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Fall-Related Physiological and Physical Risk Factors of Community-Dwelling Older Adults with Mild Cognitive Impairment: A Cross-Sectional Study

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Research Article

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Abstract

Background: The risk of falling in older adults with mild cognitive impairment (MCI) could be higher than their cognitively intact peers in the presence of both physiological and physical factors. This study aimed to compare the physiological and physical fall risks of older adults with MCI to those with normal cognition.

Methods: This cross-sectional study recruited community-dwelling older adults from Manila, Philippines. The Physiological Profile Assessment (PPA) was used to examine physiological fall risk. The Timed-Up and Go Test (TUGT) and the 10-Meter Walk Test (10MWT) were used to evaluate physical fall risk in terms of dynamic balance and gait speed (preferred mode and fastest mode), respectively. Independent samples t-test and chi-square were used to compare data for continuous and categorical variables, separately.

Results: One hundred eighty-eight older adults with MCI and 42 with normal cognition participated. With age as a confounding factor, those with MCI have statistically significant poorer PPA scores ($p < .001$, 95% CI [.736, 1.57]) compared to those with intact cognition. There is no significant difference between the two groups in terms of TUGT scores ($p = .345$), 10MWT preferred gait speed ($p = .190$) and 10MWT fastest gait speed ($p = .138$).

Conclusions: Older adults with MCI are at higher risk of falling compared to those with normal cognition based on poorer physiological profile but not on physical fall risks. An intervention study addressing both cognitive and physiological declines in older persons with MCI is warranted.

Keywords: Older Adults; Mild Cognitive Impairment; Risk of Falls

Introduction

Falling in old age is a serious health problem that could have grave consequences such as non-fatal or fatal physical injuries, bothersome psychosocial problems, and substantial economic costs to the family and community [1,2]. Preventing falls from happening in the geriatric population is often targeted by addressing the risks of falling. Mild cognitive impairment (MCI) is a risk factor and predictor for falls among community-dwelling older adults [3-5]. It is the intermediate state of cognitive function between the typical decline due to aging and the deterioration due to dementia [6,7]. In addition to this decrease in cognitive faculty, a decline in physiological and physical functions also increases the risk of falling in older adults [8]. Decreased physiological function such as low vision, diminished proprioception, compromised muscle force generation, longer reaction time, and greater postural sway [8,9], and reduced physical function such as impaired standing balance and slower walking speed are known to predispose older persons to falling [10,11].

While senescence in bodily functions is expected, having MCI and decreased physiological and physical functions at the same time is not part of the normal aging process [12-14]. Several studies have been conducted to assess these physiological or physical functions among older persons with MCI [4,15-21]. The physiological fall risk profile and its postural sway subcomponent were greater among older women having MCI than those not having MCI in a cross-sectional study [15]. Poorer balance control was more common among older persons with MCI than their normal healthy counterparts [16,17]. Furthermore, this lower balance score in MCI is be predictive of falls over 12 months [18]. Gait impairments, measured clinically and quantitatively, were common in MCI in a longitudinal aging study [19]. In particular, decreased walking speed and MCI were related [4,19-21] and associated with falling [4].

The knowledge on the cumulative effect of physiological and physical factors to fall risk or the concomitance of diminished abilities in these domains in old age is somewhat sparse and needs additional investigation among those with MCI in particular [8, 21,22]. Previous studies were based on small sample sizes [16,18,21], only older women were recruited in one study [15] and findings were based on older adults from independent retirement living centers in another study McGough EL, et al. [20] that may limit generalizability. Therefore, a more comprehensive understanding of the coexistence of physiological and physical deterioration in older persons with MCI based on an adequately powered study involving both male and female older adults living in the community must be established.

Hence, this study was conducted to compare the physiological and physical risks of falling in community-living older persons with MCI and those with intact cognition. We hypothesized that the levels of fall-related physiological and physical functions are both inferior for older adults with MCI compared to those with normal cognition. The information gathered from this study may be useful in formulating a more appropriate proactive fall prevention program for this challenging population of older adults.

Methods

Design and Participants

This study utilized a cross-sectional observational design and complied with the Declaration of Helsinki 2013 and Good Clinical Practice Guidelines. The Ethics Review Committees of the Hong Kong Polytechnic University – Department of Rehabilitation Sciences (HSEARS20161001001) and the University of Santo Tomas – College of Rehabilitation Sciences (SI-2016-017-R1) approved this study.

