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EFFECTIVENESS OF COGNITIVE-MOTOR AND BALANCE TRAINING ON GAIT, BALANCE AND ACTIVITIES OF DAILY LIVING IN PATIENT WITH PARKINSON'S DISEASE – AN INTERVENTIONAL STUDY

Physiotherapy

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ABSTRACT

Background: Parkinson's disease (PD) is a chronic, progressive neurodegenerative disorder, characterized by both motor and non-motor symptoms. Motor symptoms include the cardinal features of rigidity, generalized slowing of movement (bradykinesia), resting tremor, and in later stages postural abnormalities. Non-motor features, such as cognitive impairment, autonomic dysfunction and depression are part of the disease resulting in poor quality of life. Deficits in motor- cognitive dual-tasks (e.g., walking while talking) are common in individuals with Parkinson's disease which leads to in falls and fall injuries resulting in poor quality of life. This interventional study was conducted to determine the influence of motor- cognitive and cognitive-balance training on mobility, balance and quality of life in individuals with Parkinson's disease. **Objective:** To evaluate the effectiveness of Cognitive-motor training and balance training on gait, balance, and activities of daily living in patients with arkinson's disease and the difference between two intervention protocols. **Methodology:** With purposive sampling technique, total of fourty-nine patients with Parkinson's disease were randomly allocated in Group A (Cognitive-Motor Training) and Group B (Cognitive-Balance Training) twenty-five in one and twenty- four in other group. The inclusion criteria of age: 60-75 years, gender: male/female, Hoehn and Yahr stages from 1-3, Mini-mental state examination score ≥24, who walk independently with or without walking aids and diagnosed by Neuro physician from various hospitals attached with SPB physiotherapy college. After the formation of the groups, the physiotherapeutic intervention program was started, consisting of 12 therapy sessions 3 days per week for 4 consecutive weeks. Pre and post-intervention assessment was carried out using DGI, BBS, and QLPD. Data was collected and analysed using SPSS version 20.00. **Result:** The data were analysed using paired t-test for within-group and an independent t-test for between groups. The p-value was set at $p<0.05$. There was a statistically significant difference within-group analysis. Whereas there was no statistically significant difference between the two groups except for DGI. **Conclusion:** In this study, it was concluded that cognitive mobility and balance training are equally important to maintain a good quality of life and so according to the results, both should be incorporated into the treatment plan.

KEYWORDS

Cognitive-Balance Training, Cognitive-Motor Interference, Cognitive-Motor Training, Dual-Task Training, Parkinson's Disease and Quality of Life.

INTRODUCTION

Parkinson's disease (PD) is a chronic, progressive neurodegenerative disorder first described as "The shaking palsy" by James Parkinson in 1816.[1] It is characterized by a complex array of motor and non-motor symptoms that collectively contribute to significant functional disability and diminished quality of life. The pathological hallmark of PD involves progressive degeneration of dopamine-producing neurons in the pars compacta of the substantia nigra, a critical component of the basal ganglia circuitry responsible for planning and programming voluntary movements. As neuronal loss progresses, reaching approximately 50-70% before clinical manifestations become apparent, the characteristic motor features emerge, fundamentally altering an individual's capacity for normal movement and functional independence. [2, 3]

The clinical presentation of PD encompasses both cardinal motor features and non-motor manifestations that profoundly impact disease burden. Classic motor symptoms include resting tremor, rigidity, bradykinesia (generalized slowing of movement), and postural instability that typically manifests in later disease stages. Non-motor characteristics such as cognitive impairment, autonomic dysfunction, sleep disorders, depression, and hyposmia are integral to the disease and may appear years or decades before motor symptoms, adding considerably to the overall burden. Epidemiological data indicate that PD affects approximately 7 to 10 million individuals globally, with prevalence estimates ranging from 100 to 200 per 100,000 population. [4] The disease demonstrates a clear age-dependent pattern, affecting over 2% of individuals older than 65 years, with men being more frequently affected than women. In India, epidemiological studies suggest a relatively lower prevalence of parkinsonism, with the exception of the Parsi community, and hospital-based studies have identified both idiopathic cases and a small proportion of genetic forms. [5]

The etiopathogenesis of PD involves a complex interplay between genetic susceptibility and environmental factors. Approximately 5-10% represent monogenic forms associated with specific gene mutations including PARK1, PINK1, and LRRK2. Environmental factors implicated include viral infections, exposure to toxins such as pesticides and herbicides, vascular pathology, metabolic disorders like Wilson's disease, and drug-induced parkinsonism. The pathological cascade culminates in substantial neurodegeneration within the substantia nigra, accompanied by the deposition of intracellular inclusion bodies known as Lewy bodies, with characteristic depigmentation and pallor of the affected region.

