OPEN ACCESS
Turkish Journal of Kinesiology

ORIGINAL RESEARCH

Tele-rehabilitation-based exercise in Parkinson's disease: A pilot study of feasibility and preliminary outcomes

Emine Nur Demircan[1], Nezire Köse[2], Hatice Yağmur Zengin[3], Gül Yalçın Çakmaklı[4], Özden Baskan[5]

[1] Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Istanbul Kent University, Istanbul, Türkiye. [2] Department of Physiotherapy and Rehabilitation, Faculty of Physical Therapy and Rehabilitation, Hacettepe University, Ankara, Türkiye. [3] Department of Biostatistics, Faculty of Medicine, Hacettepe University, Ankara, Türkiye. [4] Department of Neurology, Faculty of Medicine, Hacettepe University, Ankara, Türkiye. [5] Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Istanbul Rumeli University, Istanbul, Türkiye.

Received:
May 1, 2026

Accepted:
June 11, 2026

Published:
June 30, 2026

Keywords:
Exercise, Parkinson disease, quality of life, telerehabilitation.

Abstract

This pilot study examined the feasibility and preliminary effects of two exercise programs delivered via tele-rehabilitation in individuals with Parkinson's disease (PD). Twelve individuals with PD, previously allocated to two groups in a prior face-to-face study, re-engaged in the same protocols remotely. Group 1 received a conventional exercise program (CEP) combined with cervical stabilization exercise (CSE), and Group 2 received the CEP alone. Both programs were delivered via synchronous video-based tele-rehabilitation (one 60-minute session per week for eight weeks). The following outcomes were assessed pre- and post-intervention: Unified Parkinson's Disease Rating Scale (UPDRS), visual analog scale, Short Form 36 (SF-36), 30-second chair stand test (30s-CST), static standing test, Fear of COVID-19 Scale, Beck Anxiety Inventory, Beck Depression Inventory, and ACTIVLIM Scale. Both groups showed pre-to-post improvements in total UPDRS scores, the mental health and vitality subdomains of the SF-36, 30s-CST performance, single-limb stance and depressive symptoms ($p<0.05$). Group 2 also showed improvement in UPDRS-II, bodily pain, social functioning, health transition, tandem stance, and anxiety ($p<0.05$). Group 1 exhibited numerically greater pre-to-post changes in UPDRS-III, the SF-36 mental health and role limitation subdomains, functional performance, balance, pandemic-related fear and activity limitations, with large effect sizes observed for selected parameters (Cohen's $d>0.80$). Tele-rehabilitation appears to be a feasible and well-tolerated mode of exercise delivery for individuals with PD, and was associated with improvements across multiple outcomes. Our preliminary findings suggest that integrating CSE into remote rehabilitation programs may offer additional benefit, but they should be supported in adequately powered trials.

Introduction

Parkinson's disease (PD) is the second most common neurodegenerative disorder. It primarily affects the dopaminergic pathways in the substantia nigra, leading to progressive motor dysfunction (Bloem et al., 2021). Motor symptoms include bradykinesia, resting tremor and rigidity, with postural instability typically emerging in the later stages (Magrinelli et al., 2016). Non-motor symptoms include autonomic dysfunction, depression, anxiety, fatigue, sleep disturbances, paresthesia and pain (Bloem et al., 2021).

Although the benefits of exercise are well established, many patients find it difficult to participate in regular physical therapy due to disability related to the disease, transportation issues and unequal access to rehabilitation services (Schootemeijer et al., 2020; Torriani-Pasin et al., 2022).

The disruption caused by the pandemic further limited access to physiotherapy and reduced engagement in regular physical activity, prompting a shift towards tele-rehabilitation as a practical alternative (Muñoz-Tomás et al., 2023; Papa et al., 2020; Vellata et al., 2021).

✉ E. N. Demircan, e-mail: eminenur.demircan@kent.edu.tr
Turk J Kinesiol, 12(3), 300-312. doi: 10.31459/turkjkin.1941478

Tele-rehabilitation, which involves the remote delivery of rehabilitation services via information and communication technologies, is a promising option for individuals requiring long-term care (Fırat et al., 2024). Previous studies have reported its effectiveness in improving balance in neurological disorders (Truijen et al., 2022), and in enhancing upper limb function, posture, gait and balance in PD (Gandolfi et al., 2017; Hashemi et al., 2022). Although stabilization exercises have been studied in PD, research on cervical stabilization exercise (CSE) specifically remains limited. A previous study by our team yielded promising results (Demircan et al., 2023), yet the effects of integrating these exercises into a conventional exercise program (CEP) delivered via tele-rehabilitation have not been adequately examined.

Given that postural control impairments, axial rigidity and altered head–neck alignment are common in PD and contribute to balance deficits and functional limitations, CSE was included. The cervical region plays a key role in maintaining head stability, visual orientation, and sensorimotor integration, all of which are crucial for postural control and safe movement. Therefore, targeting cervical muscle activation within a structured CEP may offer supplementary benefits beyond general strengthening and mobility training (Demircan et al., 2023).

The primary aim of this pilot study was to examine the feasibility and preliminary effects of tele-rehabilitation-delivered exercise on clinical and functional outcomes in individuals with PD who were unable to continue with face-to-face physiotherapy during the pandemic. A secondary aim was to explore whether the addition of CSE to a CEP produced any observable differences in outcomes when delivered remotely. In line with the exploratory nature of this study, the following preliminary questions were addressed: (1) whether a CEP delivered via tele-rehabilitation was associated with pre-to-post improvements in clinical and functional outcomes; (2) whether combining a CEP with CSE was similarly associated with improvements; and (3) whether any numerical differences in outcomes were observed between the two protocols.

