ISSN: 0976-3031

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 9, Issue, 4(H), pp. 26090-26094, April, 2018

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

EFFECT OF MOTOR-COGNITIVE DUAL TASK TRAINING ON DEXTERITY AND FUNCTION IN PEOPLE WITH PARKINSON'S DISEASE (PWP) USING 9 HOLE PEG TEST (9HPT)

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DOI: http://dx.doi.org/10.24327/ijrsr.2018.0904.1989

ARTICLE INFO

Article History:

Received 5th January, 2018
Received in revised form 20th February, 2018
Accepted 8th March, 2018
Published online 28th April, 2018

Key Words:

Parkinson's Disease (PD) , dexterity, motor-cognitive dual task, 9 Hole Peg test, activities of daily living (ADL)

ABSTRACT

People with Parkinson's disease (PwP) face difficulty in activities of daily living (ADL) due to disease specific cardinal features, difficulty in dual tasking and difficulty with fine motor activities. This study aims to study effect of dual task on dexterity in PD and to explore whether upper limb specific motor-cognitive dual task intervention, help to improve dexterity measured on performance of 9 Hole Peg Test (9HPT) and its effect on independent living skills measured by Lawton Instrumental Daily Living (LIADL) and on components of Part III of Movement Disorder Society Unified Parkinson's Disease Rating Scale (MDS UPDRS).

Secondary task significantly increased time taken to complete motor task. Intervention resulted in improving trend in dexterity, independent living skills and decreased tremors. Exercises for PD should incorporate dual task training with varied combinations of tasks useful for ADL to enhance their ability to withstand dual task interference induced by secondary task.

INTRODUCTION

Parkinson's disease (PD) is manifested with cardinal features of rigidity, bradykinesia, postural instability and tremor. It is also associated with various non motor symptoms. Fine motor activities are found to be typically affected in PD which can be attributed to bradykinesia, rigidity, tremors, somato-sensory dysfunction. Recent literature suggests it can be due to motor disorder known as limb kinetic apraxia (LKA) which was a new term coined by Hugo Liepman in 1920. Structure involved in this impairment is premotor area and is particularly observed in corticobasal degeneration (Gebhardt *et al*., 2008; Vanbellingen *et al*., 2016).

Fine motor activities help an individual in various activities of daily living like buttoning, tying shoe lace, combing, zipping, writing etc. With increased use of technological devices such as mobile phones, remote controls for electrical appliances, computers or laptops, impairment of fine motor control could impose considerable restriction in participation. Difficulties in performing daily chores bring about dependency on caregiver or spouse in PD, which has a negative impact on quality of life of people with Parkinson's disease (PwP). Activities of daily living also involve dual tasking for example taking note while talking on phone, talking while doing activities. These specifically are combination of motor and cognitive tasks, performance of which is decreased when compared to healthy individuals (Teixeira & Alouche, 2007). Studies suggest that addition of concurrent task affects performance of one or both task depending on automaticity of task, similarity between tasks, complexity of task, attention and mental resources. Motor learning is slowed in PwP when compared to healthy controls. Cued motor learning is reported to have beneficial effect on motor learning in PwP. Few studies have explored and designed effect of dual task oriented training. However, most of them focused on gait as outcome measure specifically step length (Brauer *et al*., 2011; Brauer & Morris, 2010; Nieuwboer *et al*, 2009; Pashler, 1994). For upper limb activities, interference effect of dual or multi task has been reported in various studies using Purdue peg board, coin rotation task, finger tapping (Broeder *et al*, 2014; Deivendran Kalirathinam, 2014; Teixeira & Alouche, 2007; Proud & Morris, 2010). Immediate effect of hand exercises using therapeutic putty on manual dexterity and strength in PwP showed improvement in both following intervention (Mateos-

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toset *et al*., 2016). Upper Extremity activities in dual task situations are studied less (Nieuwboer *et al*., 2009). 9 Hole Peg Test is a reliable and valid method to test dexterity and precision in PD (Earhart *et al*., 2011). This study aims to study effect of dual task on dexterity in PD and to explore whether task specific training on dual tasking help to improve dexterity in dual task situation and its effect on instrumental activities of daily living.

MATERIALS & METHODS

Ethical clearance for this experimental study was obtained from MGM Institute of Health Sciences, Navi Mumbai, Maharashtra, India.