Participants were consecutively sampled from five urban communities in Manila, Philippines, in coordination with the Office for Senior Citizens Affairs (OSCA) from November 2016 to August 2017. Preliminary assessment using interviews and a battery of cognitive and physical performance tests were performed to determine their eligibility. They were included if they were at least 60 years old, living in Manila for at least one year, were independent in basic activities of daily living, able to walk independently with or without an assistive device, and were able to give written consent voluntarily. The Republic Act 9994, otherwise known as The Expanded Senior Citizens Act of 2010 of the Philippines, defines a senior citizen or elderly as any resident citizen of the Philippines who are at least 60 years old [25]. Those residing in institutions for older persons, those with a diagnosis of dementia, Alzheimer's disease, or any major medical conditions, those with severe hearing or visual impairment, those who were taking sedatives, antidepressants, diuretics, and anti-epilepsy that could affect their cognitive function were excluded from this study to minimize potential confounders and modifiers.

The sample size was computed using Open Epi. Using the lower margin of the mean global prevalence rate of MCI, which is 14% [26], with 80% power, a confidence level of 95%, and a confidence limit of 5%, the calculated sample size was 185.

Exposure: Mild Cognitive Impairment

The diagnosis of MCI was based on all the following published criteria [6,7], including 1) cognitive function is considered not normal nor demented based on Montreal

Cognitive Assessment (MoCA) score of < 26 [27]; 2) subjective report of the individual or closest kin on declining cognitive function compared to five years ago [3] on objective cognitive tasks; and 3) ability to perform basic daily activities independently but may have slight impairment in complex instrumental activities [28]. The participants were assessed by a neuro-psychiatrist, who gave the final diagnosis of MCI.

Outcomes: Physiological and Physical Risks for Falls

The outcomes of interest were fall-related risks based on physiological and physical factors. The Physiological Profile Assessment (PPA) Short form was used to examine the physiological fall risk of the participants. Dynamic balance and walking speed were assessed to examine their physical fall risk. The Timed-Up and Go Test (TUGT) was used to assess dynamic balance and functional mobility, while the 10-Meter Walk Test (10MWT) was utilized to measure gait or walking speed.

The PPA measures physiological function through the conduct of five subtests, namely: 1) visual contrast sensitivity, 2) knee proprioception, 3) knee extensor strength, 4) hand reaction time, and 5) postural sway [9]. The visual contrast sensitivity was examined using the Melbourne Edge Test. In this test, participants were instructed to correctly identify the direction of the bisecting line in a set of circles. Knee proprioception was measured by obtaining the mean difference of five trials in degree angle between the lower limbs after they aligned their feet on either side of a transparent acrylic sheet after doing knee flexion and extension with their eyes closed. Knee extensor strength was determined by the best knee extension force of three trials using a spring gauge. The reaction time was recorded as the average time of 10 trials for the participants to press a button upon presentation of visual stimulus. Postural sway was obtained from the mediolateral and anteroposterior displacements using a sway meter while the participant was standing on foam with eyes open. The PPA is valid and reliable in differentiating persons at risk for falls from those who are not at risk for falls [29]. A higher composite PPA score means a poorer physiological profile or greater risk of falling [9].

The TUGT is a simple and reliable test for dynamic balance and functional mobility in older adults [30]. It is done by recording the duration in seconds it takes for an individual to rise from a chair, walk at their normal pace a 3-meter distance, turn around, walk back and sit down on the chair. It has excellent validity and reliability when used in older adults living in the community. Finishing the test more than 13.5 seconds indicates high risk of falls in community-dwelling older persons [30-32].

The 10MWT is a valid and reliable measure of walking or gait speed in older persons [33]. It is computed by dividing the distance covered in meters by the duration in seconds it takes the participant to walk that distance. The participants walked the distance three times at their preferred pace and three times at their fastest pace [33]. The mean of each mode of walking speed was then recorded. Walking speed below 1.0 m/s predisposes older persons to falls [34].

Trained assessors who conducted the tests were not aware of the cognitive level and the diagnosis of MCI of the participants to control for experimenter bias. The tests were conducted in no particular order to minimize the sequence effect. After completing the tests, one research personnel double-checked the recording sheet of each participant to ensure that all subtests were entirely performed to avoid any missing data.