Among the most functionally disabling consequences of PD are progressive impairments in gait and balance. These complications profoundly affect mobility, independence, and safety, with postural instability and gait difficulties representing particularly challenging aspects that often respond poorly to dopaminergic therapy. A critical aspect of functional mobility involves dual-task performance, wherein individuals must simultaneously execute motor and cognitive tasks—common examples include walking while talking (cognitive dual-task) or carrying objects while ambulating (motor dual-task). For individuals with PD, such dual-task demands pose extraordinary challenges due to compromised basal ganglia function and disrupted automatic movement control. The performance of simultaneous tasks typically results in decreased efficiency in one or both domains, a phenomenon termed cognitive-motor interference (CMI), reflecting competition for limited attentional resources. [11, 12]

The clinical significance of CMI extends to its relationship with fall risk, which represents one of the most serious complications of PD. Epidemiological studies indicate that between 45% and 68% of individuals with PD experience falls annually, with consequences encompassing physical injuries and psychosocial sequelae including fear of falling, activity restriction, loss of independence, and increased caregiver burden. This cascade creates a vicious cycle wherein fear of falling leads to reduced activity, promoting physical deconditioning and further balance deterioration.

Assessment of fall risk employs various standardized clinical instruments including the Dynamic Gait Index (DGI) [13], Berg Balance Scale (BBS), Balance Evaluation Systems Test, Functional Gait Assessment, and Timed Up and Go test. [14] Beyond physical function, PD profoundly impacts health-related quality of life, necessitating comprehensive outcome measurement through disease-specific instruments such as the Parkinson's Disease Questionnaire (PDQ-39) and the recently validated Quality of Life in Parkinson's Disease (QLPD) scale for Hindi-speaking populations. [15]

Physical therapy rehabilitation constitutes an essential component of comprehensive PD management, incorporating strengthening, balance training, postural exercises, cueing strategies, and treadmill training. Emerging innovative approaches include virtual reality, exergaming, motor imagery, and non-conventional therapies such as dance and martial arts. However, no consensus exists regarding optimal approaches for addressing dual-task deficits and CMI-related fall risk. Given that CMI represents a significant contributor to falls and functional limitation, targeted interventions addressing simultaneous cognitive-motor performance may offer particular benefit. This study aims to design and evaluate a protocol targeting cognitive-motor and balance training in individuals with PD, with emphasis on outcomes including gait performance, balance function, and health-related quality of life as measured by the DGI, BBS, and QLPD scales respectively, thereby contributing to improved rehabilitation strategies for the Indian PD population.

MATERIALS AND METHODS

Prior to commencement, ethical clearance was obtained from the Institutional Ethical Committee (IEC). An interventional design to evaluate the comparative effectiveness of two training protocols in individuals with Parkinson's disease was formed. The study population comprised patients diagnosed with Parkinson's disease (PD) attending various healthcare facilities. Sample size calculation was performed based on a pilot study conducted on 5 patients in each group, using the Quality of Life in Parkinson's Disease (QLPD) questionnaire as one of the primary outcome measures. Utilizing G Power software version 3.1.9.2, with an effect size of 0.88 and $\alpha = 0.05$, the initial sample size was calculated as 44 participants. Accounting for a 10% dropout rate, the final sample size was determined to be 49 subjects, who were included in the study. Purposive sampling was utilized to select participants meeting the predetermined selection criteria.

Patients willing to participate in the study were included if they met the following criteria: age between 60 to 75 years, either male or female gender, Hoehn and Yahr stages I to III, Mini-Mental State Examination (MMSE) score of 24 or above, ability to walk independently with or without walking aids, and confirmed diagnosis of Parkinson's disease referred by a neurophysician. Participants were excluded if they presented with unstable medical conditions such as uncontrolled cardiovascular disease, motor fluctuations or severe dyskinesia that might interfere with training participation including significant tremor, rigidity, or bradykinesia, or any history of other neurological or systemic diseases known to interfere with study participation.