Participants: 22 (19 males and 3 females) people with Parkinson's disease (PwP) were recruited for this study from Parkinson's Disease and Movement Disorder Society (PDMDS), Mumbai . Written informed consent was taken from them for participating in this study. They belonged to stage I to III of Hoehn & Yahr stages of disability for Parkinson's disease, with score of less than 24 in Mini-Mental State Examination (MMSE). PwPs were asked to report on affect of PD on difficulty to perform their activities of daily living in scale of 0 (no difficulties) to 4 (extreme difficulties). They had adequate vision and hearing with successful use of corrective lenses and/or hearing aid if required. They did not have any severe co morbidity, other neurological problems or any acute medical problems. Demographic information and disease condition is presented in table 1.

Table 1 Demographics and disease condition of people with Parkinson's Disease (PwP)

n=22	Frequency (%)	Mean (SD)	Minimum	Maximum
Age (in years)		69.5 (6.3)	60	81
Below 65 years	8 (36)			
65 & above	14 (64)			
Gender				
Male	19 (86)			
Female	03 (14)			
Duration of Disease (in years)		6.3 (4.6)	1	22
Hoehn & Yahr Scale		1.5 (0.7)	1	3
Stage 1	10 (45)			
Stage 2	6 (27)			
Stage 3	6 (27)			
Affect of PD		2.5 (0.8)	1	4
No Difficulties	2 (9)			
Mild Difficulties	9 (41)			
Moderate Difficulties	10 (45)			
Extreme Difficulties	1 (5)			
Mini Mental Status Examination (MMSE)		28.2 (2)	24	30

There was one drop out in this study due to fracture of lower limb and hospitalization.

Outcome Measures

1. Movement Disorder Society Unified Parkinson's Disease Rating Scale (MDS UPDRS) Part III components of upper extremities viz. rigidity (3.3), bradykinesia (combination of 3.4, 3.5 &3.6) and tremor (combination of 3.15, 3.16 &3.17) (Goetz *et al*., 2007, 2008).
2. Lawton Instrumental Daily Living (LIADL) is a self reported battery of questions revolving around activities of daily living to assess independent living skills. It has 8 domains of function with score range from 0 (dependant) to 8 (independent) for women and 0 (dependant) to 5 (independent) for men excluding food preparation, housekeeping and laundering (Graf, 2008).
3. 9 Hole Peg Test (9HPT)(Earhart *et al*., 2011)

Performance on 9 HPT as time in seconds was recorded as single task and also while performing a cognitive task as motor-cognitive dual task .2 trials of 9 HPT was performed with dominant hand and 2 with non dominant hand . All participants in our study were right handed. Participants were seated comfortably with appropriate table and chair heights and distance from pegboard, which were adjusted based on individuals need. Brief rest period was given in between trails. It was explained to participants that if peg falls on floor, they need to continue with task and it will be given back to them in order to complete task. In case peg falls on table, they themselves have to retrieve it and continue performing on 9 HPT. Average time of 2 trials was recorded for analysis.

Data on all outcome measures were recorded once before commencing intervention and following intervention after 6 weeks.

Intervention: Designed interventional protocol was administered in 'ON' phase of medication preferably within 2 hours after taking medicine for all participants. For a single session they were asked to perform on 9 HPT as fast as possible with either hand along with cognitive task of naming individuals or places or things as per participants' choice. They repeated this process after a brief rest period whenever participant required. Time in seconds & number of words was observed for every attempt. Feedback following each attempt was given by researcher as to complete test faster.

Participants were given repeated practice trials of above protocol for 30 minutes for 3 days per week for 6 weeks. They were given home program of upper limb task of picking grams or beads available in their home along with any cognitive task like talking or generating names as done in protocol. This intervention did not interfere with their regular therapy regimes and support group activities.

Statistical Analysis: Data recorded were tested for normality using Kolmogorov Smirnov Test. As data were not distributed normally, non parametric Wilcoxon Signed Ranks Test was used to compare effect of cognitive dual task dexterity in participants and also to compare effect of intervention on all outcome measures. SPSS 24 was used for analysis.

RESULTS

Objective 1: To find effect of motor-cognitive dual task on dexterity in PwP

Table 3 compares pre and post scores on outcome measures following intervention of 6 weeks. Though, results seem to be limited due to small sample size, we are presenting trend of effect of motor-cognitive dual task intervention.