Statistical Analyses

Collected data were encoded in MS Excel 2010 and evaluated using IBM SPSS version 23 for Windows. Descriptive statistics were used to summarize the characteristics of the participants. The differences in participant characteristics and outcome scores on physiological and physical fall-related risk factors between older persons with MCI and those with intact cognition were compared using independent samples t-test and chi-square for continuous and categorical variables, respectively. Age was identified as a significant confounding factor because of its effect on the participants' physiological and physical functions of the participants [35]; hence, it was factored into analysis of data. A *p*-value of .05 was the threshold set for statistical significance.

Results

Participant Characteristics

Of the 300 older adults screened for our study, 39 did not consent to participate, 21 had medical co-morbidities, seven were younger than 60 years, one was wheelchair-borne, one was taking sedatives, and one was living in Manila for less than 12 months. A total of 230 older persons were eligible and consented to participate. The characteristics of the participants are presented in Table 1. The mean age was 69.8 ±6.8 years (range of 60 - 95). One hundred seventy-six or 76.5% were women, and 226 (98.3%) live with a companion. One hundred twenty-four or 53.9% were retired, 41 (17.8%) were still working, and 65 (28.3%) did not work. The average length of education in years was 9.9 ± 3.5. Incidentally, a high percentage of the participants (81.7%) were diagnosed with having MCI. Among them, 143 (76.1%) were of the amnestic type, and 45 (23.9%) were of the non-amnestic type. Older persons with MCI in this study were significantly older (p <

.001), lesser in terms of education years ($p < .001$), and lower in MoCA scores ($p < .001$) compared to those with normal cognition.

Variable	Total Sample (N=230)	Without MCI (n=42, 18.3%)	With MCI (n=188, 81.7%)	*p value*	*Effect size*
Sex (female), n (%)	176 (76.5)	29 (69.0)	147 (78.2)	0.206	0.06
Age (yr), x̄ (SD)	69.8 (6.8)	66.7 (5.1)	70.5 (7.0)	<.001*	0.614
Education (yr), x̄ (SD)	9.9 (3.5)	11.6 (3.0)	9.5 (3.6)	<.001*	0.646
MoCA, median (IQR)	20 (7)	25 (2)	18 (6)	<.001*	0.218
Civil Status, n (%)					
Married	81 (35.2)	15 (35.7)	66 (35.1)	0.941	0.217
Widowed	111 (48.3)	19 (45.2)	92 (48.9)	0.665	0.155
Single	25 (10.9)	6 (14.3)	19 (10.1)	0.431	0.265
Separated	13 (5.6)	2 (4.8)	11 (5.9)	0.782	0.506
Employment status, n (%)					
Retired	124 (53.9)	21 (50.0)	103 (54.8)	0.574	0.136
Working	41(17.8)	9 (21.4)	32 (17.0)	0.5	0.222
Did not work	65 (28.3)	12 (28.6)	53 (28.2)	0.961	0.245
Living situation, n (%)					
Lives alone	4 (1.7)	1 (2.4)	3 (1.6)	0.725	0.113
Lives with companion	226 (98.3)	41 (97.6)	185 (98.4)		
Use of assistive device, n (%)					
None	216 (93.9)	39 (92.9)	177 (94.1)	0.752	0.115
Cane	13 (5.7)	3 (7.1)	10 (5.3)		
Walker	1 (0.4)	-	1 (0.5)		
Lifestyle, n (%)					
Smoker	25 (10.9)	3 (7.1)	22 (11.7)	0.613	0.317
Alcoholic-drinker	43 (18.7)	9 (21.4)	34 (18.1)	0.794	0.274
Body mass index (kg/m^2), x̄ (SD)	23.0 (5.3)	23.2 (4.6)	22.7 (5.9)	0.605	0.095

IQR, interquartile range; km/m^2, kilogram per meter squared; MCI, Mild Cognitive Impairment; MoCA, Montreal Cognitive Assessment; SD, Standard Deviation; x̄, mean; s, second; yr, year

*Significant if p < .05

Table 1: Characteristics of the study participants.

Physiological and Physical Risks of Falling

The mean PPA score of those with MCI is 3.4 +1.7, which is significantly higher (p <.001, 95% CI [.736, 1.57]) compared to those without MCI at 2.2 +1.1. Table 2 shows the difference between those with MCI and those with intact cognition in the five PPA subtests. Older persons with MCI have a significantly lower scores in visual contrast sensitivity ($p < .001$), slower reaction time ($p = .001$), weaker knee extensor strength ($p = .019$), and greater postural sway (p <.001), compared to those with intact cognition.