Methods

Study Design and Participants

The study was approved by the Ethics Committee of Istanbul Rumeli University (approval no: 2021/02-08, date: 31/03/2021) and registered with ClinicalTrials.gov (Identification no.: NCT04982887). Written informed consent was obtained from all participants prior to enrollment. Recruitment of participants took place between May and November 2021. All participants completed the eight-week intervention by December 2021. There was no defined follow-up period beyond the intervention.

The sample consisted of individuals diagnosed with PD who had previously completed an eight-week, face-to-face physiotherapy program involving two different exercise protocols, which was delivered as part of a Master's thesis at Hacettepe University approximately three years prior to the current study.

Of the original cohort, 18 participants were contacted by telephone. One participant had died, one could not be reached, and four declined to participate, leaving 12 individuals (six participants in each group) enrolled (Figure 1). The study was unblinded. Due to the nature of the interventions, blinding of participants was not feasible. Outcome assessments and the exercise sessions were conducted by the same individual, who was not blinded to group allocation.

As the participants were already familiar with the exercise content from the original face-to-face study, the tele-rehabilitation program was implemented exclusively with this sample, without a control group. The primary objectives were to evaluate the feasibility and preliminary effects of delivering these programs remotely, and to explore the additional impact of CSE when administered via tele-rehabilitation in individuals with PD.

The eight-week intervention consisted of one supervised tele-rehabilitation session per week delivered via synchronous video call with real-time physiotherapist guidance, and the unsupervised home-based exercise program performed independently on the remaining days.

Inclusion and Exclusion Criteria

Participants were included if they had received a clinical diagnosis of PD, had previously completed the face-to-face physiotherapy program, were classified as Modified Hoehn and Yahr stage 1–3 and were able to stand and walk independently without the use of assistive devices.

Those excluded from the study had a Modified Hoehn and Yahr stage of 4–5, orthopedic conditions that limited their ability to participate in exercise, or neurological disorders other than PD.

Prior to commencing the program, each participant's ability to maintain unsupported standing and perform balance-related tasks safely was confirmed, ensuring suitability for the exercise content delivered remotely.

Assessments

The following demographic characteristics were recorded: gender, age and BMI. Cognitive status was assessed by the Standardized Mini-Mental Test (SMMT) at baseline (Tabei et al., 2023), which was administered via video call. Participants who scored ≥ 26 were considered cognitively intact and eligible for inclusion.

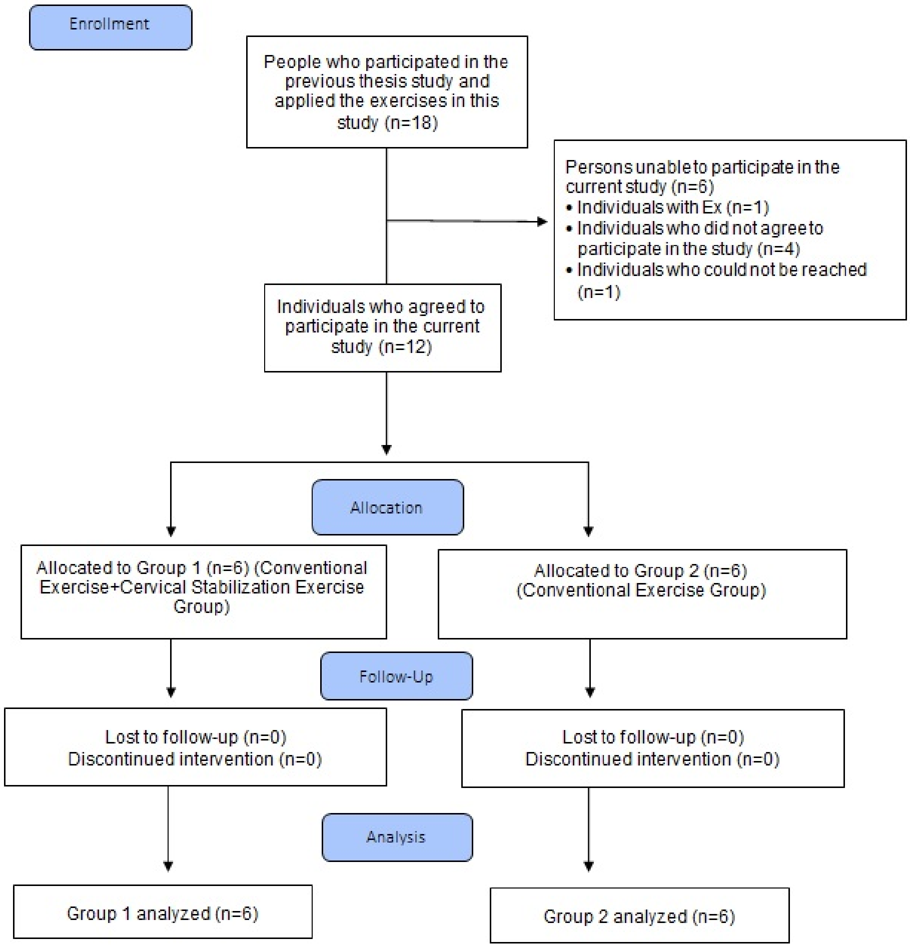

Figure 1. TREND flow chart of the study.

All outcome assessments were conducted remotely via video call by the treating physiotherapist (E. N. D.) employing a standardized online evaluation form before and after the intervention. Family members provided assistance where required.