It was observed that median of average time taken in seconds on 9HPT decreases in both single and dual task situation with most negative ranks. This indicates improvement in dexterity in both situations. However, results were statistically not significant ($p>0.05$).

Table 2 Comparison of performance on 9 Hole Peg Test in single and motor-cognitive dual task situation

Outcome measures	Single task- 9 HPT		Motor-Cognitive Dual task		Rank (n=22)			p value*
9 HPT (average time in seconds)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	-ve	+ve	Ties	
RUE Pre Scores	32.1 (12.5)	27.1 (24.6, 37)	41.5 (15.7)	37.3 (30.4,49.6)	2	18	1	0.001
RUE Post Scores	31.1 (9.6)	27.0 (23.5,36)	36.1 (12.2)	34.5 (26.3,46.3)	3	18	0	0.005
LUE Pre Scores	31.7 (8.4)	29.3 (25.2,35.6)	38.4 (9.1)	39.0 (30.7,43.8)	3	17	1	0.001
LUE Post Scores	32.3 (10.3)	29.2 (24.8,37)	37.2 (14.3)	38.0 (26,45.3)	2	19	0	0.003

* Wilcoxon Signed Rank Test; Level of significance $p<0.05$; -ve =Negative; +ve = Positive ;IQR=Inter Quartile Range

Table 2 compares performance on 9HPT in single and motor-cognitive dual task situation for both upper extremities. A motor-cognitive task combination brings statistically significant ($p< 0.001$) increase in time taken to complete motor task with maximum positive ranks indicating dual task takes more time when compared to single task situation. Similar findings were reflected in both pre and post scores of 9HPT following motor-cognitive dual task intervention of 6 weeks.

Objective 2: *To find effect of motor cognitive dual task training of upper limb using 9 HPT on dexterity and function in PwP.*

Median of rigidity and bradykinesia of both upper limbs measured on MDS UPDRS Part III tend to increase even after 6 weeks motor-cognitive dual task training with maximum ties followed by positive ranks. Results were not significant except rigidity of left upper extremity.

Median of tremor for both upper extremities remained same. However, results showed maximum ties followed by negative ranks, which indicate that tremor decreased due to motor-cognitive dual task specific intervention of 6 weeks on 9 HPT.

Table 3 Comparison of pre and post on outcome measures following 6 weeks intervention

Outcome measures	Pre Scores		Post Scores		Rank (n=22)			p value*
9 HPT (average time in seconds)	Mean (SD)	**Median (IQR)**	Mean (SD)	**Median (IQR)**	-ve	+ve	Ties	
RUE Single task	32.1 (12.5)	27.1 (24.6, 37)	31.1 (9.6)	27.0 (23.5,36)	10	8	1	0.83
LUE Single task	31.7 (8.4)	29.3 (25.2,35.6)	32.3 (10.3)	29.2 (24.8,37)	11	8	0	0.63
RUE Dual task	41.5 (15.7)	37.3 (30.4,49.6)	36.1 (12.2)	34.5 (26.3,46.3)	10	9	0	0.38
LUE Dual task	38.4 (9.1)	39.0 (30.7,43.8)	37.2 (14.3)	38.0 (26,45.3)	9	10	0	0.92
MDS UPDRS – Part III								
RUE Rigidity	0.5 (0.8)	0 (0,1)	0.7 (0.9)	0 (0,1)	5	7	9	0.35
LUE Rigidity	0.3 (0.6)	0 (0,1)	0.8 (0.8)	1 (0,1.75)	2	9	10	**0.02**
RUE Bradykinesia	1.9 (2.4)	1 (0,3)	2.1 (2.1)	2 (0,4)	6	8	7	0.80
LUE Bradykinesia	1.6 (2.2)	0.5 (0,3)	2.3 (2.5)	1 (0,4)	4	9	8	0.50
RUE Tremor	1.9 (2.6)	0 (0,3.5)	1 (1.6)	0 (0,1.75)	8	5	8	0.21
LUE Tremor	1.4 (2.2)	0 (0,2.75)	1.1 (1.8)	0 (0,1)	6	5	10	0.44
LIADL	6.5 (1.3)	3 (3.4,5)	6.5 (1.6)	4 (3,6)	7	10	4	0.96

* Wilcoxon Signed Rank Test; Level of significance $p<0.05$; -ve =Negative; +ve = Positive; IQR=Inter Quartile Range

These results were also statistically not significant ($p>0.05$).
Post median score on LIADL increased with maximum positive ranks indicating improved function following motor-cognitive dual task intervention of 6 weeks though results were non significant ($p>0.05$).