PPA Subtest	Total Sample (N=230)	Without MCI (n=42)	With MCI (n=188)	*p value*	*95% Confidence Interval*	*Effect size*
Visual contrast sensitivity (dB)	13.5 (5.6)	16.2 (4.1)	12.9 (5.8)	<.001*	-4.77, -1.76	0.59
Reaction time (ms)	436.7 (272.7)	361.9 (116.0)	453.3 (294.2)	.001*	36.27, 146.61	0.34
Proprioception (degrees)	2.6 (1.6)	2.2 (1.4)	2.7 (1.6)	0.084	-.066, 1.03	0.3
Knee extensor strength (Kg)	18.7 (6.7)	20.9 (6.4)	18.2 (6.7)	.019*	-4.92, -.449	0.4
Postural sway (mm^2)	1697.9 (2017.8)	1097.2 (636.2)	1832.1 (2187.0)	<.001*	365.7, 1104.1	0.37
PPA total score	3.1 (1.6)	2.2 (1.1)	3.4 (1.7)	<.001*	.736, 1.57	0.73

*Significant if p < .05

Table 2: Mean scores and standard deviation in Physiological Profile Assessment (PPA) subtests.

Table 3 shows the mean scores and standard deviations of the participants in physical tests based on TUGT and 10MWT. Older adults with MCI demonstrated statistically significant slower performance in TUGT (*p* = .001, 95% CI [-2.644, -.707]), finishing the procedure with an average of 11.9 +5.1 seconds, which is faster compared to older adults without MCI at 10.2 +2.1 seconds. In terms of performance in the 10MWT, however, there was no statistically significant difference between the two groups both in the preferred walking speed (*p* = .190, 95% CI [-.028, .138]) and in the fastest walking speed (*p* = .138, 95% CI [-.028, .195]).

	Total Sample (N=230)	Without MCI (n=42)	With MCI(n=188)	*p value*	*95% Confidence Interval*	*Effect size*
TUGT (s)	11.6 (4.7)	10.2 (2.1)	11.9 (5.1)	.001*	-2.644, -.707	0.43
10MWT (m/s)						
Preferred speed	1.0 (0.2)	1.1 (0.3)	1.0 (0.2)	0.19	-.028, .138	0.2
Fastest speed	1.3 (0.3)	1.4 (0.4)	1.3 (0.3)	0.138	-.028, .195	0.246

*Significant if p < .05

Table 3: Mean scores and standard deviation in Timed Up and Go Test (TUGT) and 10-meter Walk Test (10MWT).

Age was considered a confounding factor in the outcomes on the performance of the assessment procedures. Factoring age into data analysis revealed that those with MCI still had statistically significant higher PPA scores (*p* = .002) but demonstrated no significant difference in TUGT scores (*p* = .345) with normal cognition.

Discussion

The current study found that MCI is highly prevalent in the study population. Community-dwelling older adults with MCI are at greater risk of falling than their peers with intact cognition due to poorer inferior physiological profile. They, however, have a comparable physical level of function in terms of dynamic balance control and walking speeds.

The reported prevalence of MCI in the current study is relatively high compared to the global estimated range of 5.0–36.7% [28]. This incidental finding of high MCI rate could be due to the low mean education in years of the participants. Those with MCI have statistically significantly lower education years compared to those without MCI. It was reported that not finishing a secondary education or high school is a factor for having MCI [28,36]. Amnestic-MCI is more common than the non-amnestic type in the current study, similarly reported in other studies [37,38]. Non-random consecutive sampling of the study participants may have resulted in a biased sample resulting in a higher number of older persons with MCI.

In this study, participants with MCI demonstrated statistically significant higher composite PPA score than those with normal cognition. Higher scores in PPA indicate a higher risk of falling [9]. This finding is supported by a previous cross-sectional study involving community-living older women, which reported that those who have MCI showed higher composite PPA scores and greater postural sway performance compared to those who do not have MCI [15]. However, the current study found that significantly lower visual acuity, slower reaction time, and weaker knee extensor strength were also found among older persons with MCI compared to those with intact cognition aside from just increased postural sway which was reported in the earlier study. This findings suggests that a multifactorial intervention is warranted to target low vision, reduced reaction time, decreased strength of lower extremities and poor postural balance control to reduce the physiological risk of falling of older adults with MCI [39,40].