Primary Outcome Measures

Disease severity and treatment-related complications were evaluated by the Unified Parkinson's Disease Rating Scale (UPDRS) ("The Unified Parkinson's Disease Rating Scale (UPDRS): status and recommendations," 2003); pain via the visual analog scale (VAS) (Reed & Van Nostran, 2014); and quality of life (QoL) via the Short Form 36 (SF-36) (Jenkinson et al., 1993). The UPDRS was administered via video call. All items were completed through structured questioning by the assessor, with responses provided by the participant and, where necessary, their family member. For motor items, participants were given verbal commands and their movements were observed remotely by the assessor. Items requiring physical examination, such as rigidity and postural stability, were assessed with the assistance of family members present during the session, who performed the necessary maneuvers under the assessor's visual guidance.

Secondary Outcome Measures

Dynamic balance was assessed through the 30s-CST (Jones et al., 1999). Static balance was evaluated using the static standing test (SST), which comprises five positions (feet apart, step stance, feet together, tandem stance, and single-limb stance), each of which was held with the eyes open and timed (Smithson et al., 1998). Pandemic-related fear was measured using the Fear of COVID-19 Scale (FCV-19S) (Ladı́klı́ et al., 2020); anxiety, using the Beck Anxiety Inventory (BAI) (Ferreira et al., 2018); and depression, using the Beck Depression Inventory (BDI) (Chuquilín-Arista et al., 2020). Activities of Daily Living (ADLs) were measured by means of the ACTIVLIM scale (Vandervelde et al., 2007).

Intervention

Approximately three years earlier, participants had been allocated to two exercise groups as part of a randomized face-to-face study conducted at Hacettepe University. In our study, the same group assignments were retained and the same protocols were re-administered via tele-rehabilitation, with minor adaptations based on individual baseline assessments to preserve the original structure and content.

Sessions were conducted synchronously via WhatsApp video calls over eight weeks, each lasting 60 minutes and taking place once per week under the supervision of a physiotherapist (E.N.D.). On the remaining six days, participants performed the exercises independently at home, and adherence was monitored via daily checklists completed by relatives and submitted weekly. Family members were present during all sessions and no adverse events were reported.

The CEP comprised standardized physiotherapy components commonly used in PD rehabilitation, including joint mobility, muscle strengthening, flexibility, postural control, balance, and functional activities.

Group 1 received the CEP combined with a progressive three-phase CSE program. Group 2 received the CEP alone (Appendix). To ensure equivalence in exercise volume and session duration, the total exercise time was matched by adjusting the CEP content for Group 1 and modifying the intensity or duration for Group 2 where necessary. Participants did not receive any other formal physiotherapy or rehabilitation programs during the study.

Data Analysis

Statistical analyses involved all 12 participants who were enrolled. There were no missing data. No additional subgroup or sensitivity analyses were conducted. All analyses were performed in IBM SPSS Statistics (version 23.0, IBM Corporation, Armonk, NY, USA). The Shapiro–Wilk test was used to assess data normality, which is appropriate for small samples. Given the limited sample size, effect sizes were calculated and reported alongside significance values to improve interpretability.

Categorical variables were presented as frequencies (n) and percentages (%), while numerical data were presented as the mean ± standard deviation and the median (minimum–maximum). Depending on data distribution, between-group comparisons of numerical variables were conducted using either Student's t-test or the Mann–Whitney U test, while the Fisher–Freeman–Halton exact test was applied to categorical variables.

Given the small sample size and the absence of an a priori power calculation, between-group comparisons are considered exploratory and should be interpreted with caution. Effect size estimates are reported to aid interpretation but should be regarded as imprecise given the limited sample; very large values in particular may reflect sampling variability rather than true effects. Symmetrical percent change (SPC) was calculated as (Post – Pre)/(Post + Pre) × 100 (Berry & Ayers, 2006) to assess relative change. Within-group comparisons were performed using the paired samples t-test or the Wilcoxon signed-rank test for normally and non-normally distributed variables, respectively. Effect sizes were computed using Cohen's d and interpreted as small (≈0.20), medium (≈0.50), or large (≈0.80) (Cohen, 1992).

Results

The study involved 12 participants (six participants in each group), with the groups being comparable in terms of age, BMI, gender, and SMMT scores (p>0.05; Table 1). No adverse events or harms were observed during the study.

Table 1
Comparison of socio-demographic and clinical characteristics of the participants.

Variables	Group 1 (n=6)	Group 2 (n=6)	p
Age (years)	58.33 ± 9.31	59.67 ± 13.84	0.849[a]
BMI (kg/m^2)	28.59 ± 5.92	24.84 ± 3.13	0.310[a]
Gender			
Female	2 (33.3 %)	3 (50.0 %)	1.000[b]
Male	4 (66.7 %)	3 (50.0 %)	
SMMT	28.00 ± 0.89	27.67 ± 1.37	0.628[a]

Numerical variables are presented as the mean ± standard deviation, whereas categorical variables are presented as frequencies (percentage). BMI: Body Mass Index, SMMT: Standardized Mini-Mental Test. Significance at p<0.05 is indicated by bold font. [a]: Independent Samples t-test p-value; [b]: Fisher–Freeman–Halton exact test p-value.

Significant improvements were detected by within-group analyses in total UPDRS scores, as well as in the mental health and vitality subdomains of the SF-36, in both groups (p<0.05). Group 2 also showed improvement in the UPDRS-II subdomain and the social functioning, pain and health transition SF-36 subdomains. Effect sizes were numerically larger for Group 1 in UPDRS-III, Mental Health and Vitality subdomains of the SF-36, and for Group 2 in UPDRS-I, UPDRS-II and total UPDRS, VAS and the remaining SF-36 subdomains (Table 2).

Table 2
Intra-group comparisons of primary measurements.

