Motor Speed Matters! Cognitive Profile of Parkinson’s Disease Patients With and Without Deficits in Motor Speed

Vidy Menon¹, Shantala Hegde², Pratyusha P V¹,³, Nitish Kamble¹,³, Ravi Yadav¹, Amitabh Bhattacharya¹, Pramod K Pal¹

Abstract:
Background: Parkinson’s disease (PD) is characterized by bradykinesia, tremor, rigidity, postural instability and cognitive deficits in attention, executive functions, learning and memory. Motor speed, measured using Finger Tapping Test (FTT), is an important indicator and predictor of cognitive and motor functions. Deficits in motor speed have significant impact on performance on other neuropsychological tests.

Objective: This study aimed to understand and compare the cognitive profile of patients with and without deficits in motor speed as evaluated on the FTT.

Method and Material: A detailed neuropsychological evaluation using the NIMHANS Neuropsychological Battery was carried out on 70 PD patients. The PD patients were divided into patients with (n = 46) and without (n = 24) motor speed deficits. The two groups were comparable with regard to age (P = 0.591), years of formal education (up to 10ᵗʰ – 24.3, above 10ᵗʰ – 75.7) duration of illness (P = 0.703) and age of onset (P = 0.721).

Results: Across the various cognitive domains such as executive functions, verbal recognition, visuospatial functions, visual learning and memory, the group without deficits in motor speed performed significantly better in comparison to patients with motor symptoms.

Conclusion: A short and simple test such as FTT may be helpful in predicting the range and severity of cognitive deficits across other cognitive domains in patients with PD. Future studies on larger cohort examining the intricate role and association of FTT and other motor functions such as dexterity may be helpful in understanding the nature and severity of other cognitive functions in this clinical population.

Key Words: Cognitive deficits, finger tapping test, motor speed, neurocognitive profile, Parkinson’s disease

Key Message:
Neuropsychological assessment in Parkinson’s disease should be carried out with great caution owing pharmacological treatment (on-state and off-state) and tremors. A simple and less time-consuming test such as Finger Tapping test measuring motor speed could be a quick method to gauge the extent of cognitive deficits in patients with Parkinson’s disease.

Motor speed is a function that involves motor and cognitive domains of brain.[1] Finger Tapping Test (FTT), is a universally used neuropsychological tool, commonly employed to quantitatively assess motor performance in upper extremities. Studies have indicated that motor speed deficits can be considered as a marker for evaluating motor and cognitive functioning and that both are related.[2] Present study compares the cognitive profile of PD patients with (WD) and without deficits (WOD) in motor speed as evaluated on FTT and thereby understand the predictive value of motor speed in cognitive functioning.

Methods
The present study included 70 PD patients. Patients were recruited from the inpatient, outpatient and Movement disorders clinic of the department of Neurology, National Institute of Mental Health and Neurosciences (NIMHANS),...
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Results

The present study included 70 PD patients. The clinical details are provided in Table 2. The sample was divided into two categories: with motor speed deficits (WD) and without motor speed deficits (WOD) based on their performance scores in FTT (n = 46 WD and n = 24 WOD). Results indicated that in most of the cognitive domains such as attention, executive functions (fluency, planning and problem solving, set shifting), visuospatial functions, visual learning and memory there was a significant difference among the two groups. The results are provided in Table 3.

Further, based on the bivariate analysis results, an attempt was also made to find the predictors of cognitive domains, and the domains that correlated with both right and left finger tapping scores were considered for the regression analysis. Multiple linear regressions were performed to identify whether finger tapping (right and left) score will predict the cognitive domains and results indicate that finger tapping scores can predict attention and executive functions, however as the R² is less, results should be interpreted with caution. Table 3 delineates the results of predictive analysis. Please refer to Table 4.

Discussion and Conclusion

In the current study, on comparing the cognitive profile of WD and WOD patients, results indicated that in most of the cognitive domains such as verbal and category fluency, planning and problem solving, set shifting, verbal recognition, visuospatial functions, visual learning and memory there was a significant difference among the two groups. PD is a neurological disorder associated with dopamine depletion in the basal ganglia and this dopamine loss results in frontal disconnections and this is directly related to the manifestation of motor and cognitive symptoms in PD.[10] A study included comprehensive neuropsychological assessment such as tests of executive functions, memory, psychomotor speed, attention, visuospatial, and language functions to compare 94 PD patients with 84 healthy controls, and it concluded that PD patients performed significantly worse on executive functions (i.e., category of card sorting) and psychomotor speed.

