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# Effect of dual-task interference on upper extremity motor experience with Parkinson's disease motor effect of dual-task in Parkinson's disease

Emre Şenocak[1*], Seda Karaca[2] and Adem Aktürk[3,4]

## Abstract

**Objective** Humans use their motor and cognitive functions simultaneously while voluntarily performing real-time selective motor movements in daily life. This study aimed to investigate the effects of dual-task training on upper extremity motor skills and daily living activities in patients with Parkinson's disease.

**Methods** The patients were randomized into two groups. One of the groups (Control) received a conventional physiotherapy program, while the other group (Dual-Task) also performed a cognitive-based dual-task intervention in addition to traditional rehabilitation. All rehabilitation programs were continued for 60 × 5 × 6 min/day/week. The assessments were performed twice: The two subsections of the MDS-Unified Parkinson's Rating Scale (MDS-UPDRS II and III), Box Block Test (BBT), and Parkinson's Disease Questionnaire-39 (PDQ-39).

**Results** There was no difference in any parameter between the groups, neither baseline nor after treatment ($p > 0.05$ for all). In the within-group assessments, the amount of change was higher in the MDS-UPDRS II and III sub-dimensions scores of the Dual-Task group. An increase was observed in the BBT results of both groups compared to pre-treatment ($p < 0.05$ for all). While the PDQ-39 score of the Dual-Task group improved by approximately 18% ($p = 0.003$), no change was detected in the control group ($p = 0.413$).

**Conclusion** Dual-task interference maintained throughout rehabilitation may enable the development of motor-cognitive functions required by individuals with Parkinson's disease to perform daily living activities. For this reason, including dual-task training in rehabilitation to manage upper extremity impairment due to Parkinson's disease may be helpful to maximize gains.

**Trial registration** This study was registered to clinicaltrials.gov with NCT06803212 ID (01.30.2025).

**Keywords** Parkinson, Dual-Task, Conventional rehabilitation, Upper extremity, Motor

*Correspondence:
Emre Şenocak
emresenocak@ktu.edu.tr
[1]Department of Physiotherapy and Rehabilitation, Kanuni Campus, Karadeniz Technical University, Ortahisar/Trabzon, Turkey
[2]Department of Physiotherapy and Rehabilitation, Recep Tayyip Erdogan University, Rize, Turkey
[3]Department of Podology, Istanbul Gelişim University, İstanbul, Turkey
[4]Department of Physical Therapy and Rehabilitation, Private Medivita İncirli Hospital, İstanbul, Turkey

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## Introduction

Dual-task applications can be defined as the simultaneous performance of cognitive and motor tasks that can be performed independently of each other, with different goals [1]. The first task given to the patient consists of the modality that the researcher wants to observe, while the second task, with no organic connection to the first task, includes only an activity that challenges focus on the current task [2]. Dual-task applications are frequently used in daily life activities, and it has been suggested that simultaneous dual-task applications lead to more efficient coordination [3]. Previous studies have focused on dual-task training for various disease groups [4–6]. There are also studies on dual-tasking in patients with Parkinson's disease, generally focusing on lower limb function, which reported that dual tasks improved the motor clinical complaints of patients [7]. However, there are only a limited number of studies on upper extremity dexterity [8]. Although previous studies reported that complaints from patients with Parkinson's disease, associated with lower extremity involvement, had more adverse effects on daily life, upper extremity involvement also directly affects patients' daily activities and participation in such activities [9, 10]. In particular, the difficulties experienced by patients in using tools that require manual dexterity and challenges in performing daily activities are among the most important markers of the disease [11]. The primary sources of these difficulties include loss of automatic movements, decreased attention, and impairments in executive functions associated with basal ganglia dysfunction [8]. Dual-tasking is a treatment approach with the potential to improve attention and executive functioning in patients with Parkinson's disease [12].

