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Association of impaired cognitive function with balance confidence, static balance, dynamic balance, functional mobility, and risk of falls in older adults with depression

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Abstract

Objectives: Increased depression severity has been linked to cognitive impairment (CI). Importantly, CI is a known risk factor for impaired balance and falls. Therefore, this study aims to explore the relationship between CI and neuromuscular functions and secondarily it aims to find out if CI is a potential predictor for neuromuscular functions deficits in depressed elderly.

Methods: Eighty-four depressed elderly participated in the study. Assessment for CI symptoms were done using Mini Mental Status Examination (MMSE) in subjects having confirmed depression. Neuromuscular functions such as balance confidence, static and dynamic balance, functional mobility, and fall risk were subjectively assessed using Activities-specific Balance Confidence (ABC) Scale, Berg Balance Scale (BBS), Timed Up and Go (TUG) Test, and Performance Oriented Mobility Assessment (POMA), respectively.

Results: Pearson's analysis revealed that there was moderate positive linear-correlation between MMSE and BBS ($R = 0.382$, $p = <0.001$) and between MMSE and ABC ($R = 0.229$, $p = 0.036^*$). Further, regression analysis (R^2) revealed that MMSE significantly predicted the neuromuscular functions using BBS [$F(1, 82) = 14.013$, $p < 0.001$, with an R^2 of 0.146] and ABC [$F(1, 82) = 4.545$, $p = 0.036^*$, with an R^2 of 0.053].

Conclusion: Results of this study points to an impaired CI as a possible factor in development of neuromuscular function impairment in depressed elderly.

KEYWORDS
balance, cognitive impairment, depression, fall, functional mobility, older adults

1 | INTRODUCTION

The major burden comes from depression, which affects around one-third of the older population.[1] Depressive disorders have a significant social impact and a high likelihood of becoming chronic because of their higher prevalence, functional burden, and consequences. According to a recent survey, depression is thought to afflict more than 300 million individuals worldwide, and between 2005 and 2015, the number of instances rose by 18%.[2] Additionally, it was predicted that depression will rank as the second most common health issue in the globe by the year 2020.[3]

Cognition is a function that is altered in depression and has received increasing interest.[4] The prevalence of combined depression and cognitive impairment in older persons varies, but studies have indicated that it affects about 25% of them.[5] After the age of 70, the group with both depressive symptoms and impaired cognition doubles in size.[6] Neurocognitive dysfunction, such as deficiencies in episodic memory and executive function, has been associated to increased depression severity.[7] These deficiencies add to the burden of depression and are typical signs of depression.[8] More precisely, poor psychosocial functioning is closely correlated with abnormalities in neurocognitive performance[9] and had poor response to treatment.[10]

Impaired balance and decreased postural stability are two additional comorbidities and consequences that have been associated to greater depression severity.[11] According to a recent meta-analysis[12] that compiled the results of 17 prospective studies and found an odds ratio for the association of depression with falls of 1.63 (95% CI: 1.361–1.940), depressive symptoms have been frequently linked to poor mobility and falls in older adults.[13] They also share a significant two-way relationship.[14] Depressive symptoms have a significant impact on motor function, which frequently manifests as impaired postural control and increased sway regions,[14] high risk of falls,[15] slowness of psychomotor function, and slowness of executive function in older people with depressive symptoms.[16]

Importantly, cognitive impairment (CI) is a known risk factor for impaired balance[17] and falls.[17,18] Cognitive processing plays a vital role in balance functions[19] and gait[20] and relationship between them is well described.[21] Motor functions like walking and balancing become less automatic and more cognitively demanding as people age as their cognitive areas deteriorate.[22,23] Some studies also reported bidirectional relationship, that recurrent balance loss and falling may result in cognitive decline.[24] Further, people with postural instability/gait disturbance (PIGD) have greater impairment on measures of global cognition.[25]

Therefore, in this study we primarily aim to explore the relationship between mild cognitive impairment (MCI) and neuromuscular functions such as static balance, dynamic balance, functional mobility and fall risk in older adults with depression and secondarily we aim to find out if the cognitive impairment is a potential predictor for neuromuscular functions deficits. To the best of our knowledge, this is the first study to evaluate the association between post-depression MCI and neuromuscular functions such as static and dynamic balance, functional mobility, and fall risk using the mini mental status examination (MMSE), Berg balance scale (BBS), Timed Up and Go (TUG) Test, and $p = < 0.001$ Performance Oriented Mobility Assessment (POMA), respectively, in depressed older adults with MCI.