Table 1: Neuropsychological tests, their respective domains and functions

| Domain             | Cognitive functions            | Test                                      |
|--------------------|--------------------------------|------------------------------------------|
| Speed              | Motor speed                    | Finger Tapping Test (FTT)                |
|                    | Mental speed                   | Digit Symbol Substitution Test (DSS)      |
|                    |                                | Digit Span Test (DS)                     |
| Attention          | Focused Attention              | Color Trail (CT)                         |
|                    | Sustained Attention            | Digit Vigilance Test (DVT)               |
| Executive Functions| Verbal Fluency                 | Controlled Oral Word Association Test (COWA) |
|                    | Category Fluency               | Animal Names Test (ANT)                  |
|                    | Planning                       | Tower of London (TOL)                    |
|                    | Concept formation and Set Shifting | Wisconsin Card Sorting Test (WCST)         |
|                    | Response Inhibition            | Stroop Test (ST)                         |
|                    | Working memory                 | Verbal N back Test                        |
| Learning and Memory| Verbal                         | Digit Span Test (DS)                     |
|                    | Visual                         | Spatial Span Test (SS)                    |
| Visuo spatial Construction | Copy trial of the test | Auditory Verbal Learning Test (AVLT)    |
|                    |                                | Complex Figure Test (CFT)                |

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(i.e., processing speed index). A study that was undertaken on PD patients from India, reported deficits in executive functions on screening tool such as the Frontal Assessment Battery (FAB) developed by Alexander Luria. This study included 170 patients with PD and observed that levels of formal education correlated significantly with the observations on the FAB. A study on relationship between motor impairment and cognitive impairments in PD had also revealed that the severity of motor impairment positively correlated to impairment on cognitive domains such as memory, language, visuospatial, and frontal lobe functions.

Deficits in motor speed is found to have major impact on the performance on other neuropsychological tests and clinicians often keep this in mind before interpreting the performance of patients on other neuropsychological tests. A study on 170 elderly patients (83 men, 87 women; M age = 82.1 yr., SD = 6.2) underwent cognitive assessment and 15 seconds of finger tapping and results indicated a significant increase in the length and variability of the finger-touc1h phase among participants with mild cognitive impairment or dementia compared to participants who did not have cognitive impairment, thus suggesting a relationship between finger tapping and attention, short-term memory and cognitive functions. In Alzheimer’s disease (AD) and mild cognitive impairment (MCI) patients it was found that, decreased finger dexterity was associated with decline in cognitive function and thus it can be a marker for cognitive functions. Motor speed has also been shown to predict the specific and general deficits of verbal fluency, set shifting, reasoning, executive functions, and attention of both bipolar-I and patients with schizophrenia because of a common pathogenic factor related to psychomotor slowness. Thus, motor speed appears to be an appropriate endophenocognitve for schizophrenia and bipolar disorder.

FTT has been used to measure outcome in stroke patients, who did not present any clinical motor deficits of the preferred hand. Stroke-related action slowing is mainly due to slowing of perceptual and motor processes. Action slowing was related to lesions of the large network. In FTT the lesion location was in the left middle frontal gyrus and lenticulate nucleus. Further, FTT performance predicted outcome, over and above what other motor and perceptual tasks contributed, suggesting the action slowing, and thus FTT was considered as a promising prognosis index.

A study found that patients with MCI, AD, and PD all have abnormalities in finger tapping as compared to healthy adult controls. During a repeated ten-second response window, patients with AD and MCI produced the fewest number of finger taps, while patients with PD produced even more than cognitively healthy older adults. In addition, AD and MCI individuals had the longest inter-tap interval, while the PD patients had the shortest, and this was similar to cognitively healthy older adults.

In the current study, domains such as mental speed, focused attention and amount of time taken in planning task, the group WOD in motor speed has performed significantly better than WD (Figure 2). WOD in motor speed has performed significantly better than WD (Figure 2).

Table 2: Demographic profile and clinical characteristics of the patients

| Cognitive Domain | Mean (SD) | t/U | P |
|------------------|-----------|----|---|
| WOD (n=24)       | WD (n=46) |    |   |
| Age (years)      | 56.33 (9.07) | 57.63 (9.77) | -0.54 | 0.591 |
| Age at onset (years) | 50 (10.73) | 51 (10.75) | -0.359 | 0.721 |
| Median (Q1, Q3)  |           |    |   |
| Duration (years) | 7 (1.88, 10) | 5 (3.10) | 477 | 0.703 |