Physiotherapy applications, including exercise, are considered one of the most basic non-pharmacological treatment modalities in alleviating the physical and non-physical complaints of patients with Parkinson's disease [13]. Furthermore, cognitive-based secondary task interventions, mainly when applied in addition to motor movements, have recently been used to relieve motor complaints associated with Parkinson's disease [7]. The integrated activity of the brain's motor and cognitive areas during dual-tasking can lead to efficient movement and coordinated functional activities [14]. This study investigated the effect of a motor-cognitive-based physiotherapy approach on motor experiences in daily life and gross manual dexterity in the upper extremities. The secondary aim was to investigate the effect of the adopted treatment approach on the patient's quality of life.

## Materials and methods

### Ethics, sample size, and randomization

The study population consisted of patients diagnosed with Parkinson's disease in Istanbul, Turkey. Ethical approval from the Karadeniz Technical University Scientific Research Ethics Committee was obtained prior to the commencement of the study (Approval No: 2024/109). Also, this study was registered to clinicaltrials.gov with NCT06803212 ID (01.30.2025). Also, this study is a randomized controlled trial and has been reported in accordance with the CONSORT guidelines.

The GPower 3.1.9.7 (Heinrich-Heine-Universität Düsseldorf, Germany) software was used to calculate the sample size required for the study. A study by Park et al. was used as a reference for the effect size, which was accepted as 0.94 based on this [14]. The GPower software calculated the minimum required sample size as 30 participants, with an effect size of 0.94, alpha error of 0.5, power of 80%, and a group sample distribution of 1:1. Patients were divided into two groups using tools available at the www.randomready.com website by the non-blinded researcher according to the basic randomization rules. One group received a routine upper extremity rehabilitation program, while the other group received dual-tasking and routine treatment (Fig. 1).

### Participants

Patients aged 50–85 years with a diagnosis of Stage 1–3 Parkinson's disease, based on the Hoehn & Yahr Scale, were included in the study. Furthermore, as per the

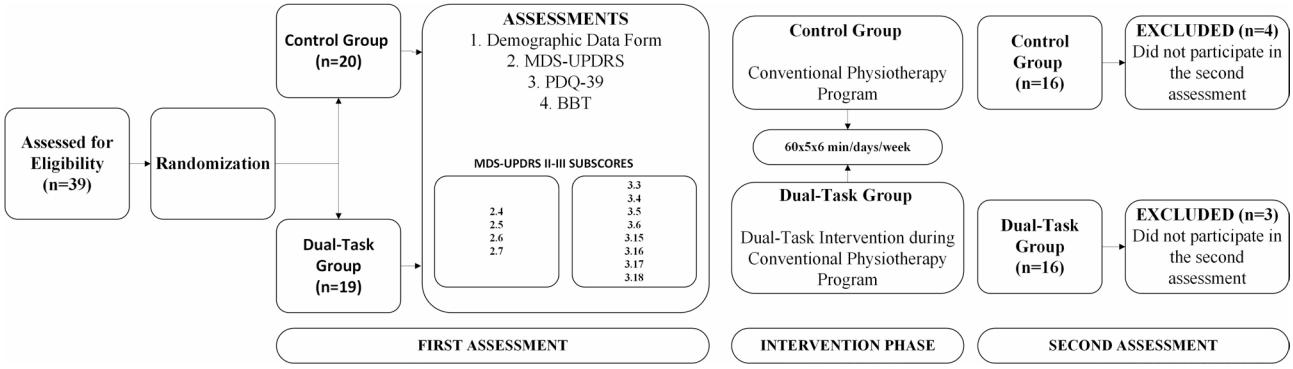



**Fig. 1** Flow Diagram Summary of the Study

inclusion criteria, patients had to have no issues with performing basic mathematical operations, a Mini-Mental State Examination (MMSE) score above 24 points, regular medication use for at least 4 weeks (for patients who were prescribed medical treatment), and no comorbid neurological, neuromuscular, or orthopedic diseases. Exclusion criteria included patients with vision or hearing impairments, moderate-to-severe fluctuations in tremor or dyskinesia, deep brain stimulator implants, or sensory loss in the upper extremities.