2 | MATERIALS AND METHODS

2.1 | Sample size

Number of subjects was determined with Software G. Power 3.1.9.2 using data from a study done by,[26] which investigate the association between cognitive function and motor functions using MMSE and BBS, respectively, in patients with mild to moderate Alzheimer's dementia.[26] A total of 84 subjects were shown to be necessary with the effect size of 0.3 (medium), alpha level of 0.05, & power (1 – beta) of 0.80.

2.2 | Procedures

This study was approved by the Institutional-Ethical-Committee (IEC) (Ethical approval number-24/5/324/JMI/IEC/2021), Jamia Millia Islamia (A Central University), and this clinical trial has been registered prospectively on Clinical Trial Registry India (CTRI) with the identification code-CTRI/2021/09/036539. The study was communicated to participants during the first contact, and a preliminary diagnostic interview and evaluation of admission requirements were undertaken, following which written informed consent was obtained from the participants. Research procedures in the present study were performed in conformity with the Declaration of Helsinki, 1964 and its updates. Eligible, consenting subjects then underwent a SCID-I/NP interview to estimate the DSM-IV diagnosis, followed by a comprehensive mental clinical interview and physical examination with the help of clinical neurologist. The observer-rated PHQ was administered to the depressed subjects to verify the degree of depressive symptom severity as it has 61% sensitivity and 94% specificity in older adults and takes less time to administer.[27] The good psychometric performance of the PHQ-9, along with its ease of use and relative brevity, makes it attractive compared with the longer GDS-15 and other tools for use in older adults.[28] Further, recent studies have found that PHQ-9 is more authentic for screening depression in psychiatric clinics.[29] The PHQ-9 is available in over 30 languages[30] and is therefore valid for use in different ethnicities and is accessed for free.[31] Following which, assessment for the MCI symptoms was done using MoCA in subjects having confirmed depression. Subsequently, neuromuscular functions such as balance confidence, dynamic balance and static balance, functional mobility, and fall risk were subjectively assessed using the ABC scale, BBS, TUG test, and POMA, respectively, by a physical therapist. Physiotherapists who performed the assessment received training on conducting the assessments as per standard operating procedure. All tests were administered in a standardized manner and order of tests was kept the same for all individuals.

2.3 | Participants

Unmedicated depressed older adults, including both males and females, were recruited from Jamia Nagar, Delhi-India. The subjects were included based on the following inclusion criteria: (i) age ≥ 60; (ii) DSM-IV criteria for unipolar major depression based on the structured clinical interview for DSM Disorders – non-patient version (SCID-I/NP)[32]; (iii) subjects were in depressive episode at time of their recruitment with PHQ scores ≥10[33]; (iv) subjects having

MCI with MMSE score between 18 and 24[34]; (v) medically healthy subjects or, if having any chronic medical conditions, these conditions need to be stable; (vi) subjects having general understanding of English language and ability to provide informed consent. The exclusion criteria were: (i) medical illness; (ii) febrile illness; (iii) medications that could affect cytokine concentrations; (iv) immunizations within 4 weeks; (v) any psychotropic medication use within previous 6 weeks; (vi) meeting DSM-IV criteria for psychotic, bipolar, or post-traumatic stress disorder; and (vii) subjects with a diagnosis of schizophrenia, depression brought on by a medical condition, dementia, amnestic disease, delirium, substance misuse or dependency within the past 12 months, an active suicidal plan, or a history of suicidal attempts within the past 12 months. The study participants were 84 depressed older adults with MCI. Demographic details of the participants are shown in Table 1.