Table 3: Comparison of Cognitive domains among WOD and WD groups

| Cognitive Domains | Mean (SD) | t/U | P |
|-------------------|-----------|----|---|
| WOD (n=24)        | WD (n=46) |    |   |
| LT score          | 43.01 (6.98) | 29.9 (6.8) | 7.736 | <0.001 |
| CT2               | 192.54 (63.81) | 257.8 (103.62) | -3.251 | 0.002 |
| COWA              | 8.92 (3.56) | 6.65 (3) | 2.814 | 0.006 |
| ANT               | 12.67 (3.28) | 9.87 (2.86) | 3.695 | <0.001 |
| CFT DR            | 16.5 (6.3) | 12.96 (7.23) | 2.026 | 0.047 |
| TNMM              | 8.92 (1.93) | 7.7 (1.94) | 2.501 | 0.015 |

WOD: Without motor deficits, WD: With motor deficits, LT: Left Finger tapping, CT2: Color trail2, COWA: Controlled Oral Word Association Test, ANT: Animal Names Test, TNMM: Total number of minimum moves, DSS: Digit Symbol Substitution, MT: Mean time, NMM: Number of minimum moves, PR: Perseverative response, PE: Perseverative error, %CLR: Conceptual level response, CFT IR: Complex Figure Test Immediate recall
Motor speed is found to be an important determinant for cognitive functions and deficits in motor and cognitive domains have been found to be closely interrelated. Thus, a short and simple test such as FTT may be helpful in predicting the range and severity of cognitive deficits across other cognitive domains in patients with PD. Future studies on larger cohort examining the intricate role and association of finger tapping speed and other motor functions such as reaction time, dexterity may be helpful in understanding the nature and severity of cognitive functions in this clinical population.

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**Conflicts of interest**

There are no conflicts of interest.

**Disclosure**

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### Table 4: Predictive analysis of finger tapping (Right and Left) scores

| Dependent Variable (DV) | Predictor | β (SE) | t | P | R² |
|-------------------------|-----------|--------|---|---|----|
| CT2                     | R         | -5.068 (1.69) | -3.002 | 0.004 | 0.131 |
|                         | Lt        | 1.828 (1.79)  | 1.024  | 0.309 |
|                         | Constant  | 355.36 (44.66) | 7.957  | <0.001 |
| COWA                    | Rt        | 0.124 (0.06)  | 2.054  | 0.044 | 0.079 |
|                         | Lt        | -0.017 (0.06) | -0.261 | 0.795 |
|                         | Constant  | 3.531 (1.597) | 2.211  | 0.030 |
| ANT                     | Rt        | 0.065 (0.055) | 1.815  | 0.240 | 0.189 |
|                         | Lt        | 0.106 (0.058) | 1.823  | 0.073 |
|                         | Constant  | 4.810 (1.460) | 3.294  | 0.002 |
| Total                   | Rt        | 0.065 (0.25)  | 0.263  | 0.793 | -0.002 |
|                         | Lt        | 0.170 (0.260) | 0.685  | 0.496 |
|                         | Constant  | 38.324 (6.499) | 5.897  | <0.001 |
| DS                      | Rt        | 0.120 (0.06)  | 1.867  | 0.064 | 0.090 |
|                         | Lt        | 0.004 (0.07)  | 0.058  | 0.954 |
|                         | Constant  | 8.306 (1.71)  | 4.856  | <0.001 |
| DSS                     | Rt        | -6.846 (3.61) | -1.895 | 0.063 | 0.072 |
|                         | Lt        | 0.576 (3.89)  | 0.148  | 0.883 |
|                         | Constant  | 623.987 (99.18) | 6.292 | <0.001 |

CT2: Color trail2. COWA: Controlled Oral Word Association Test. ANT: Animal Names Test. DS: Digit span test. DSS: Digit Symbol Substitution Test.

The predictive analysis result in this study has indicated that the right finger tapping score predicted CT2 and COWA scores, and a slight inclination towards prediction was also observed in right finger tapping score obtained in DS and DSS, and in left finger tapping score in ANT. Thus, the finger tapping score was found to predict attention and executive functions. Motor speed has been shown to predict the specific and general deficits of verbal fluency, set shifting, reasoning, executive functions, and attention of patients with bipolar-I and schizophrenia and has been recognized as an important indicator and predictor of cognitive and physical symptoms in PD. Balancing skill and functional mobility in patients with PD were also found to be significantly correlated with executive functions, cognitive impairment and patient’s ability to switch attention between two tasks. However, in contrast to most of these studies, a study on predictors of cognitive impairment in advanced PD, found that older age and tremor at the onset were significant predictors of poor cognitive performance. Tremor was explained as a marker for more widespread brain pathology that contributes to an increased risk of cognitive impairment, than predominant akinesia/rigidity.
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