An unauthorized version of the Turkish MMSE was used by the study team without permission, however this has now been rectified with PAR. The MMSE is a copyrighted instrument and may not be used or reproduced in whole or in part, in any form or language, or by any means without written permission of PAR (www.parinc.com).

## Interventions

### *Routine conventional physiotherapy program*

The rehabilitation programs were developed individually, based on patients' needs in the physical therapy clinic of the private hospital. Overall, balance, strengthening, and coordination exercises were used for the lower extremities, while stretching, strengthening, coordination, sequencing, and reaction exercises were included for the upper extremities. A physiatrist and physiotherapist planned the routine rehabilitation program for the patients within the scope of the study. Routine treatment programs were performed for 60 min a day, 5 days a week, for 6 weeks by physiotherapists.

### *Dual-Tasking*

Dual-tasking was integrated into rehabilitation sessions as part of the routine upper extremity rehabilitation. These practices included reading words backwards, counting backwards from 100 by sevens, and reciting the months of the year in reverse order. The physiotherapist selected the words for backward reading from commonly used in daily life. Dual-tasking was applied during all routine treatment program sessions, with only one patient in the treatment room at a time.

Approximately half of the routine rehabilitation program for Parkinson's disease patients (30–35 min) included upper extremity rehabilitation. Dual-tasking interventions continued throughout all upper extremity rehabilitation sessions. Dual task interventions of reading words backwards and counting backwards were performed throughout all sessions. While counting backwards from 100 was the same across all sessions but different words were used in each session for the word backwards.

### *Assessments*

Study data were collected face-to-face from all patients, and all assessments were performed while patients were in the "ON" state. "This state means that patients must have used medication before coming to the hospital for rehabilitation. All assessments, except the demographic data form, were performed twice—at the beginning and at the end of the treatment. Assessments were performed by a physiotherapist experienced in neurological rehabilitation who was not a researcher for this study.

Demographic data form This form was developed by the investigators and included age, body mass index, disease duration, sex, dominant limb, education level, presence of freezing, presence of tremor, MMSE score, total daily dose of levodopa, and Hoehn & Yahr Staging.

### *Movement Disorder Society (MDS)-Unified Parkinson's Disease Rating Scale (MDS-UPDRS)*

The scale consists of four separate domains. The first section includes non-motor experiences in daily life (13 items), the second section includes motor experiences in daily life (13 items), the third section involves motor examination (33 items), and the last section addresses motor complications (6 items). The scale contains 65 individual items in total. Items are generally scored between 0 and 4, but also there are Yes/No items [15]. The domains of the scale directly related to the upper extremities, including eating, dressing, cleaning, writing, rigidity, finger movements, hand movements, pronation and supination of the hand, postural tremor in the hands, kinetic tremor in the hands, resting tremor, and tremor persistence, were used in this study (Fig. 1). The MDS-UPDRS scoring was performed while patients were in the "ON" state.

### *Box block test (BBT)*

The BBT consists of a panel and two boxes, one containing 150 wooden blocks. The patient is asked to transfer blocks from one box to another within 60 s, one block at a time, using only one hand. The test is repeated with both hands. The number of blocks moved provides the total score [16]. A higher score indicates better manual dexterity.

### *Parkinson's Disease Questionnaire – 39 (PDQ-39)*

This licensed tool assesses the quality of life associated with Parkinson's disease with a total of 39 items. Each item is scored between 0 and 4, with higher scores indicating poor quality of life. Responses are converted into hundredths for scoring, and the total score ranges from 0 to 100 points. The questionnaire includes eight domains: mobility, daily activities, emotional well-being, stigma, social support, information, communication, and physical dysfunction. The total score represents overall