2.4 | Outcome measures

2.4.1 | Mini Mental State Examination (MMSE)

Thirty items make up the MMSE for neurocognitive testing, which is focused on seven different cognitive domains. The total score ranges from 0 to 30, with a score of 18 or less indicating severe impairment, 18–24 indicating mild cognitive impairment, 25 deemed borderline, and 26 or above indicating cognitive normality.[34]

2.4.2 | Activities-specific Balance Confidence (ABC) scale

The ABC scale was developed by Powell and Myers[35,36] to assess confidence in activities involving balance. Sixteen different components make up this instrument, each of which represents a variety of indoor and outdoor activities requiring varied degrees of balance function. Each item is rated by respondents on a continuous range from 0% (no confidence) to 100% (full confidence), which results in a final score out of 100%. High internal consistency, test–retest reliability, and convergent validity with the physical activities' subscales have all been proven to be positive psychometric aspects of the ABC scale.[35]

TABLE 1 Mean and SD scores for cognitive function status (Mini Mental Status Examination) and neuromuscular functions status (Activities-specific Balance Confidence, Berg Balance Scale, Timed Up and Go test, and Performance Oriented Mobility Assessment).

Test	Mean	SD
MMSE	23.119	1.034
TUG test	18.833	1.421
POMA	20.619	1.139
BBS	44.000	1.951
ABC	62.531	3.560

Note: Data are presented as mean and SD; Significant difference is $p < 0.05$.

Abbreviations: ABC, Activities-specific Balance Confidence; BBS, Berg Balance Scale; MMSE, Mini Mental State Examination; POMA, Performance Oriented Mobility Assessment; SD, standard deviation; TUG test, Time Up and Go test.

2.4.3 | Berg Balance Scale (BBS)

As a clinical measure of functional balance (both dynamic and static balance), BBS was created specifically for older people.[37] The BBS consists of 14 tasks, each of which is given a score on a scale of 0 to 4, with 0 denoting the lowest degree of function and 4 the maximum level, for a total possible score of 56. Highest possible score −56; larger risk of falling 45; low fall risk (41–56); medium fall risk (21–40); and high fall risk (0–20) are the cutoff scores for quantification. It has been clearly established that scales have reliable and valid psychometric features.[38]

2.4.4 | Timed Up and Go (TUG) test

TUG test is frequently used to assess senior individual's functional mobility, balance, risk of falling, and physical fitness. It entails watching a person stand up from a chair, walk three meters in a straight line, then go back in the chair and sit down once more. Each person's performance is rated according to how long it takes them to complete the activity, and this route is timed in seconds. Using the cutoff score suggested by Podsiadlo & Richardson, total TUG test time was utilized to compare the groups.[39] According to these authors, a time of less than 10 s should be taken as normal for healthy, independent adults who are not at risk of falling, a time of 11–20 s for frail or disabled elderly people who have some level of independence and a low risk of falling, and a time of more than 20 s would indicate a significant problem with physical mobility and a significant risk of falling.[39]

2.4.5 | Performance Oriented Mobility Assessment (POMA)

The risk of falling is measured using the POMA scale.[40] POMA is a straightforward clinical balancing test that assesses risk factors for falls. This exam yields a total score out of 40, with a higher score indicating better performance, and measures balance with 14 items (scoring out of 24) and gait with 10 items (score out of 16). Health practitioners can easily give it at a clinic or at home. In terms of concurrent validity and inter-rater reliability, POMA performs well.[41]

2.5 | Statistical analysis

SPSS version 28.0. was used for statistical analysis. The normality distribution of all outcome measures was verified using the

Shapiro–Wilk test, skewness, and histogram. The outcome variables that show non-normal distribution were analyzed using a non-parametric test or log-transformed before proceeding into inferential analysis. The associations between MCI, ABC, BBS, TUG test, and POMA were calculated using Pearson correlation coefficient. *R* values of 0.10 or less are typically regarded as small effect, >0.10 to <0.50 a moderate effect, and >0.50 a substantial effect.[42] Stepwise method of multiple linear regression was used to identify whether MCI significantly predicts ABC, BBS, TUG test, and POMA scores.[26] Age, gender, and body mass index (BMI) were all entered to the regression analysis along with the cognitive decline level to examine their predictive role to neuromuscular functions (ABC, BBS, TUG test, and POMA).

3 | RESULTS

A sample of 84 depressed older adults was assessed for cognitive functions using MMSE and neuromuscular functions using ABC, BBS, TUG test, and POMA. All the demographic characteristics (mean age = 62.40 ± 2.27 (years), mean height = 163.92 ± 7.24 cm, mean weight = 73.44 ± 7.35 kg, and mean BMI = 27.54 ± 3.07 kg/m^2) were found to be comparable at the baseline, assessed by independent *t* test (Table 1).