DISCUSSION

Results of this study was presented under two objectives. Firstly, effect of motor-cognitive dual task on performance of 9 HPT as outcome of dexterity, demonstrated that addition of cognitive task deteriorates motor task performance. Studies state that additional task effects performance of handwriting, buttoning, performance on therapeutic putty, arm-hand and wrist-hand movements, dexterity measured on coin rotation task and finger tapping test (Broeder *et al*., 2014; Gebhardt *et al*., 2008; Teixeira & Alouche, 2007). 9 HPT is clinically useful measure for assessing upper extremity function in people with Parkinson's disease. It is reported that average time taken with dominant hand is 31.4 ± 15.7 seconds and with non dominant hand is 32.2 ± 12.4 seconds(Earhart *et al*., 2011). Our results demonstrated similar average time taken by participants in single task situation. Pre test values on 9 HPT with a cognitive task of naming demonstrated increase in 50^{th} percentile score to 37.3 seconds for dominant hand and 39 seconds for non dominant hand. Post value scores in dual task condition were also higher than single task condition.

There are few studies on dual task oriented training on people with PD which usually have focused on lower limb function specifically step length. Moreover, researchers reported on immediate effect of intervention only. Upper limb function under dual task training seemed to be less researched area with low level evidence(Janssens *et al*., 2014). Therefore, in second section we brought out effect of dual task oriented training on dexterity in PwP. Though results were statistically not significant, it definitely presents that with training in dual task situation dexterity improves in terms of average time taken to complete 9 HPT in both single and dual task situation. However, effect of intervention did not check rigidity and bradykinesia which may be due to progressive nature of disease. Interesting observation was effect of intervention on tremor scores on MDS UPDRS Part III. There was decreasing trend in tremor for both dominant and non dominant hand following intervention. Mystery of tremor in PD is still not known, but main reason is reported to be fall in dopamine levels in thalamic circuit affecting sensory feedback to brain from thalamus to control complex movements(Helmich *et al*., 2012). Interventions or protocols designed which stimulates these circuits might bring about significant change in decrease of tremor in PD. This will aid PwP to perform their daily living activities with less efforts and reduced energy expenditure.

Dual tasking is compromised in PwP due to affected executive function as striato-frontal connections are hypoactive and concurrent tasks poses additional limitation on motor learning. Though evidence are limited, it is reported that learning a dual task and achieving automatization might be possible in PwP (Nieuwboer *et al*., 2009). Also few studies report , PwP show greater activation of other areas of brain when subjected to sequential learning with specific instructions, especially dorsolateral prefrontal cortex, premotor cortex , cerebellum, posterior parietal cortex and occipital association areas in order to compensate through a more extended task-specific activation and improve outcome (Marinelli *et al*., 2017). Our study results affirm these findings demonstrating trend towards improvement in dexterity and function following a 6 weeks motor-cognitive dual task specific intervention with home program.

CONCLUSION

Rehabilitation protocols for PwP should incorporate dual task specific training with combinations of tasks useful for activities of daily living to enhance their ability to withstand dual task interference induced by secondary task, thereby increasing automatization of motor learning of primary task. This will enhance their functional independence and improve quality of life.

A limitation of this study is small sample size. Further scope of study is to explore effect various dual task combination rehabilitation protocols for PwP in order to improve their function in daily living.

Conflict of Interest: No declared conflict of interest

Acknowledgement

We acknowledge immense support from MGM Institute of Health Sciences, Navi Mumbai, Maharashtra, India. Researchers extend immense gratitude to Parkinson's Disease and Movement Disorder Society (PDMDS) to permit us to conduct this study. We thank People with Parkinson's disease and their caregivers who actively participated in this study.

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How to cite this article:

Bose Meruna *et al*.2018, Effect of Motor-Cognitive Dual Task Training on Dexterity And Function In People With Parkinson's Disease (PWP) Using 9 Hole Peg Test (9HPT). *Int J Recent Sci Res.* 9(4), pp. 26090-26094.
DOI: http://dx.doi.org/10.24327/ijrsr.2018.0904.1989

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