Measures		Group 1 Baseline Mean ± SD Median (Min-Max)	Group 1 After Mean ± SD Median (Min-Max)	p (dz)	Group 2 Baseline Mean ± SD Median (Min-Max)	Group 2 After Mean ± SD Median (Min-Max)	p (dz)
UPDRS	I (Mental status, behavior and mood) (0-16 point)	1.67 ± 3.14 0.50 (0.00-8.00)	1.17 ± 0.75 1.00 (0.00-2.00)	0.713 (0.153) [b]	3.67 ± 2.42 3.50 (1.00-8.00)	2.50 ± 3.02 2.00 (0.00-8.00)	0.135 (0.728) [a]
UPDRS	II (Activities of daily living) (0-52 point)	8.33 ± 3.50 8.00 (4.00-13.00)	6.50 ± 4.89 8.00 (0.00-11.00)	0.130 (0.738) [a]	14.33 ± 9.22 15.00 (4.00-26.00)	11.33 ± 9.63 11.00 (0.00-25.00)	**0.048* (1.061)** [a]
UPDRS	III (Motor examination) (0-92 point)	9.50 ± 1.87 9.50 (7.00-12.00)	5.67 ± 4.72 3.50 (1.00-13.00)	0.126 (0.749) [a]	12.00 ± 8.65 13.50 (0.00-22.00)	9.17 ± 7.68 9.50 (0.00-22.00)	0.102 (0.705) [b]
UPDRS	IV (Treatment complications) (0-23 point)	**1.67 ± 1.51**** **1.00 (0.00-4.00)**	1.33 ± 1.97 0.50 (0.00-5.00)	0.741 (0.143) [a]	**6.50 ± 3.45**** **6.00 (2.00-11.00)**	4.83 ± 3.60 5.00 (0.00-10.00)	0.054 (1.021) [a]
UPDRS	Total (0-183 point)	21.17 ± 7.68 20.00 (12.00-34.00)	14.67 ± 10.46 15.50 (2.00-28.00)	**0.049* (1.056)** [a]	36.50 ± 19.70 40.00 (10.00-56.00)	27.83 ± 21.52 25.00 (0.00-54.00)	**0.032* (1.208)** [a]
VAS (0-10 point)	Activity	1.83 ± 2.99 0.00 (0.00-7.00)	1.17 ± 1.84 0.00 (0.00-4.00)	0.666 (0.187) [a]	4.67 ± 2.73 5.50 (0.00-7.00)	2.67 ± 2.94 2.50 (0.00-6.00)	0.210 (0.587) [a]
VAS (0-10 point)	Rest	1.00 ± 2.00 0.00 (0.00-5.00)	0.67 ± 1.63 0.00 (0.00-4.00)	0.157 (0.645) [b]	2.50 ± 2.43 1.50 (0.00-6.00)	1.00 ± 1.27 0.50 (0.00-3.00)	0.137 (0.723) [a]
SF-36 (Each subparameter is 0-100 points)	Physical Functioning	79.17 ± 11.58 77.50 (65.00-100.00)	86.67 ± 10.33 87.50 (75.00-100.00)	0.215 (0.580) [a]	55.83 ± 29.57 55.00 (10.00-90.00)	69.17 ± 33.08 85.00 (10.00-95.00)	0.057 (1.003) [a]
SF-36 (Each subparameter is 0-100 points)	Role Limitations due to Physical Problems	65.00 ± 39.37 70.00 (0.00-100.00)	75.00 ± 41.83 100.00 (0.00-100.00)	0.180 (0.500) [b]	50.00 ± 47.43 50.00 (0.00-100.00)	75.00 ± 38.73 100.00 (25.00-100.00)	0.102 (0.645) [b]
SF-36 (Each subparameter is 0-100 points)	Mental Health	68.00 ± 15.60 70.00 (40.00-84.00)	78.00 ± 16.54 84.00 (52.00-92.00)	**0.022* (1.336)** [a]	65.33 ± 17.28 64.00 (44.00-88.00)	76.83 ± 18.57 82.50 (52.00-96.00)	**0.039* (0.804)** [b]
SF-36 (Each subparameter is 0-100 points)	Role Limitations due to Emotional Problems	61.17 ± 39.04 67.00 (0.00-100.00)	72.17 ± 44.36 100.00 (0.00-100.00)	0.642 (0.202) [a]	66.83 ± 36.52 67.00 (0.00-100.00)	72.33 ± 38.95 83.50 (0.00-100.00)	0.851 (0.081) [a]
SF-36 (Each subparameter is 0-100 points)	Vitality	56.67 ± 12.91 57.50 (40.00-75.00)	69.17 ± 13.57 70.00 (50.00-90.00)	**0.037* (1.153)** [a]	42.50 ± 28.06 42.50 (10.00-75.00)	50.00 ± 28.28 50.00 (20.00-90.00)	**0.017*(1.430)** [a]
SF-36 (Each subparameter is 0-100 points)	Social Functioning	73.17 ± 18.64 81.50 (50.00-88.00)	81.33 ± 15.19 75.00 (63.00-100.00)	0.433 (0.348) [a]	69.00 ± 13.16 69.00 (50.00-88.00)	85.17 ± 18.94 94.00 (60.00-100.00)	**0.028*(1.248)** [a]
SF-36 (Each subparameter is 0-100 points)	Bodily Pain	74.83 ± 34.11 84.00 (13.00-100.00)	84.33 ± 17.41 90.00 (58.00-100.0)	1.000 (0.284) [b]	60.17 ± 23.51 61.50 (25.00-90.00)	74.67 ± 25.78 79.00 (45.00-100.00)	**0.009*(1.673)** [a]
SF-36 (Each subparameter is 0-100 points)	General health	53.33 ± 17.22 47.50 (40.00-85.00)	61.67 ± 19.41 57.50 (40.00-85.00)	0.378 (0.394) [a]	49.17 ± 25.58 40.00 (25.00-85.00)	54.17 ± 27.10 45.00 (25.00-90.00)	0.111 (0.791) [a]
SF-36 (Each subparameter is 0-100 points)	Health Transition	37.50 ± 13.69 37.50 (25.00-50.00)	54.17 ± 24.58 62.50 (25.00-75.00)	0.175 (0.645) [a]	41.67 ± 34.16 37.50 (0.00-100.00)	62.50 ± 26.22 62.50 (25.00-100.00)	**0.042*(1.107)** [a]