A correlation analysis was also done in accordance with the previous study[42] for MMSE and TUG test ($R=0.145$, $p=0.189$; Figure 1; Table 2) and for MMSE and POMA ($R=-0.145$, $p=0.188$; Figure 2; Table 2), but no association was found in any of the analysis. Interestingly, a significant moderate positive linear correlation was found between the global cognition on MMSE and static and dynamic balance on BBS ($R=0.382$, $p=<0.001$; Figure 3; Table 2), and between MMSE and balance confidence on ABC ($R=0.229$, $p=0.036$*; Figure 4; Table 2), demonstrating that participants who score more on MMSE scale performed better on BBS and ABC, and those who score less on MMSE performed badly on both BBS and ABC.

Further, we carried out the regression analysis for MMSE and BBS in accordance with the previous study.[26] The dependent variable BBS was regressed on predicting variable MMSE to test whether MMSE has a significant impact on BBS. Multiple stepwise linear regression analysis (R^2) revealed that MMSE significantly predicted the neuromuscular functions using BBS [$F(1, 82)=14.013$, $p<0.001$, with an R^2 of 0.146; Table 3] accounting for 14.6% of the variance of BBS total score of sample. Similarly, we also carried out the regression analysis for MMSE and ABC. To see if MMSE significantly affects ABC, the dependent variable ABC was regressed on the predictive variable. Multiple stepwise linear regression analysis (R^2) revealed that MMSE significantly predicted the neuromuscular functions using ABC [$F(1, 82)=4.545$, $p=0.036$*, with an R^2 of 0.053; Table 3] accounting for 5.3% of the variance of ABC total score of sample.

4 | DISCUSSION

This study examined the association between cognitive functions using MMSE and measures of neuromuscular functions in depressed older adults. Moreover, we also assessed the predictive ability of cognitive functions measures for neuromuscular functions in the target sample. Main findings of this study revealed that cognitive functions score is not associated with TUG test and POMA measures of neuromuscular functions. These results are consistent with previous studies that revealed no significant association between MMSE and TUG test[26,43] and between MMSE and POMA. However, few contradictions to our studies are there, which demonstrated a correlation between MMSE and TUG test[44,45] and between MMSE and POMA.[46] These contradictions may be explained by use of different sample size and different study populations in present study and the previous studies such as 30 subjects who are elderly nursing home residents[44] and 33 subjects who are healthy elderly.[45]

Secondly, in the present study, cognitive functions using MMSE scoring demonstrated a significant correlation with BBS

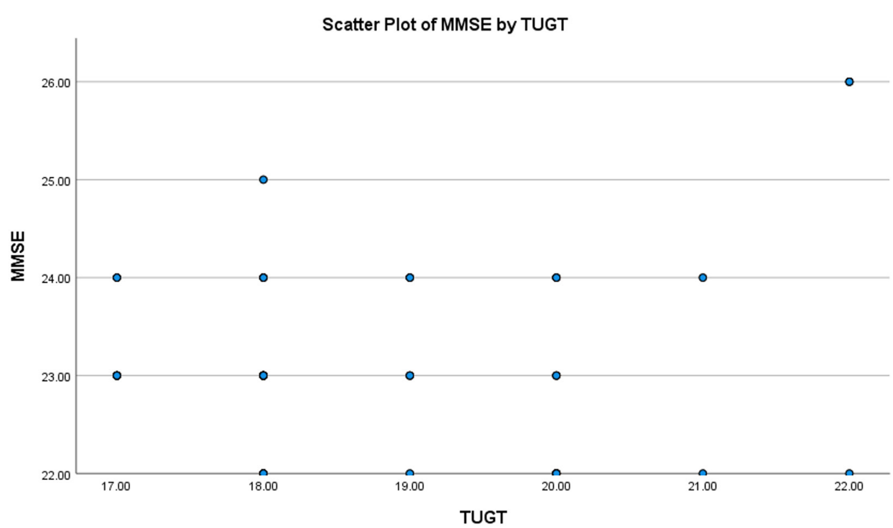


FIGURE 1 Pearson correlation coefficients showing no association between MMSE (Mini Mental Status Examination) and TUG test (Timed Up and Go test) ($R=0.145$, $p=0.189$).