This study also found that those with MCI are slower in performing TUGT with statistical significance in comparison with their counterparts with no cognitive impairment. However, considering age as a covariate, we found that the performance in TUGT is not significantly different between older adults with MCI and older adults without MCI. An age-related decline in TUGT is an expected trend in the aging population [32]. One normative study Mirelman A, et al. [41] found that the performance of TUGT is longer in MCI in association with older age and female gender. A cross-sectional study concluded that MCI was significantly associated with an impaired performance of the TUGT subtasks, including lesser walking consistency, smaller pitch range during transitions, lower angular velocity during turning, and increased time to complete the turn-to-walk phase [42]. Some other studies employed other measures on balance, such as BES Test and posturography with parallel findings that balance is indeed impaired in MCI. Balance dyscontrol, particularly mediolateral balance [44], is believed to be affected by impaired executive function [43,44].

Based on our gathered data, there was no statistically significant difference in walking speed between those with MCI and those with intact cognition in both the normal pace and fast pace of ambulation. This finding contrasts with previous studies that reported that MCI and slow walking were related [4,20,21,45]. One study, however, supported our finding that there is no difference in the fast pace of ambulation between older adults with MCI and healthy controls [46]. Slow walking speed is associated with a comprehensive range of cognitive functions and not just one specific function [4]. Walking speed was reported to be associated with executive function [20,21,45,47], with low working memory and also with memory performance [45]. In the current study, the participants were merely instructed to walk with no cognitive tasks involved as a simple automatic task during both the normal pace and fast pace of ambulation. Better detection of gait speed reduction may be more evident under dual-tasking conditions in older adults with MCI [48].

The interplay and combined presence of MCI and reduced physiological function in community-dwelling older adults signifies a greater risk of falling and should then be considered in designing more appropriate falls preventive measures, exercises and interventions for older adults with MCI [17,43,49]. Based on our findings, we recommend that fall prevention programs include cognitive training to address the cognitive decline in MCI and interventions to improve the physiological profile of the community-dwelling older adults, mainly focusing on improving visual acuity, reaction time, lower limb muscle strength, and postural stability.

This study has several limitations. This study used a cross-sectional design and focused on comparing the levels of physiological and physical fall-related factors between community-living older adults with MCI and those with intact cognition; as such, causation cannot be inferred. Causality may need to be investigated prospectively in a prospective longitudinal study. Data were obtained from relatively healthy older adults living in an urban city. Caution should be exercised in interpreting the findings to frail older adults with multi-morbidity and those living in rural areas or specialized institutions. There could also be a gender bias in the findings as 76.5% of the participants were women.

Conclusion

In conclusion, we found that those with MCI have a higher risk of falling compared to those without MCI based on poorer physiological profiles. No significant difference in physical factors, terms of dynamic balance and gait speed, were observed between those with MCI and those with intact cognition when age was factored into the equation. Greater risk of falling is seen among older adults with MCI than their cognitively intact peers due to the concomitant presence of fall risk factors, such as advanced age, decreased cognitive level, and impaired physiological functions. We recommended that further investigation in the form of an intervention study must be conducted to determine if combined physical exercise and cognitive training will be more effective compared to when physical and cognitive interventions are singly implemented in addressing the cognitive, physiological, and physical risks of falling in older adults with MCI.

Declaration

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Conflicts of Interest/Competing Interests: The authors declare no relevant financial and non-financial competing interests.

Availability of Data and Material: The data were kept confidential and stored in a password-protected computer. The ethical approval of this study did not include the public availability of the dataset.

Code Availability: Not applicable

Authors' Contributions: Both authors contributed to the conception and design of the study. DL carried out the acquisition of participants, collection and analysis of data, and the initial draft of the manuscript. Both authors made significant contributions to revising and finalizing the content of the manuscript. Both approved and agreed to be accountable for the submitted manuscript for publication.

Ethics Approval: The Ethics Review Committees of the Hong Kong Polytechnic University – Department of Rehabilitation Sciences and the University of Santo Tomas – College of Rehabilitation Sciences approved this study.

Consent to Participate: Only those who voluntarily gave written consent were included in this study.

Consent for Publication: The consent for publication was included in the Participant Information Sheet and Informed Consent Form voluntarily signed by the participants.

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