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Impact of Cognitive Impairments on Functional Ambulation in Stroke Patients

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Abstract

Background: Regaining the ability to walk independently is the most important functional goal in rehabilitation of stroke patients. Cognitive impairments are increasingly recognized as affecting functional outcome in stroke. The purpose of this study was to determine the association between cognition and functional ambulation level in chronic stroke patients.

Methods:

Design: Cross-sectional, observational

Setting: Tertiary care centre, Mumbai, India

Participants: 60 ambulatory post-acute stroke patients

Main outcome measures:

• Cognition was assessed using Montreal Cognitive Assessment (MoCA) scale

• Functional ambulation level was determined using Modified Hoffer functional ambulation classification (FAC).

Results: The prevalence of cognitive impairments was 46%. According to FAC, 28.3% of the patients were community walkers. MoCA score discriminated between unlimited household and most limited community walkers ($p<0.03$) and also between least limited community and community walkers ($p<0.04$).

Conclusion: Community ambulation is significantly limited in chronic stroke patients. Cognitive impairments are prevalent and persistent even after the acute phase. Cognition is an important factor in the attainment of community ambulation in chronic stroke patients. Along with physical impairments, cognitive impairments need to be specifically addressed for successful rehabilitation outcome in stroke.

Keywords: Stroke; Cognitive impairments; Functional ambulation; MoCA

Introduction

Stroke is the second most common cause of acquired cognitive impairment [1-3] with the prevalence of post-stroke cognitive impairments ranging from 20% to 80% across different countries [4]. In India, the prevalence of cognitive impairment is reported as 20% in total stroke survivors [5]. With an aging population and a decline in mortality after stroke, the rates of post-stroke cognitive impairment will increase. Cognitive impairment is associated with decreased activities of daily living and instrumental activities of daily living function, and patients may require longer-term, ongoing rehabilitation [6]. Cognitive impairment predisposes patients toward institutionalization, disability, increased mortality, and poorer quality of life [1-3]. Despite being as common as other neurological deficits, such as motor and sensory, cognitive impairment is often overlooked in the follow-up of stroke survivors unless they have progressed to dementia [7]. Recently, there is a growing body of evidence showing an association between cognition and physical performance. Individuals with mild dementia have worse balance performance and decreased walking speed [8,9] whereas disturbances in gait are suggested as one of the earliest predictors of dementia [10-12].

Stroke is the third leading cause of adult disability [13]. The limited walking ability that follows the stroke restricts a patient's independent mobility about the home and community, a significant social handicap. Regaining the ability to walk independently is the most important functional goal in rehabilitation of stroke patients. Despite the efforts taken to achieve good mobility outcomes, most of the patients with stroke do not get out in the community. Community ambulation is the ability to integrate walking with other tasks in a complex environment [14]. In addition to walking function, patients must be able to adapt physically and cognitively to sudden disturbances in body movement when they encounter environmental barriers and unexpected events during community ambulation. Cognition and gait have often been studied separately after stroke whereas it has been suggested that these

two domains could interact through a cognitive-motor interference. Although walking speed is a relevant predictor of health outcomes, there is limited research on the interaction of impaired cognitive function in stroke with resultant effect on community ambulation. Also, due to context-specificity of environmental factors, results of previous studies cannot be generalized to Indian population. Therefore, this study aimed to determine the association between cognition and functional ambulation level in chronic stroke patients. The results of the study can shed light on new ways to approach and understand stroke rehabilitation.

Methodology

This was a cross-sectional study conducted on a convenience sample of stroke patients receiving outpatient rehabilitation in a tertiary care center. Individuals i) Between the age group 18-65 years, ii) Having unilateral hemiplegic involvement, iii) Ambulatory (with or without assistive devices), iv) Community-dwelling were recruited. Individuals were excluded from participation if they had i) Pre-stroke cognitive impairment and dementia ii) Neurological conditions apart from stroke, iii) Perceptual deficits, iv) Uncorrected visual impairment, v) Vestibular impairment, vi) Symptomatic musculoskeletal conditions which affect balance and mobility, vii) Unstable medical conditions. Institutional review board approved design and conduct of the study. The procedures followed protocol and accord with the ethical standards of the institutional review board. All the participants were volunteers and informed written and verbal consent was obtained from them. For every participant general demographic data, health-related comorbidity and stroke characteristics were collected.