that assess both the dynamic and static balance of neuromuscular functions. Our results are consistent with previous reports examining moderate samples.[26,44,45] These studies indicate that cognitive dysfunctions negatively impact the neuromuscular and motor functions particularly when assessed by BBS.[26,44,45] As discussed before, cognitive impairment is a known risk factor for impaired balance[17] and falling.[17,18] Importantly, cognitive processing along with a variety of other elements, such as emotional state, visual feedback, and cerebellar activity, are thought to have an impact on balance and postural stability. Any of these issues may negatively affect neuromuscular functions and increase the likelihood of injury and accidental falls.[47] However, it is unclear what brain processes contribute to postural control and falls. Existing research shows that in older persons with and without MCI, lower gray and white matter volume, white matter lesions, and impaired functional connectivity are all linked to a history of falls.[48,49] Brain areas involved in executive, motor, and visual functions (e.g., prefrontal cortex, pre- and post-central gyrus, occipital lobe) are predominantly affected.[48,50] Further, elderly fallers with and without MCI have been found to have a lower capacity to deactivate brain connectivity during a task (i.e., greater functional connectivity in the default mode network, which is typically activated at rest but deactivated during a task).[51,52] Though, according to intervention studies, treating cognitive issues in depressed patients improved their ability to cope with the disorder.[53,54]

Our study also demonstrated a significant correlation of MMSE measuring the cognitive function with that of ABC assessing the balance confidence. Our results are in line with previous study reporting the reduced balance confidence ($p < 0.05$) was associated with worse global cognition (poorer cognition).[55] Functional ambulation requires concurrent performance of motor and cognitive tasks involving the processing of multiple cognitive inputs and therefore problems in either or both may degrade the performance (functional ambulation) and thus increase the risk of falling.[55] Though, few other studies demonstrated no such correlation between cognitive function assessed by MMSE and neuromuscular functions assessed by BBS.[56,57] Again, these contradictions may be explained by different study populations and the use of different sample size in the other studies.

Lastly but importantly, our study also documented that impairment in cognitive function is a significant predictor of neuromuscular functions (BBS) in depressed older adults even after adjusting the confounding factors including BMI, gender, and age that can influence the neuromuscular functions status in humans. This provides the suggestion that as intensity of cognitive dysfunction increased, the participant's ability in performing functional balance tasks in their everyday life decreased. It can also be extrapolated that for participants in our study, decrease in cognitive function was found to affect the neuromuscular function especially with the fact that BBS has been shown to reliably predict the neuromuscular and motor function status.[26] Although not backed by sufficient literature, a very few preliminary studies[26,44,45] reported similar ability of subjective cognitive function measuring scales to predict the neuromuscular functions impairment. Similarly, we also documented

TABLE 2 Correlation analysis between mild cognitive impairment (Mini Mental Status Examination) and Neuromuscular functions (Activities-specific Balance Confidence, Berg Balance Scale, Timed Up and Go test, and Performance Oriented Balance scale) (*r* and *p* values are presented).

	Cognitive function status	
	MMSE	
Neuromuscular functions status	*R*	*p*
TUG test	0.145	0.189
POMA	−0.145	0.188
BBS	0.382	<0.001*
ABC	0.229	0.036*

Note: *$p < 0.05$.

Abbreviations: ABC, Activities-specific Balance Confidence; BBS, Berg Balance Scale; MMSE, Mini Mental State Examination; POMA, Performance Oriented Mobility Assessment; TUG test, Time Up and Go test.