The purpose of the study was explained to all potential participants, and written informed consent along with demographic details was obtained from those willing to participate. Subjects underwent preliminary screening based on the predetermined inclusion and exclusion criteria and were evaluated using a standardized physiotherapy assessment form. Participants were allocated sequentially to Group A and Group B in the order of recruitment. Following group allocation and baseline evaluation, the physiotherapeutic intervention program commenced, consisting of 12 therapy sessions conducted three days per week for four consecutive weeks, and this sequence was maintained consistently throughout the study period.

Figure 1: Flow Chart- Participant's Recruitment

Group A received Cognitive-Motor Training combined with Conventional Therapy, while Group B received Cognitive-Balance Training combined with Conventional Therapy. Both training groups received 12 supervised, individual sessions over four weeks, with each session lasting approximately 50 minutes and incorporating regular rest periods between exercises. The conventional treatment protocol remained identical for both groups and consisted of active joint mobilization and active exercises for muscles of the shoulder, elbow, wrist, hip, knee, and ankle joints to maintain joint range of motion and muscle function. Muscle stretching exercises were administered for muscles of both upper and lower limbs, with each stretch held for 30 seconds and repeated for three repetitions to address rigidity and maintain muscle length. Motor coordination exercises included bending the left upper limb while simultaneously extending the right lower limb, while sitting on a bench touching the left shoulder with the right hand while straightening the left arm at shoulder level followed by touching the right shoulder with the left hand while straightening the right arm, and in standing position against a wall performing a standing march by alternately tapping the right and left foot on the ground.

Participants in Group A receiving Cognitive-Motor Training walked at a self-selected speed, barefoot, while performing various cognitive-motor tasks. The walking tasks included walking forward, obstacle crossing, walking on an S-shaped route, tandem walking, and walking backward. These walking activities were combined with cognitive tasks including walking while repeating words, walking while counting a three-digit number forward, walking while counting a three-digit number backward, walking while answering simple questions with yes or no, walking while reciting a shopping list, walking while talking, walking while reciting a short sentence backward, and walking while singing. Participants were progressively trained with increasing difficulty of tasks based on their individual capabilities and performance.

Participants in Group B receiving Cognitive-Balance Training performed cognitive tasks concurrently with static and dynamic balance exercises. The cognitive tasks included categorization of words, spelling words forward or backward, telling a random story, and counting the occurrence of specific letters or numbers in an auditory sequence. These were combined with balance exercises including side steps progressed from widening steps, reducing hand support, double step side taps, to adding arm curls while reducing hand support; side sway progressed from adding knee bend, reducing hand support, to incorporating arm swing; lunges in all directions progressed by reducing support, increasing range of movement, reducing depth of movement, and increasing repetitions; toe walk progressed by increasing repetitions and reducing support; heel walk progressed by increasing repetitions and reducing support; and tandem walk performed with progression based on patient ability. The progression of exercises was individualized and depended on each patient's ability to perform the tasks safely and effectively.

All subjects underwent conventional therapy for 30 minutes, followed by either cognitive-motor training or cognitive-balance training for 20 minutes, with a 10-minute rest period between conventional therapy and the specialized training components, and sessions were conducted on alternate days three times per week. Assessments were conducted at three time points: prior to treatment initiation at baseline, at the end of the second week, and at the end of the fourth week using the Dynamic Gait Index (DGI) [11], Berg Balance Scale (BBS) [12], and Quality of Life in Parkinson's Disease Questionnaire (HRQoL) [13] as outcome measures.

Data Analysis and Results

All statistical tests and calculations were performed using SPSS version 20.0 software. The quantitative variables included in this study were age, duration of disease in years, Hoehn and Yahr stage, Dynamic Gait Index (DGI), Berg Balance Scale (BBS), and Quality of Life in Parkinson's Disease Questionnaire (QLPD) scores. The Shapiro-Wilk test was applied to assess the normality of data distribution, and all quantitative data followed a normal distribution. Consequently, parametric tests were employed for data analysis. Baseline characteristics were compared to verify homogeneity between the intervention groups. A paired t-test was utilized to analyze differences between pre-training and post-training assessments within each group, while an independent t-test was used for between-group comparisons on post-training measures. The confidence interval was maintained at

95%, and the level of significance for all statistical analyses was set at 0.05.