**Table 1** Demographic characteristics of the patients

| Demographic Variables | Control | Dual-Task | *p* |
|---|---|---|---|
| Age (years) | 61.06 ± 10.63 | 66.06 ± 9.66 | 0.174 |
| Body Mass Index (kg/m$^2$ ) | 28.42 ± 4.93 | 28.88 ± 5.04 | 0.794 |
| Duration of Disease (years) | 3.53 ± 3.29 | 2.75 ± 2.38 | 0.452 |
| Sex, *n* (%) | | | |
| Female | 11 (68.80) | 6 (37.50) | 0.077 |
| Male | 5 (31.20) | 10 (62.50) | |
| Dominant Side, *n* (%) | | | |
| Right | 16 (100.00) | 16 (100.00) | NC |
| Left | 0 (0.00) | 0 (0.00) | |
| Education Status, *n* (%) | | | |
| Primary School | 8 (50.00) | 9 (56.30.20) | 0.934 |
| High School | 7 (43.80) | 6 (37.50) | |
| University | 1 (6.20) | 1 (6.30) | |
| Freezing Complaint, *n* (%) | | | |
| Yes | 10 (62.50) | 9 (56.20) | 0.719 |
| No | 6 (37.50) | 7 (43.80) | |
| Tremor Symptom, *n* (%) | | | |
| Yes | 14 (87.50) | 14 (87.50) | 1.000 |
| No | 2 (12.50) | 2 (12.50) | |
| Mini-Mental State Examination (score) | 25.25 ± 1.73 | 24.68 ± 1.35 | 0.314 |
| Levodopa-Equivalent Daily Dose (mg) | 165.00 ± 155.49 | 281.81 ± 285.18 | 0.192 |
| Hoehn & Yahr Stage, *n* (%) | | | |
| I | 6 (37.40) | 2 (12.40) | 0.236 |
| II | 3 (18.80) | 3 (18.80) | |
| III | 7 (43.80) | 11 (68.80) | |

*NC* Could not be Calculated

health-related quality of life [17]. General quality of life was calculated within the scope of this study. Written permission for the use of the scale was obtained from the copyright holder (International Parkinson and Movement Disorders Society) via email.

### Statistical analysis

The Shapiro–Wilk test, mean and standard deviation values and histogram curves were used to test whether the study data met the normal distribution hypothesis. Descriptive statistical data that met normal distribution were presented as frequency, mean, and standard deviation. Independent groups *t*-test and paired groups *t*-test were used for intergroup comparisons, as the data met the normal distribution hypothesis. Chi-squared analysis was performed for categorical variables. A p-value of $< 0.05$ was considered statistically significant for all analyses. All analyses were conducted by researchers.

## Results

All demographic characteristics of the groups were similar in this study of 32 patients ($p > 0.05$). The mean age of the control group was 61.06 ± 10.63 years, and the mean age of the Dual-Task group was 66.06 ± 9.66 years ($p = 0.174$). The time from diagnosis was 3.53 ± 3.29 years for the control group and 2.75 ± 2.38 years for the Dual-Task group ($p = 0.452$). There were no left-hand dominant patients in either group. Upon intergroup review of freezing complaints, 10 patients in the control group and nine patients in the Dual-Task group reported freezing. Tremor symptoms were present in 14 patients in each group ($p = 1.000$). The mean daily dose of levodopa in the control group was 165.00 ± 155.49 mg, and in the dual-task group was 281.81 ± 285.18 mg ($p = 0.192$). The distribution of the groups by Hoehn & Yahr staging was also similar ($p = 0.236$) (Table 1).

**Table 2** Comparison of the variables between groups

| Variables | Groups | Baseline | 30th Session | Difference (%) | $p^a$ |
|---|---|---|---|---|---|
| MDS-UPDRS II | Control | 5.18 ± 2.25 | 5.37 ± 2.36 | 3.67 | 0.383 |
| | Dual-Task | 6.43 ± 2.70 | 5.62 ± 2.68 | −12.50 | 0.072 |
| | $p^b$ | *0.166* | *0.781* | - | - |
| MDS-UPDRS III | Control | 16.62 ± 7.48 | 15.87 ± 7.63 | −4.51 | 0.013 |
| | Dual-Task | 24.56 ± 13.75 | 21.25 ± 10.85 | −13.48 | 0.080 |
| | $p^b$ | *0.054* | *0.116* | - | - |
| BBT - right | Control | 26.81 ± 8.87 | 29.00 ± 8.12 | 8.17 | 0.001 |
| | Dual-Task | 22.18 ± 4.18 | 25.06 ± 4.41 | 12.98 | 0.001 |
| | $p^b$ | *0.073* | *0.796* | - | - |
| BBT - left | Control | 24.93 ± 7.57 | 27.46 ± 7.03 | 10.15 | 0.002 |
| | Dual-Task | 24.12 ± 5.89 | 26.75 ± 6.22 | 10.90 | 0.012 |
| | $p^b$ | *0.102* | *0.805* | - | - |
| PDQ-39 | Control | 54.50 ± 24.27 | 52.43 ± 24.46 | −3.80 | 0.413 |
| | Dual-Task | 59.87 ± 22.70 | 49.43 ± 19.64 | −17.44 | 0.003 |
| | $p^b$ | *0.523* | *0.705* | - | - |