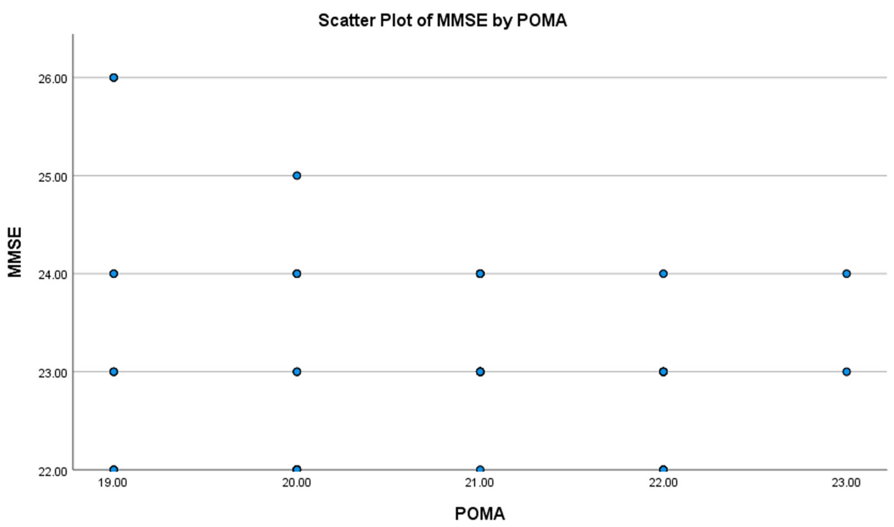
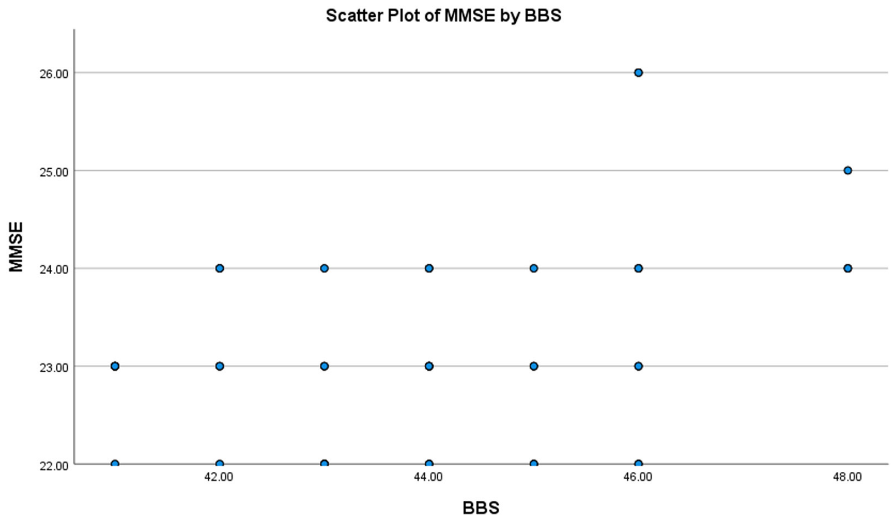


FIGURE 2 Pearson correlation coefficients showing no association between MMSE (Mini Mental Status Examination) and POMA (Performance Oriented Mobility Assessment) ($R = -0.145$, $p = 0.188$).

FIGURE 3 Analysis showing the correlation between the MMSE (Mini Mental Status Examination) and BBS (Berg Balance Scale) ($R = 0.382$, $p = <0.001$).



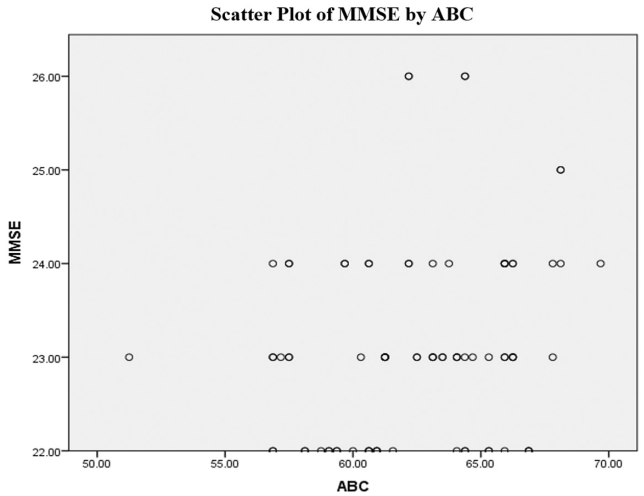


FIGURE 4 Analysis showing the correlation between MMSE (Mini Mental Status Examination) and ABC (Activities-specific Balance Confidence) ($R = 0.229$, $p = 0.036$).