*Numeric variables are presented as the mean ± standard deviation and the median (minimum–maximum). UPDRS: Unified Parkinson's Disease Rating Scale, VAS: visual analog scale, SF-36: Short Form 36. p(dz): p-value and effect size of within-group comparisons. *: Significant p-value (alpha level set to p<0.05). **: Parameters that differ between groups in baseline measurements are indicated in bold at p<0.05. [a]: Paired samples t-test p value, [b]: Wilcoxon test p value.*

For the secondary outcomes, significant improvements were observed in both groups in the 30s-CST, single-limb stance and BDI (p<0.05). Group 2 also improved in tandem stance and BAI. Effect sizes were numerically larger for Group 1 in the 30s-CST, single-limb stance overall, the FCV-19S and the ACTIVLIM scale, and for Group 2 in the tandem stance, the BAI and the BDI scale (Table 4).

Pre-treatment values were homogeneously distributed (*p*>0.05). SPC comparisons for feet apart, step stance and feet together in Group 1 could not be computed due to an absence of change. However, a between-group SPC difference was observed for single-limb stance (p<0.05); but this finding should be interpreted cautiously given the small sample size and exploratory nature of the study. Large effect sizes were observed for step stance, feet together, single-limb stance, and BAI (Cohen's d>0.80). Of these, the effect sizes for step stance and feet together are artifacts of a ceiling effect, as is the effect size for feet apart (d=0.58): Group 1 remained at the 60-second maximum for all three positions, resulting in zero variance and rendering these estimates uninterpretable as meaningful between-group differences. The effect size for BAI (d=1.32) should likewise be interpreted with caution, as the estimate is imprecise given the small sample size (Table 5).

Table 3
Intergroup comparisons of symmetrical percent change in primary measurements.

Measures	Group 1 Mean ± SD Median (Min-Max)	Group 2 Mean ± SD Median (Min-Max)	p	Cohen's d
UPDRS				
I (Mental status, behavior and mood) (0-16 point)	25.93 ± 68.01 16.67 (-77.78-100.00)	-35.71 ± 50.10 -7.14 (-100.00-0.00)	0.093[b]	0.26
II (Activities of daily living) (0-52 point)	-27.65 ± 42.82 -6.80 (-100.00-7.69)	-29.14 ± 38.46 -15.00 (-100.00-0.00)	0.951[a]	0.44
III (Motor examination) (0-92 point)	-34.13 ± 37.41 -45.00 (-80.00-23.81)	-12.38 ± 14.88 -7.14 (-33.33-0.00)	0.215 [a]	0.22
IV (Treatment complications) (0-23 point)	-35.56 ± 64.59 -40.00 (-100.00-66.67)	-28.73 ± 39.70 -11.20 (-100.00-0.00)	0.830 [a]	0.66
Total (0-183 point)	-28.17 ± 30.75 -20.94 (-77.78-5.66)	-28.63 ± 37.41 -15.23[-100.00-(-1.82)]	1.000[b]	0.32
VAS (0-10 point)				
Activity	-2.38 ±63.51 0.00 (-100.00-100.00)	-31.94 ± 54.37 -8.33 (-100.00-25.00)	0.407 [a]	0.38
Rest	-18.52 ± 40.16 0.00 (-100.00-0.00)	-38.89 ± 49.07 -16.67 (-100.00-0.00)	0.589[b]	0.77
SF-36 (Each Subparameter is 0-100 points)				
Physical Functioning	4.62 ± 7.82 2.94 (-3.23-14.29)	9.92 ± 9.66 6.98 (0.00-21.43)	0.321[a]	0.44
Role Limitations due to Physical Problems	6.43 ± 13.35 0.00 (0.00-33.33)	35.71 ± 50.10 7.14 (0.00-100.00)	0.485[b]	0.15
Mental Health	7.11 ± 5.81 8.49 (-3.03-13.04)	8.13 ± 10.01 4.81 (0.00-27.78)	0.589[b]	0.13
Role Limitations due to Emotional Problems	3.29 ± 63.76 0.00 (-100.00-100.00)	3.29 ± 64.97 9.88 (-100.00-100.00)	1.000[a]	0.09
Vitality	10.15 ± 9.97 10.10 (-4.76-21.74)	12.56 ± 11.62 11.69 (0.00-33.33)	0.708[a]	0.59
Social Functioning	5.88 ± 15.52 3.19 (-7.98-33.33)	10.07 ± 7.72 8.53 (0.00-22.70)	0.566[a]	0.42
Bodily Pain	10.26 ± 31.77 0.00 (-7.94-74.76)	11.78 ± 9.69 11.46 (0.00-28.57)	0.093[b]	0.20
General health	6.83 ± 18.08 7.49 (-20.00-36.00)	5.18 ± 6.08 3.85 (0.00-14.29)	0.836[a]	0.21
Health Transition	15.00 ± 28.89 20.00 (-33.33-50.00)	33.89 ± 37.74 26.67 (0.00-100.00)	0.353[a]	0.18

UPDRS: Unified Parkinson's Disease Rating Scale, VAS: visual analog scale, SF-36: Short Form 36. p: Comparison of SPC between groups. d: Effect size for between-group comparisons. [a]: Student's t-test p-value, [b]: Mann–Whitney U test.