Main outcome measures

Cognition: Montreal Cognitive Assessment (MoCA) was used for assessing cognitive functions. The MoCA assesses several cognitive domains and has been considered as a useful cognitive screening tool for several neurological diseases including vascular cognitive impairment. Neuropsychological functions assessed by this scale include short-term memory recall task; visuospatial abilities; multiple aspects of executive functions; attention, concentration, and working memory; language, and orientation to time and place. MoCA scores range between 0 and 30 [15]. Score of 26 or over is considered to be normal.

Functional ambulation: It was determined using Modified Hoffer functional ambulation classification (FAC) [16]. The patient's level of functional walking ability at home and in the community was assigned by the investigator to one of the six categories as per the criteria after his/her gait was examined and certain data were obtained by questioning the subject. The degree of walking independence, agility, and safety was assessed, as was information obtained directly from both patients and their relatives. Attention was given especially to the patient's ability to deal with different surroundings. Only the patient's usual walking level was considered, not the level he/she could potentially achieve.

These two tests were administered by two different assessors independently.

Results and Discussion

60 Stroke patients met the eligibility criteria and volunteered to participate in the study. Data thus collected was subjected to statistical analysis using computerized software. All the variables were examined by descriptive statistics. Table 1 shows the demographic and stroke characteristics of the participants.

Characteristic	Descriptive statistics
Age (in years)	58.4 ± 8.12 (mean ± SD)
Gender – Male : Female	02:03
Time post stroke (in months)	15.18 ± 19.33 (mean ± SD)
Side of hemiplegic involvement: Right/Left	02:03
Gait speed (m/min)	59.9 ± 16.1 (mean ± SD)
MoCA score	24.1 ± 6.7 (mean ± SD)

Table 1: Demographic and stroke characteristics.

Though this sample consisted of 78% patients with gait speed ≥ 48 m/min (cut-off value for community ambulation, Perry et al, 1995) [16], only 28.3% of the patients were community walkers (according to FAC). Similar figures on community mobility have been reported in previous studies on post-acute stroke survivors using performance-based and/or self-reported outcome measures [17-19].

Cognitive impairments

For neuropsychological testing, we chose an interval of three months following onset of stroke to allow sufficient time for the acute and/or transient effects of stroke to subside [20,21]. MCI and dementia were merged into a main outcome named cognitive impairment in the analyses of the data. In this sample of sub-acute stroke patients, the prevalence of cognitive impairments was 46% (as per the cut-off of ≤ 26 on MOCA). Our results are in line with previous studies which suggested that cognitive impairments may continue for a long time in approximately 1/3 of the patients [22-24]. The predominant cognitive deficits were observed in visuo-constructional abilities and memory (37.5% each) followed by attention (17.5%) and abstraction (15%). In a large cohort of stroke patients cognitive impairments occurred in 35.2% of patients with stroke and 3.8% of controls and cognitive domains most likely to be defective in stroke were memory, orientation, language, and attention [22].

Relationship between cognition and functional ambulation categories

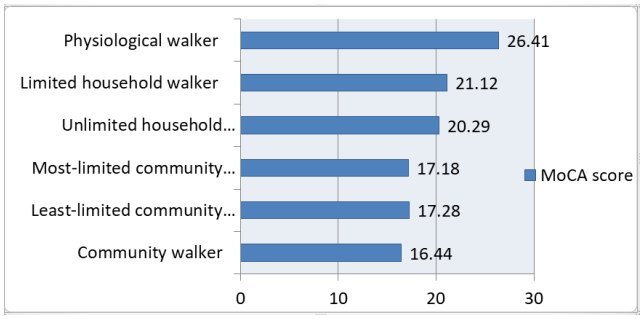
Patients were stratified according to the level of functional ambulation into six different categories as determined by the FAC. The score of cognition on MoCA scale served as the independent variable whereas the functional ambulation level served as the dependent variable in the association model. Variables distribution was tested using Kolmogorov-Smirnov test which exhibited normality, and therefore parametric test was used for all the analyses. The test applied was one way ANNOVA with post-hoc analysis. 2-tailed significance level of p value was set at 0.05