A total of 67 patients were assessed for eligibility. Among these, 49 participants were enrolled in the study and allocated to either Group A (cognitive-mobility training) or Group B (cognitive-balance training). During the intervention period, 5 patients dropped out, resulting in a final analysis of 44 participants who completed assessments on the first day and after four weeks of intervention.

Table 1: Patient's Baseline Characteristics for Group A and Group B

VARIABLES	GROUP A (n=25) MEAN±SD	GROUP A (n=24) MEAN±SD	P-VALUE
AGE (YEARS)	66.4±4.2	68.18±4	0.79
DISEASE DURATION (YEARS)	2.8±2	3.9±2.5	0.16
HOEHN AND YAHR STAGE	2.2±0.68	2.2±0.86	0.63
PRE DGI	15.54±3.09	17.4±2.7	0.98
PRE BBS	40.55±6.7	35.5±9	0.84
PRE QLPD	39±16	37.86±15	0.3

Within Group Analysis

Table 2: Intragroup Mean and Standard Deviation Comparison For Group A Using Paired T-test

OUTCOME VARIABLES	PRE MEAN±SD	POST MEAN±SD	p-VALUE
DGI	15.54±3.09	17.81±3.17	0.00
BBS	40.55±6.7	43.10±6.7	0.00
QLPD	39±16	35.5±16	0.00

Results of intragroup comparison in Group A (CMT), showed a statistically significant difference between pre-intervention data 15.54±3.09 for DGI, 40.55±6.7 for BBS, and 39±16 for QLPD. Mean improvement in DGI was 1.5 with SD 0.9 ($p<0.05$), BBS score was 3.04 with SD 1.13 ($p<0.05$), and QLPD was 3.04 with SD 1.5 ($p<0.05$).

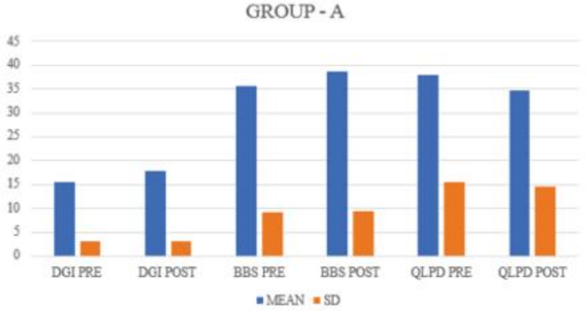

Figure 2: Intra Group Mean and Standard Deviation Comparison of DGI, BBS and QLPD for Group A

Table 3: Intragroup Mean and Standard Deviation Comparison for Group B Using Paired t-test

OUTCOME VARIABLES	PRE MEAN±SD	POST MEAN±SD	p-VALUE
DGI	17.4±2.7	19.04±2.3	0.00
BBS	35.5±9	38.5±9	0.00
QLPD	37.86±15	35±14	0.00

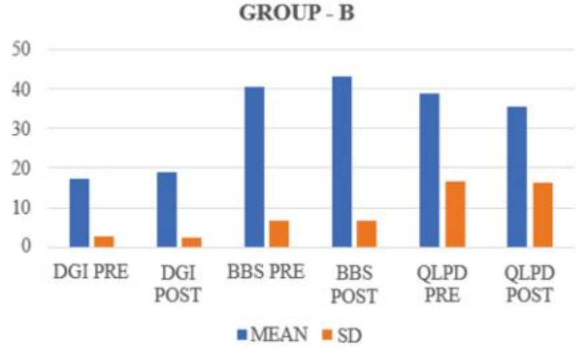

Figure 3: Intra Group Mean and Standard Deviation Comparison of DGI, BBS and QLPD for Group

Group B in which CBT was provided shows a statistically significant difference between pre-intervention data was 17.4±2.7 for DGI, 35.5±9 for BBS, and 37.86±15 for QLPD. Mean improvement in DGI was 2.27 with SD 1.2 ($p<0.05$), BBS score was 2.72 with SD 1.12 ($p<0.05$), and QLPD was 3.5 with SD 1.18 ($p<0.05$).