Table 4
Intra-group comparisons of secondary measurements.

Measures		Group 1 Baseline Mean ± SD Median (Min-Max)	Group 1 After Mean ± SD Median (Min-Max)	p (dz)	Group 2 Baseline Mean ± SD Median (Min-Max)	Group 2 After Mean ± SD Median (Min-Max)	p (dz)
30s-CST (number)		17.00 ± 5.22 17.50 (10.00-24.00)	21.67 ± 5.20 23.00 (15.00-27.00)	**<0.001*(3.416)** [a]	13.17 ± 6.82 14.00 (3.00-20.00)	17.50 ± 8.39 19.50 (6.00-26.00)	**0.005* (1.925)** [a]
Static Standing Test Positions (0-60 seconds)	P1	60.00 ± 0.00 60.00 (60.00-60.00)	60.00 ± 0.00 60.00 (60.00-60.00)		55.00 ± 12.25 60.00 (30.00-60.00)	60.00 ± 0.00 60.00 (60.00-60.00)	0.317 (0.408) [b]
	P2	60.00 ± 0.00 60.00 (60.00-60.00)	60.00 ± 0.00 60.00 (60.00-60.00)		48.83 ± 17.44 60.00 (23.00-60.00)	56.33 ± 8.98 60.00 (38.00-60.00)	0.180 (0.598) [b]
	P3	60.00 ± 0.00 60.00 (60.00-60.00)	60.00 ± 0.00 60.00 (60.00-60.00)		48.33 ± 18.35 60.00 (20.00-60.00)	52.50 ± 12.55 60.00 (30.00-60.00)	0.180 (0.627) [b]
	P4	49.67 ± 16.99 60.00 (20.00-60.00)	58.33 ± 4.08 60.00 (50.00-60.00)	0.180 (0.539) [b]	26.67 ± 20.41 25.00 (0.00-60.00)	34.33 ± 20.26 34.00 (0.00-60.00)	**0.037* (1.152)** [a]
	P5 (right)	7.50 ± 6.25 6.00(0.00-16.00)	19.67 ± 11.89 19.00 (3.00-34.00)	**0.006* (1.874)** [a]	8.50 ± 5.79 8.00 (0.00-18.00)	13.83 ± 9.07 14.50 (0.00-27.00)	**0.016* (1.453)** [a]
	P5 (left)	8.83 ± 4.45 8.00(3.00-14.00)	22.0(9.53) 17.50 (14.00-34.00)	**0.003* (2.143)** [a]	9.83 ± 7.86 9.00 (0.00-24.00)	15.83 ± 12.86 13.50 (0.00-38.00)	**0.044* (1.095)** [a]
FCV-19S (7-35 point)		15.50 ± 8.14 15.50(7.00-25.00)	14.33 ± 7.09 14.50 (7.00-22.00)	0.059 (0.793) [b]	15.50 ± 8.92 13.50 (7.00-26.00)	13.33 ± 6.71 11.50 (7.00-23.00)	0.122 (0.758) [a]
BAI (0-63 point)		9.50 ± 9.16 8.00(1.00-26.00)	8.33 ± 6.56 6.50 (3.00-21.00)	0.420 (0.359) [a]	20.50 ± 9.09 23.00 (8.00-31.00)	14.17 ± 10.30 14.50 (2.00-25.00)	**0.018* (1.421)** [a]
BDI (0-63 point)		9.50 ± 3.27 9.00 (6.00-14.00)	6.67 ± 3.45 7.00 (1.00-10.00)	**0.047* (1.073)** [a]	13.50 ± 7.09 13.50 (6.00-22.00)	9.50 ± 5.93 10.00 (3.00-16.00)	**0.026* (1.581)** [b]
ACTIVLIM Scale (0-36 point)		34.67 ± 1.21 34.50 (33.00-36.00)	35.67 ± 0.52 36.00 (35.00-36.00)	0.055 (0.791) [a]	28.00 ± 6.81 29.00 (19.00-36.00)	28.83 ± 8.98 33.50 (15.00-36.00)	0.620 (0.215) [a]

*Numeric variables are presented as mean ± standard deviation and median (minimum–maximum). 30s-CST: 30 Second Chair Stand Test, P1: feet apart, P2: step stance, P3: feet together, P4: tandem stance, P5: single limb stance, FCV-19S: Fear of COVID-19 Scale, BAI: Beck Anxiety Inventory, BDI: Beck Depression Inventory. p(dz): p-value and effect size of within-group comparisons. *: Significant p value (alpha level set to p<0.05, indicated by bold font). [a]: Paired Samples t-test p value, [b]: Wilcoxon test p value.*

Table 5
Intergroup comparisons of symmetrical percent change in secondary measurements.