Table 2 and Graph 1 show the comparison of cognition among the different groups stratified by functional ambulation classification. It was observed that MoCA score discriminated between unlimited household and most limited community walkers ($p<0.03$) and also between least limited community and community walkers ($p<0.04$). It should be noted that in this sample MoCA score did not discriminate

between categories with lower levels of functions. This finding could be because of lack of responsiveness of FAC for these categories [23,24] and should be interpreted with caution. It can also be inferred that cognition is more closely associated with community than household ambulation [25,26].

Functional ambulation category	No. of subjects n (%)	MoCA score (mean ± SD)
Physiological walker	6 (10%)	16.44 ± 0.34
Limited household walker	10 (16.66%)	17.28 ± 0.23
Unlimited household walker	8 (13.33%)	17.18 ± 3.11
Most-limited community walker	9 (15%)	20.29 ± 4.12
Least-limited community walker	10 (16.66%)	21.12 ± 4.15
Community walker	17 (28.3%)	26.41 ± 3.07

Table 2: Comparison of cognition among the different groups stratified by functional ambulation classification.



Graph 1: Comparison of cognition among the different groups stratified by functional ambulation classification.

Currently our understanding of how to predict and prevent cognitive impairment and dementia following a stroke is limited. Thus, finding the strongest motor predictor of cognitive impairment is requested in order to develop potential interventions. Some studies using a prospective design have examined baseline gait speed, other motor signs and mobility as predictors of the future development of cognitive impairment in stroke survivors, however have found conflicting results [27-29]. Ursin et al. found that balance on figure of eight and Berg balance scale in the acute phase of stroke predicted cognitive impairment 1 year after stroke whereas the measures of maximum walking speed and Timed Up and Go test did not have predicting ability [30]. Recently, a multicentre study suggested that the motoric cognitive risk syndrome, a combined assessment of walking speed and memory, identify those at risk of developing cognitive impairment [31].

On the other hand, several prospective studies pointed out that initial cognitive status is a predicting factor of rehabilitation success, especially for motor skills and functional independence, in post-stroke patients [32-34]. Tatemichi et al. 1994 found that in stroke patients functional impairment was greater with cognitive impairment; and dependent living after discharge either at home or nursing home was more likely (55.0% with, vs. 32.7% without cognitive impairment) [22]. They concluded that the presence of cognitive impairment in patients with stroke has important functional consequences, independent of the effects of physical impairment. Yet another study assessed outcomes up to 4 years after stroke and found that cognitive impairment is associated with poor long-term outcomes, including death and disability, and higher institutionalization [23].

Because physical and cognitive impairments after stroke have independent prognostic implications, measures that evaluate both functions should be used in future studies of stroke outcome and in care of stroke patients.

Cognition and gait have often been studied separately after stroke whereas it has been suggested that these two domains could interact through cognitive-motor interference. While still poorly understood, the close interaction between cognition and gait could be related to a cortical competition amidst cognitive and motor processes [35]. This phenomenon could be exacerbated by various brain changes in stroke patients, the main one being the extent of white matter lesions and, as was recently described the amyloid brain burden [36-38]. Cognitive motor interference following a stroke could be because of a reduced capacity to perform cognitive and motor tasks simultaneously, reduced cognitive function, or decreased walking ability secondary to post-stroke deficits. The strong interaction between these two domains has been well described in neurodegenerative disorders [35]; and only recently has been evaluated in post-stroke studies. Also, this relationship in stroke has been mentioned however, from the dual-task paradigm wherein the attentional demands of gait are tested. However, relatively few studies have evaluated this relationship in the context of community ambulation. The cognitive efforts required to detect environmental changes and to compensate postural perturbations when walking suggests that these two domains could interact even more during walking in the community.

