[36,37] dance,[38] or dual-tasking training[39,40] may be well suited to providing appropriate training challenges for enhancing these abilities in this group.

Our study has some limitations. First, the data analyzed were cross-sectional, which precludes causal inferences about the direction of effects studied. Second, under our dual-task test condition, we used a serial subtraction of the number 5 rather than considering varying the number so that the level of task difficulty could be increased.[30,41] Also, the lack of dual-task prioritization during walking represents another weakness in our assessment approach. Third, because participants were drawn from an exercise intervention trial there is a possibility of self-selection bias inherent in our study sample. Fourth, in quantifying risk, we used a global cognitive screening measure to define cognitive impairment. Other dimensions of cognition, for example, executive function may also be associated with

Table 3 Descriptive Statistics on the Study Outcome Measures by Cognitive Status

	Cognitively Impaired (n = 209)	**Cognitively Unimpaired (n = 461)**	**P value**	**Cohen's *d***
Functional reach, cm, mean (SD)	19.43 (5.64)	21.76 (5.17)	<0.001	0.43
Timed Up and Go, sec, mean (SD)	16.34 (6.65)	13.29 (4.14)	<0.001	0.55
Short Physical Performance Battery, points, mean (SD)	7.49 (1.96)	8.73 (1.88)	<0.001	0.65
Single-task walking, sec, mean (SD)	25.73 (7.24)	21.52 (4.78)	<0.001	0.68
Dual-task walking, sec, mean (SD)	29.48 (11.42)	22.97 (6.06)	<0.001	0.71
Dual-task cost, percentage,[a] mean (SD)	13.14 (19.67)	6.54 (12.07)	<0.001	0.40

Notes: [a]Calculated as the difference between dual-task and single-task on walking speed performance (in seconds), normalized to single-task gait performance and expressed as a percentage (ie, [dual-task walking − single-task walking/single-task walking] × 100), with a positive value indicating performance decrement (ie, dual-task cost) compared with the single-task performance.

increased risk of falling.[42,43] Finally, our fall ascertainment relied primarily on self-reported retrospective data, which is known to be subject to recall bias.[25] When possible, future studies should attempt to involve proxy informants to corroborate the recalls provided by the participants.

In conclusion, findings from this study add new knowledge to the literature showing that older adults at high risk for falls and who have cognitive impairment are associated with a greater risk for falls and impaired physical and dual-task performance. Our results highlight the clinical need for allocating intervention resources specifically targeting this high-risk older adult population to reduce falls and improve physical performance and dual-task abilities.

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Author Contributions

All authors contributed to data analysis, drafting or revising the article, gave final approval of the version to be published, and agreed to be accountable for all aspects of the work.

Disclosure

The authors of this paper reported no financial conflicts of interest.

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