Between Group Analysis

Table 4: Intergroup Comparison Between Group A and Group B Using Independent T-test

OUTCOME VARIABLE	POST VALUE GROUP A	POST VALUE GROUP B	p-VALUE
DGI	2.3±1.1	1.6±0.9	0.03
BBS	2.7±1.1	3.0±1.1	0.35
QLPD	3.5±1.1	3.04±1.5	0.23

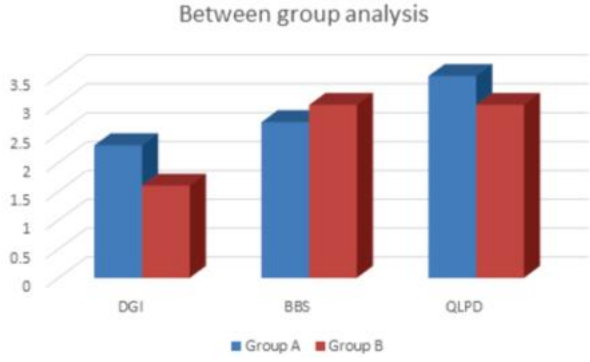

Figure 4: Between Group Analysis

Whereas when comparison was done (Table 6.6) between the groups none of the differences were statistically significant in BBS and QLPD except for DGI scores which showed advantage for the CMT ($p<0.05$).

DISCUSSION

This study compared the effects of Cognitive-Motor Training (CMT) and Cognitive-Balance Training (CBT) on mobility, balance, and quality of life (QoL) in individuals with Parkinson's disease (PD). The results demonstrated significant intra-group improvements in both groups, supporting the existing evidence that dual-task training is beneficial for enhancing gait, balance, and perceived QoL in this population [14, 15, 16].

The significant improvements observed in Group A (CMT) and Group B (CBT) suggest that combining conventional physiotherapy with a cognitive component can lead to better motor outcomes. These findings align with previous research indicating that dual-task training can improve gait parameters and balance [17, 18]. The positive changes in QoL, despite no significant changes in all its sub-components, may be attributed to increased self-confidence from mastering dual-tasks, highlighting the close relationship between cognitive function and QoL [19].

While both groups improved, the between-group analysis showed no significant difference on the Berg Balance Scale (BBS) and the Quality of Life in Parkinson's Disease (QLPD) questionnaire. This suggests that both forms of training are equally effective for improving overall balance and QoL. However, Group A (CMT) demonstrated a statistically significant advantage on the Dynamic Gait Index (DGI) ($p<0.05$). This slight advantage for the CMT group may be due to the specific focus on mobility-oriented exercises, which more directly targets gait performance under cognitive load.

The integration of cognitive tasks in training is crucial, as diminished attentional capacity is a known contributor to falls and cognitive-motor interference (CMI) in PD [20, 21]. By challenging patients to perform motor and cognitive tasks concurrently, these interventions likely promote experience-dependent neuroplasticity and motor relearning, leading to improved automaticity of movement [22, 23].

In this population, the imbalance was evident. During silent standing as well as transitions between static and dynamic equilibrium, such as during gait initiation, termination, or turning, patients exhibit difficulty in maintaining equilibrium. [24] Hence, both mobility and balance training are equally important to maintain a good quality of life and so both should be incorporated into the treatment plan. As the result suggest intervention focused on walking could be priotized over balance once to make programme more specific to balance performance during walking thereby reflecting in daily life. Protocol of study was feasible in all patients as there was not any dropout throughout the study.

The participants in this study were in general not severely motor or cognitive impaired, the results are therefore not generalizable to more severely impaired patients with PD, having frequent freezing gait. Patient characteristics such as the degree of motor or cognitive impairment might influence responsiveness to the different interventions. Another point to consider is the choice of the cognitive activities used. The sample was heterogeneous in relation to years of education, characterized mostly by individuals with low educational levels so simpler cognitive activities were selected, which may have underestimated the ability of some participants with better cognitive function.The results should be interpreted considering certain limitations. The participants were not severely impaired, limiting generalizability to those with more advanced PD. The short intervention period precluded assessment of long-term effects. Furthermore, the cognitive tasks were not tailored to patients' daily activities, making it difficult to measure transfer of learning. The heterogeneity of educational levels, while addressed by choosing simpler tasks, may have underestimated the potential for improvement in higher-functioning individuals.

CONCLUSION

This study concludes that both cognitive-mobility and cognitive-balance training are equally important and effective interventions for improving balance and QoL in individuals with PD. However, cognitive-mobility training may offer a slight advantage for enhancing gait performance. The findings support incorporating both types of dual-task training into standard rehabilitation programs for this population.

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