Community ambulation requires walking in a complex environment while focusing on multiple attention-demanding tasks, including walking faster when crossing the street, negotiating obstacles, and holding conversations in a busy environment. Thus, it is considered as much more demanding cognitively than walking in a controlled environment. Cognitive-motor interference, owing to a concurrent cognitive or motor task, is postulated to affect walking speed and the quality of walking, leading to poor participation in the community. Paker et al. concluded that cognitive dysfunction interfered with community ambulation after 6 months in patients with stroke [39]. More than 2/3 of the cognitively normal stroke patients were doing community ambulation; however, this rate was only 1/5 for the cognitively impaired persons.

Some authors have suggested that domain-specific neuropsychological evaluation tests should be considered in the acute phase of stroke to predict the recovery of functional mobility. Park et al. reported that verbal fluency test and construction praxis test about two weeks after stroke were predictors for community ambulation at six months after stroke [40]. In another study, baseline orientation seemed to be the most important variable, more than the total MMSE [41]. Self-awareness and perception of environment had an effect on ambulation, which required complicated corroborating activities including balance, transfers, and reciprocal movements. It has been suggested that executive functions as opposed to global cognition or memory, are important for gait and balance. Executive function is regarded as higher-level cognitive function, implying a control function of other cognitive functions. Performance of balance and mobility tasks involves executive functioning often linked to vascular disease and partly regulated by the prefrontal areas of the frontal lobe

[42]. Executive function is associated with balance in older adults after mild stroke [43] and with falls among older people [44], which might correspond well with our results. In a study on post-stroke patients, fallers showed lower cognitive function as assessed using MMSE than the non-fallers [45]. Sustained and divided attention scores correlated with balance, ADL ability and fall-status highlighting that attention deficit might contribute to accident prone behaviour and falling [46]. To achieve effective goal-directed behaviour, it is not only important to be able to initiate and plan actions, but also to be flexible, to be able to shift plan and to inhibit irrelevant information or responses during action. Possibly, the individual's cognitive flexibility also described as a set-shifting ability is challenged when performing functional ambulation [42].

We therefore conclude that cognitive impairment is not only frequent with stroke, but also significantly affects functional adaptation after the acute phase. Community ambulation is a more meaningful outcome of stroke but has not been studied extensively in the context of cognitive impairments. Results of this study emphasize the broader aspects of stroke impairments including the neuropsychological deficits and can shed light on new ways to approach and understand functional consequences in stroke rehabilitation.

The WHO-ICF (2001) is an amalgam of the medical and social models and brings into focus the interaction of the body's structure and function, activities, and participation in life situations [47]. With the advent of WHO-ICF model, health professionals are encouraged to evaluate and consider the impact of stroke more comprehensively. In order to adequately address decreased post-stroke activity and participation, it is important to understand the factors that contribute to this reduction. The influence of cognitive impairments on stroke survivors' ability to negotiate obstacles and move over different terrains (functional ambulation performance) has not received much attention in literature. An important highlight of the present study is that it attempted to associate cognitive impairments with the activity limitation (walking) and participation restriction (functional ambulation) in stroke patients (Figure 1).

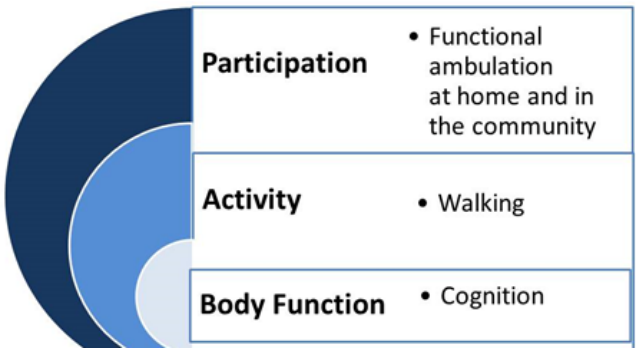


Figure 1: ICF Model.