$p^a$: Paired Sample *t*-test results; $p^b$: Independent Sample *t*-test results; *MDS-UPDRS* Movement Disorders Society-The Unified Parkinson's Disease Rating Scale,*PDQ*-39 Parkinson Disease Questionnaire-39,*BBT* Box and Block Test

Upon analysis of intergroup comparisons, there was no difference in baseline MDS-UPDRS II ($p = 0.166$) and III sub-scores ($p = 0.054$); PDQ-39 ($p = 0.523$); BBT-right extremity ($p = 0.073$); and BBT-left extremity ($p = 0.102$) variables between the groups. No intergroup difference was found after 30 treatment sessions ($p > 0.05$ for all).

Based on the results of intragroup analyses, the MDS-UPDRS II ($p = 0.383$) and PDQ-39 ($p = 0.413$) variables in the control group did not change significantly after the treatment, while improvements were seen in MDS-UPDRS III ($p = 0.013$), BBT-right ($p = 0.001$), and BBT-left ($p = 0.002$) variables. In the Dual-Task group, statistically significant positive changes were observed in all variables except MDS-UPDRS II ($p = 0.072$) and III ($p = 0.080$) sub-variables ($p < 0.05$ for all) (Table 2).

## Discussion

The aim of the study was to investigate whether a motor-cognitive-based physiotherapy rehabilitation program would affect upper extremity motor experiences and

quality of life in patients with Parkinson's disease. The study results indicated that adding non-motor secondary tasks to traditional physiotherapy practices positively influenced the treatment's effectiveness. Although there were no intergroup differences in results, the dual-task group showed more favorable changes in MDS-UPDRS II-III, BBT and PDQ-39 variables in intragroup analyses.

Functional involvement of the upper extremity in patients with Parkinson's disease is initially asymmetric, and decreased amplitude and functional capacity in repetitive activities of the upper extremities can be observed in subsequent years [18]. Conventional physiotherapy applications are used to reduce motor symptoms in managing Parkinson's disease [19]. In summary, while no intergroup difference was found in the parameters of upper extremity motor evaluations, the Dual-Task group showed more positive effects upon intragroup comparisons.

There are only a few previous studies on the effect of dual-tasking in treating Parkinson's disease-induced upper extremity involvement. Most studies have focused on lower limb function. Some studies on the upper extremity report varying results. For instance, Park and Kim reported that dual-task-based upper extremity practice significantly improved motor control and attention [14]. Another study found that patients who received both conventional and dual-tasking improved their BBT performance [20]. However, Varalta et al. introduced dual-tasking after physiotherapy and found no difference in movement capacity compared to the physiotherapy-only group. Upon intragroup evaluations, both groups improved in the same parameters [21]. A study by Proud et al. found that simultaneous cognitive-based dual-tasking with the Purdue Pegboard Test (PPT) decreased patients' manual dexterity. It was suggested that this could be due to patients focusing more on manual dexterity and allocating insufficient cognitive resources to the dual-task practice [22]. Cognitive involvement in patients with Parkinson's disease, particularly in later stages, is linked to an inability to meet the demand for high-level cognitive functions required for functional activities of the upper limbs, resulting in worsened dexterity during dual-tasking [8]. In the present study, improvements in upper extremity function and manual dexterity were observed after 30 sessions of dual-tasking. This supports individuals in their daily activities and coping strategies [23]. The relatively early diagnosis of patients and the length of the treatment period may have directly affected the positive outcomes observed in this study.