TABLE 3 Regression analysis for (Mini Mental Status Examination and Berg Balance Scale) and for (Mini Mental Status Examination and Activities-specific Balance Confidence).

Regression weights	Beta coefficients	R^2	*F*	*p*-Values
MMSE→BBS	0.721	0.146	14.013	<0.001*
MMSE→ABC	0.791	0.053	4.545	0.036*

Note: R^2 and beta coefficients values are presented. *$p < 0.05$.
Abbreviations: ABC, Activities-specific Balance Confidence; BBS, Berg Balance Scale; MMSE, Mini Mental State Examination.

that impairment in cognitive function is a significant predictor of neuromuscular functions (ABC) in depressed older adults, which is in agreement with another study[58] that states that cognitive deficits are associated with an increased fall risk in community-dwelling older adults. The community-dwelling older adults who have mildly or severely impaired cognitive functions were more expected to be fallers or frequent fallers than those who are cognitively intact. Nevertheless, more relevant is the implication that we may make from our own and other researchers' findings, which is that subjective cognitive function impairment plays a big part in predicting changes in neuromuscular functions (BBS) governed by the occipital lobe.[50]

It is advisable to use caution when interpreting the findings of the current study due to a number of limitations. The primary drawback of the current study was the dependence of the cognitive function data on accurate participant responses on the MMSE. Incorporating objective data from neuropsychological battery tests, event-related potential ERPs, or other biomarkers like BDNF may give a more precise and reliable estimate of overall cognitive function, including both its quantity and quality. Another drawback of our study is that it may not be generalizable to other populations because we included older persons with depression in our sample. Further, despite the fact that our measurements are widely accepted measures of neuromuscular functions, people with cognitive impairment are probably more likely to be prone to self-report bias on subjective measurements. In the future, self-report bias may be reduced by using objective measurements and analysis. Furthermore, we did not record information regarding participant's use of any drugs that can worsen depression. Additionally, conditions including peripheral polyneuropathy, vitamin B12 and vitamin E deficiency, cervical and lumbosacral spinal stenosis, and visual and vestibular impairments should have been ruled out as potential causes of balance problems. As well, it is unknown how cognitive impairment and neuromuscular dysfunction are related to one another; therefore, the future studies may address the potential underlying mechanisms.

5 | CONCLUSION

In conclusion, this research offers preliminary evidence for the relationship between cognitive and neuromuscular function tests in older depressed persons. The results of this study point to a global

MMSE score between 18 and 24 as a possible factor in the development of neuromuscular function impairment in older persons with depression. However, the potential limitations of our study are smaller sample size and the reliance on accurate participant responses on the subjective measures such as PHQ-9 and MoCA, to determine the presence of depressive symptoms and the degree of cognitive impairment respectively. Further, it is critical to realize that cognitive deficits may make it more difficult to recover balance; therefore, it is crucial to have regular assessments of cognitive functioning performed by rehabilitation specialists. Intervention programs for older persons with depression may also benefit from including treatment for both symptoms of cognitive dysfunction and balance problems. Our study also demonstrates that when a patient's level of cognitive impairments is known, related health care professionals can predict the patient's risk of falling, which enables them to design an efficient and personalized treatment plan and prevent the development of cognitive functions–related decline in neuromuscular functions impairment.

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AUTHOR CONTRIBUTIONS

ZK conceived the study, executed the analysis and drafted the manuscript; NC helps in comprehensive mental clinical examination and screening of the subjects for this study. AS and AP assisted in interpreting the results and critically appraised the manuscript. All authors have read and approved the final manuscript, and agree with the order of the presentation of the authors.

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CONFLICT OF INTEREST STATEMENT

Authors disclose no conflict of interest.

ETHICS STATEMENT

The Institutional Ethical Committee (IEC), Jamia Millia Islamia (A Central University), gave its approval for this investigation (Ethical approval number-24/5/324/JMI/IEC/2021).

PATIENT CONSENT STATEMENT

Participants were informed about the study during the initial contact, and after a preliminary diagnostic interview and assessment of the admission requirements, their written informed permission was obtained.

CLINICAL TRIAL REGISTRATION

This clinical trial has been prospectively registered on Clinical Trial Registry India (CTRI) with the number CTRI/2021/09/036539.

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