Measures		Group 1 Mean ± SD Median (Min-Max)	Group 2 Mean ± SD Median (Min-Max)	p	Cohen's d
30s-CST (number)		12.84 ± 4.97 12.08 (5.88-20.00)	16.28 ± 9.17 12.08 (9.09-33.33)	0.438a	0.18
Static Standing Test Positions (0-60 seconds)	P1	0.00 ± 0.00 0.00 (0.00-0.00)	5.56 ± 13.61 0.00 (0.00-33.33)	NA	0.58
	P2	0.00 ± 0.00 0.00 (0.00-0.00)	9.65 ± 15.21 0.00 (0.00-33.33)	NA	0.85
	P3	0.00 ± 0.00 0.00 (0.00-0.00)	6.67 ± 10.33 0.00 (0.00-20.00)	NA	0.91
	P4	10.61 ± 20.06 0.00 (0.00-50.00)	13.53 ± 13.22 12.38 (0.00-33.33)	0.485[b]	0.08
	P5 (right)	55.50 ± 25.13 49.07 (36.00-100.00)	19.70 ± 12.01 21.90 (0.00-33.33)	**0.010**[a]	**1.30**
	P5 (left)	43.66 ± 15.33 41.67 (21.74-66.67)	18.48 ± 12.57 17.81 (0.00-35.48)	**0.011**[a]	**1.23**
FCV-19S (7-35 point)		-3.04 ± 3.30 -2.39 (-8.70-0.00)	-5.25 ± 6.82 -2.08 (-15.56-0.00)	0.492[a]	0.44
BAI (0-63 point)		6.29 ± 30.87 -1.47 (-25.00-60.00)	-27.04 ± 25.73 -16.90 [-69.23-(-5.88)]	0.070[a]	1.32
BDI (0-63 point)		-22.62 ± 27.94 -12.88 (-71.43-6.67)	-21.23 ± 11.43 -21.68 [-33.33-(-6.25)]	0.913[a]	0.45
ACTIVLIM Scale (0-36 point)		1.44 ± 1.83 0.72 (0.00-4.35)	0.29 ± 8.84 2.01 (-16.67-7.94)	0.761[a]	0.06

*Numeric variables are presented as the mean ± standard deviation and the median (minimum–maximum). 30s-CST: 30 Second Chair Stand Test, P1: feet apart, P2: step stance, P3: feet together, P4: tandem stance, P5: single limb stance, FCV-19S: Fear of COVID-19 Scale, BAI: Beck Anxiety Inventory, BDI: Beck Depression Inventory. NA: not applicable; p: Comparison SPC between groups. *: Significant p-value (alpha level set to p<0.05, indicated in bold). d: Effect size for between-group comparisons. [a]: Student's t-test p-value, [b]: Mann–Whitney U test.*

Discussion

We explored the feasibility and preliminary effects of two tele-rehabilitation-based exercise programs in individuals with PD. Both groups showed pre-to-post improvements across motor, functional, and psychological outcomes, with Group 1 having numerically larger effect sizes in several domains. Such findings are consistent with previous research reporting the benefits of exercise for individuals with PD (Song et al., 2025; Yang et al., 2023), and with growing evidence that tele-rehabilitation can produce outcomes comparable to face-to-face rehabilitation in neurological populations (Goffredo et al., 2023; Vellata et al., 2021). In the present cohort, both the conventional and the combined remote programs were associated with pre-to-post changes in clinical and functional outcomes, in line with reports that remote exercise delivery is feasible and beneficial in this setting (Muñoz-Tomás et al., 2023; Seron et al., 2021).

One methodological consideration is that all participants had previously completed the same exercise protocols in a face-to-face setting approximately three years prior. Prior familiarity may have influenced movement confidence and exercise adherence. However, given the three-year interval and the progressive nature of PD, the extent to which motor memory retention contributed to the observed improvements remains uncertain and cannot be ruled out as a potential source of bias.

Effect sizes were numerically larger for Group 1 in UPDRS-III, mental health, role limitations, 30s-CST, SST, ACTIVLIM and the FCV-19S. A statistically significant between-group difference was observed for single-limb stance; numerically larger effect sizes were also noted for step stance, feet-together stance and BAI, though these did not reach significance. All between-group comparisons should be interpreted with caution given the small sample size.

Total UPDRS score reductions of 6.5 and 8.7 points in Groups 1 and 2 respectively are comparable to the reported Minimal Clinically Important Difference (MCID) range of 4–8 points (Schrag et al., 2006; Shulman et al., 2010). For the 30s-CST, the change of roughly 4–5 repetitions is larger than the MCID of 2 repetitions, although that threshold was derived in non-PD populations (Wright et al., 2011). Such comparisons are descriptive: without a control group, the pre-to-post changes cannot be attributed to the programs themselves, and meeting an externally derived MCID does not by itself mark a clinically meaningful effect. The SF-36 mental health change, larger in Group 1 (d=1.336), is reported on the same exploratory footing.

Primary Measurements

Unified Parkinson's Disease Rating Scale

Exercise has been shown to reduce the severity of PD symptoms, as supported by improvements in UPDRS scores (Radder et al., 2020). In the present study, both groups exhibited pre-to-post improvements in total UPDRS scores, consistent with previous research.

Group 1 showed numerically larger improvement in UPDRS-III, which may reflect the additional contribution of CSE to motor control. CSE targets the deep cervical musculature, which has an important role in proprioceptive signaling and sensorimotor integration. By enhancing cervical proprioceptive input and improving head–neck alignment, CSE may facilitate better axial postural control and anticipatory postural adjustments (Demircan et al., 2023). Both are commonly impaired in PD and are directly assessed by the UPDRS motor examination. Improved vestibulo-cervical interactions resulting from cervical stabilization may also contribute to more efficient motor planning and execution (Türkmen et al., 2023).

Group 2, which received CEP alone, exhibited more pronounced changes in UPDRS-I, UPDRS-II and UPDRS-IV, which may reflect greater room for improvement given the higher baseline scores in this group. These preliminary findings support the potential value of conventional exercise in addressing non-motor symptoms, ADLs and treatment-related complications in PD (Song et al., 2025). The numerically larger UPDRS-III improvements observed in Group 1 suggest that the addition of CSE to a CEP may offer further benefits for axial motor control, though confirmation in larger, adequately powered trials is needed (Demircan et al., 2023).