Motor complications associated with Parkinson's disease not only limit daily activities but also worsen quality of life [24]. Based on the results of the present study, while improvements in quality of life were observed in both groups, there was a significant improvement in the PDQ-39 score of the dual-task group. Previous studies have primarily investigated the effect of conventional physiotherapy on quality of life [25]. However, there are only a few studies on the effect of dual-tasking on quality of life in Parkinson's disease patients. Most of these studies have focused on lower extremity functionality [19, 26, 27]. Dual-tasking has been suggested as a strong predictor of upper extremity-related daily activity performance in patients with Parkinson's disease [28]. Acaröz et al. reported decreased manual function during dual-tasking and emphasized that rehabilitation programs should aim to enhance dual-task performance [29]. Another study reported that dual-tasking prolonged motor task completion time and led to improvements in independent living skills [30]. In the present study, dual-tasking in addition to conventional methods resulted in further improvements in motor functions, which we suggest has a direct positive effect on quality of life.

The present study has some limitations. Patients were included during their "ON" period, which may have affected their upper extremity performance. Additionally, the patients did not undergo upper extremity rehabilitation alone during conventional physiotherapy programs, as the programs were adapted to individual needs. Nonetheless, upper extremity applications were incorporated in each session. Another limitation is that patients were between Stages 1–3 based on the Hoehn & Yahr classification. Due to the nature of the study, blinding of participants was not possible, and information about their assignment to a group was shared with them after randomization. Furthermore, with the ethics committee's approval, participants were given general information regarding the study's purpose and the treatment to be administered within the voluntary consent form. This may have led to higher expectations, particularly among participants in the additional intervention group, and therefore, the emergence of response biases that could have influenced subjective assessment results. This potential bias should be considered when interpreting the study's findings based on subjective criteria. A final limitation is the use of the MMSE to assess cognitive status. While the MMSE, a rapid assessment tool in the clinical setting, can be used to identify severe cognitive deficits, it is limited in its sensitivity to executive functions and dual-task performance. So, we believe that tools that can assess executive functions in more detail (such as the Montreal Cognitive Assessment-MoCA) would be more appropriate for future studies. Future studies investigating each individual stage may provide valuable insights into the effects of dual-task interventions.

## Conclusion

This study investigated the effects of a motor-cognitive-based dual-task intervention on motor function and quality of life in patients with Parkinson's disease. The results showed that motor improvement and quality of life were greater in the dual-task group. Dual-tasking has the potential to strengthen patients' attention processes and increase their coordination skills. Furthermore, incorporating dual-tasking into the rehabilitation process can simulate real-world tasks and facilitate transitions between them, helping patients perform daily activities. Therefore, the inclusion of dual-task applications in rehabilitation practices can be a useful tool to maximize rehabilitative gains.

Our results suggest that not only physiological but also cognitive changes may occur during the intervention process in Parkinson's disease patients. Future studies are recommended to clarify these mechanisms more clearly, with larger sample sizes, longer-term follow-up, more detailed assessments of cognitive functions, and incorporating neurophysiological parameters. Furthermore, comparative studies with control groups may allow for the dissociation of learning effects, intervention contributions, and compensatory strategies.

## Supplementary Information

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Supplementary Material 1.

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**Authors' contributions**
All authors contributed to conception, drafting, and reviewed the manuscript. In addition, E.Ş. contributed to the data collection, analysis, and interpretation section. S.K contributed to the analysis and interpretation. A.A. contributed to the data collection.

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**Data availability**
All data analyzed during this study are included in this published article.

## Declarations

**Ethics approval and consent to participate**
All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Karadeniz Technical University Scientific Research Ethics Committee approved this research (Approval No: 2024/109). Patients were verbally informed before the study and then signed a written consent form stating that they participated in the study voluntarily.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare no competing interests.

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