Nevertheless we acknowledge some limitations. It is important to note that cognitive outcome following a stroke is dependent on socio-demographic, health, and stroke-related risk factors, the timing of cognitive assessment, inter hemispheric differences, etc. Also, other confounding factors for functional ambulation viz. physical impairments, fatigue and walking endurance, etc. were not considered in the study. To address these possible limitations in the current study, we recommend future studies with multivariate logistic regression model.

The inherent diversity of abilities involved in cognitive function is naturally difficult to grasp in single assessments and entails a lack of gold standard measure. It has been found that stroke survivors with cognitive deficits may decline, initially decline and then improve, remain stable, or progress to dementia over time [48,49]. Considering the changing longitudinal pattern of cognition function in stroke survivors, this relationship between cognition and functional ambulation could be more dynamic and thus, should be explored further with a longitudinal study design [50].

Conclusion

Community ambulation is significantly limited in chronic stroke patients. Cognitive impairments are prevalent and persistent even after the acute phase. Though gait speed remains central to community ambulation, cognition is an important factor in the attainment of community ambulation in chronic stroke patients. Studies of stroke outcome and intervention should take into account both cognitive and physical impairments.

Clinical Implications

Community ambulation is a multidimensional task. This study highlights the important role of cognition in functional ambulation in chronic stroke patients. Along with physical impairments, cognitive impairments need to be specifically addressed for successful rehabilitation outcome in stroke. Results of this study relate the social disadvantage in stroke patients to the impairments in body function as per the ICF model of WHO.

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Conflict of Interest

The author declares that there is no conflict of interest.

References

1. O'Brien JT, Erkinjuntti T, Reisberg B, Roman G, Sawada T, et al. (2003) Vascular cognitive impairment. Lancet Neurol 2: 89-98.
2. Ankolekar S, Renton C, Sare G, Ellender S, Sprigg N, et al. (2014) Relationship between poststroke cognition, baseline factors, and functional outcome: data from "efficacy of nitric oxide in stroke" trial. J Stroke Cerebrovasc Dis 23: 1821-1829.
3. Leys D, Hénon H, Mackowiak - Cordoliani MA, Pasquier F (2005) Poststroke dementia. Lancet Neurol 4: 752-759.
4. Jia-Hao Sun, Lan Tan, Jin-Tai Yu. (2014) Post-stroke cognitive impairment: epidemiology, mechanisms and management. Ann Transl Med 2: 80.
5. Das S, Paul N, Hazra A, Ghosal M, Ray BK, et al. (2013) Cognitive Dysfunction in Stroke Survivors: A Community-Based Prospective Study from Kolkata, India. J Stroke Cerebrovasc Dis 22: 1233-1242.
6. Robert Teasell, Katherine Salter, Pavlina Faltynek, Andreea Cotoi, Gail Eskes. Post-Stroke Cognitive Disorders.

7. Jacova C, Pearce LA, Costello R, McClure LA, Holliday SL, et al. (2012) Cognitive impairment in lacunar strokes: the SPS3 trial. Ann Neurol 72: 351-362.
8. Scherder E, Eggermont L, Swaab D, van Heuvelen M, Kamsma Y, et al. (2007) Gait in ageing and associated dementias; its relationship with cognition. Neurosci Biobehav Rev 31: 485-497.
9. Pettersson AF, Engardt M, Wahlund LO (2002) Activity level and balance in subjects with mild Alzheimer's disease. Dement Geriatr Cogn Disord 13: 213-216.
10. Ramakers IH, Visser PJ, Aalten P, Boesten JH, Metsemakers JF, et al. (2007) Symptoms of preclinical dementia in general practice up to five years before dementia diagnosis. Dement Geriatr Cogn Disord 24: 300-306.
11. Verghese J, Wang C, Lipton RB, Holtzer R, Xue X (2007) Quantitative gait dysfunction and risk of cognitive decline and dementia. J Neurol Neurosurg Psychiatry 78: 929-935.
12. Verghese J, Lipton RB, Hall CB, Kuslansky G, Katz MJ, et al. (2002) Abnormality of gait as a predictor of non-Alzheimer's dementia. N Engl J Med 347: 1761-1768.
13. World Health Organization (2012) Global Health Estimates. Geneva.
14. Lord SE, Rochester L (2005) Measurement of community ambulation after stroke: Current status and future developments. Stroke 36: 1457-1461.
15. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, et al. (2005) The Montreal Cognitive Assessment, MoCA: A Brief Screening Tool For Mild Cognitive Impairment. J Am Geriatr Soc 53: 695-699.
16. Perry J, Garrett M, Gronley JK, Mulroy SJ (1995) Classification of walking handicap in the stroke population. Stroke 26: 982-989.
17. Lord SE, McPherson K, McNaughton HK, Rochester L, Weatherall M (2004) Community ambulation after stroke: how important and obtainable is it and what measures appear predictive? Arch Phys Med Rehabil 85: 234-239.
18. Wesselhoff S, Hanke TA, Evans CC (2018) Community mobility after stroke: A systematic review. Top Stroke Rehabil 25: 224-238.
19. Hill K, Ellis P, Bernhardt J, Maggs P, Hull S (1997) Balance and mobility outcomes for stroke patients: A comprehensive audit. Austral J Physiotherapy 43: 173-180.
20. Skilbeck CE, Wade DT, Hewer RL, Wood VA (1983) Recovery after stroke. J Neurol Neurosurg Psychiatry 46: 5-8.
21. Wade DT, Wood VA, Hewer RL (1985) Recovery after strokethe first three months. JTNeurol Neurosurg Psychiatry 48: 7-13.
22. TK Tatemichi, DW Desmond, Y Stern, M Paik, M Sano, et al. (1994) Cognitive impairment after stroke: frequency, patterns, and relationship to functional abilities. J Neurol Neurosurg Psychiatry 57: 202-207.
23. M Patel, C Coshall, AG Rudd, CD Wolfe (2003) Natural history of cognitive impairment after stroke and factors associated with its recovery. Clin Rehabil 17: 158-166.
24. Lawrence ES, Coshall C, Dundas R, Stewart J, Rudd AG, et al. (2001) Estimates of the prevalence of acute stroke impairments and disability in a multiethnic population. Stroke 32: 1279-1284.
25. Collen FM, Wade DT, Bradshaw CM (1990) Mobility after stroke: reliability of measures of impairment and disability. Int Disabil Stud 12: 6-9.
26. Lord SE, McPherson K, McNaughton HK, Rochester L, Weatherall M (2004) Community ambulation after stroke: how important and obtainable is it and what measures appear predictive? Arch Phys Med Rehabil 85: 234-239.
27. Buracchio T, Dodge HH, Howieson D, Wasserman D, Kaye J (2010) The trajectory of gait speed preceding mild cognitive impairment. Arch Neurol 67: 980-986.
28. Verghese J, Wang C, Lipton RB, Holtzer R (2013) Motoric cognitive risk syndrome and the risk of dementia. J Gerontol A Biol Sci Med Sci 68: 412-418.
29. Marquis S, Moore MM, Howieson DB, Sexton G, Payami H, et al. (2002) Independent predictors of cognitive decline in healthy elderly persons. Arch Neurol 59: 601-606.
30. Helene Ursin M, Bergland A, Fure B, Tørstad A, Tveit A, et al. (2015) Balance and mobility as predictors of post-stroke cognitive impairment. Dement Geriatr Cogn Dis Extra 5: 203-211.
31. Verghese J, Annweiler C, Ayers E, Barzilai N, Beauchet O, et al. Motoric cognitive risk syndrome: multicountry prevalence and dementia risk. Neurology 83: 718-726.
32. Sisson RA (1995) Cognitive status as a pre-dictor of right hemisphere stroke out-comes. J Neurosci Nurs 27: 152-164.
33. Mysiw WJ, Beegan JG, Gatens PF (1989) Pro-spective cognitive assessment of stroke patients before inpatient rehabilitation: The relationship of the Neurobehavioral Cognitive Status Examination to functional improvement. Am J Phys Med Re-habil 68: 168-715.
34. Kong KH, Chua KS, Tow AP (1998) Clinical characteristics and functional outcome of stroke patients 75 years old and older. Arch Phys Med Rehabil 79: 1535-1539.
35. Odasso MM, Verghese J, Beauchet O, Jeffrey M. Hausdorff (2012) Gait and Cognition: A Complementary Approach to Understanding Brain Function and the Risk of Falling. J Am Geriatr Soc 60: 2127-2136.
36. Ly M, Motzkin JC, Philippi CL, Kirk GR, Newman JP, et al. (2012) Cortical thinning in psychopathy. Am J Psychiatry 169: 743-749.
37. Del Campo N, Payoux P, Djilali A, Delrieu J, Hoogendijk EO, et al. (2016) Relationship of regional brain β-amyloid to gait speed. Neurology 5: 86: 36-43.
38. Kim TW, Choi HH, Chung YR J (2016) Treadmill exercise alleviates impairment of cognitive function by enhancing hippocampal neuroplasticity in the high-fat diet-induced obese mice. Exerc Rehabil 12: 156-162.
39. Paker N, Buğdaycı D, Tekdöş D, Kaya B, Dere C (2010) Impact of Cognitive Impairment on Functional Outcome in Stroke. Stroke Res Treat pii: 652612.
40. Park J, Lee SU, Jung SH (2017) Prediction of post-stroke functional mobility from the initial assessment of cognitive function. NeuroRehabilitation 41: 169-177.
41. Ozdemir F, Birtane M, Tabatabaei R, Ekuklu G, Kokino S (2001) Cognitive evaluation and functional outcome after stroke. Am J Phys Med Rehabil 80: 410-415.
42. Royall DR, Lauterbach EC, Cummings JL, Reeve A, Rummans TA, et al. (2002) 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. J Neuropsychiatry Clin Neurosci 14: 377-405.
43. Liu-Ambrose T, Pang MY, Eng JJ (2007) Executive function is independently associated with performances of balance and mobility in community-dwelling older adults after mild stroke: implications for falls prevention. Cerebrovasc Dis 23: 203-210.
44. Holtzer R, Friedman R, Lipton RB, Katz M, Xue X, et al. (2007) The relationship between specific cognitive functions and falls in aging. Neuropsychology 21: 540-548.
45. Cho K, Lee G (2013) Impaired dynamic balance is associated with falling in post-stroke patients. Tohoku J Exp Med 230: 233-239.
46. Hyndman D, Pickering RM, Ashburn A (2009) Reduced sway during dual task balance performance among people with stroke at 6 and 12 months after discharge from hospital. Neurorehabil Neural Repair 23: 847-854.
47. World Health Organization (2001) International Classification of Functioning, Disability and Health.
48. Rasquin SM, Lodder J, Verhey FR (2005) Predictors of reversible mild cognitive impairment after stroke: a 2-year follow-up study. J Neurol Sci 229-230:21-25.
49. Ballard C, Rowan E, Stephens S, Kalaria R, Kenny RA (2003) Prospective follow-up study between 3 and 15 months after stroke: improvements and

decline in cognitive function among dementia-free stroke survivors>75 years of age. Stroke 34: 2440-2444.

50. Van de Port IG, Kwakkel G, Lindeman E (2008) Community ambulation in patients with chronic stroke: how is it related to gait speed? 40: 23-27.