Visual Analog Scale

Exercise is recognized for its analgesic effects, attributed to endorphin release, improved circulation, and reduced muscle rigidity (Radder et al., 2020). While both groups experienced reductions in pain, these did not reach statistical significance, which is consistent with evidence indicating modest pain relief in neurological patients with low baseline pain levels. The observed reductions may also reflect exercise-induced neuromodulation; repeated physical activity modulates central pain processing pathways and reduces peripheral sensitization (Núñez-Cortés et al., 2025). Future studies should include individuals with moderate-to-severe baseline pain and employ longer protocols to more thoroughly evaluate the role of exercise in pain management in PD.

Quality of Life

Previous research noted that tele-rehabilitation and home-based exercise can improve QoL in people with PD. A systematic review concluded that tele-rehabilitation improves QoL, gait and balance (Vellata et al., 2021). A randomized controlled trial found that home-based and tele-rehabilitation approaches produce comparable QoL outcomes (Ge et al., 2024).

In line with this evidence, both groups in the present study exhibited significant improvements in the mental health and vitality subdomains of the SF-36. Group 2 also showed better social functioning, bodily pain, and health transition, which likely reflects their lower baseline scores in these areas. Group 1 showed numerically larger effect sizes in mental health, which may be attributable to the additional effects of CSE on postural control and movement confidence; they are known to influence psychological well-being and self-efficacy in individuals with PD (Demircan, 2020).

These findings support the adaptability of remote exercise models, particularly when in-person care is limited. However, the implementation of tele-rehabilitation in PD is not without challenges. Technology literacy limitations and motor symptoms such as tremor and bradykinesia may impede the use of digital devices. Internet connectivity issues, reduced therapist ability to provide manual correction, and home environmental variability may further affect delivery quality. Caregiver support was essential in the present study, which may limit the generalizability of these findings to patients without such support. Future studies should compare tele-rehabilitation, home-based, and hybrid formats to identify the most suitable long-term approaches to PD management.

Secondary Measurements

Dynamic Balance Assessment

The 30s-CST is a validated measure of functional lower limb strength and dynamic balance (Jones et al., 1999). Structured exercise programs, including mat Pilates, have been shown to improve performance on the 30s-CST in people with PD compared with general aerobic or calisthenic exercise (Mollinedo-Cardalda et al., 2018).

Significant post-intervention improvements were observed in both groups, consistent with meta-analytic evidence supporting exercise-induced gains in muscle strength and dynamic balance (Radder et al., 2020). The numerically larger effect size found in Group 1 suggests that CSE may contribute to enhanced neuromuscular control during functional movements. By improving cervical proprioceptive input and head–neck alignment (Norasteh et al., 2025), CSE may facilitate more efficient anticipatory postural adjustments during sit-to-stand transitions, which are particularly impaired in PD.

Static Balance Assessment

Home-based and tele-rehabilitation balance interventions have been shown to improve static balance in people with PD, with outcomes comparable to center-based approaches (Flynn et al., 2019; Flynn et al., 2021).

Both study groups improved from pre- to post-assessment. Group 1 showed numerically greater change, which might reflect CSE-related proprioceptive feedback and postural control (Norasteh et al., 2025), although for most positions the between-group difference was not significant. Larger controlled studies are needed to determine the added contribution of CSE.

Delivering balance-focused exercises remotely raises a practical safety concern. Tandem and single-limb stance positions carry a fall risk for individuals with postural instability, and a therapist working through a screen cannot step in physically. In our study, family member presence, verbal safety instructions, and synchronous supervision served as safeguards, and no adverse events occurred. Even so, the lack of hands-on correction and the variability of home environments are limitations that the design could not fully address. Standardized safety protocols for remote balance training in PD do not yet exist, and future work should aim to establish them. One further issue is measurement rather than safety: camera positioning and home setup varied between participants, which may have introduced inconsistency into the balance assessments.

Fear of COVID-19 Scale

Fear related to the pandemic significantly reduced participation in face-to-face rehabilitation among individuals with PD (Díez-Cirarda et al., 2018). Both groups showed reductions in virus-related fear following the intervention, though these did not reach statistical significance. That reduction may be reflecting participants' increased sense of safety when exercising at home. Regular physical activity has also been shown to reduce anxiety and improve psychological well-being (Wilke et al., 2022), which may have contributed to the observed reductions in fear scores. Since there were no differences between groups, both programs may have contributed similarly to psychological reassurance. Such a pattern is consistent with the findings of Barboza et al. (Barboza et al., 2024), who reported high satisfaction with remote formats during the pandemic.

Beck Anxiety Inventory

Exercise has been reported to reduce anxiety in PD; one study noted significant reductions in BAI score following resistance training (Ferreira et al., 2018). In the present study, anxiety was reduced in both groups, though statistical significance was only reached in Group 2, possibly reflecting greater room for improvement given the higher baseline anxiety scores in this group. The anxiety-reducing effects of exercise may be mediated through endorphin release, reduced muscle tension, and improved autonomic regulation, as well as the psychological benefits of structured activity and social engagement during supervised sessions (Fang et al., 2026). The concurrent improvements in functional performance and SF-36 subdomains in Group 2 further suggest a close association between physical function, psychosocial well-being, and anxiety reduction in PD.

Beck Depression Inventory

Meta-analyses report that exercise significantly alleviates depressive symptoms in PD (Kim et al., 2023). Both groups were observed to experience significant reductions in BDI scores, likely due to the release of endorphins and neurotrophic factors induced by exercise, as well as the psychological benefits of resuming structured physical activity and social interaction during supervised sessions (Chen & Nakagawa, 2023).

ACTIVLIM Scale

No significant between-group differences were observed in ACTIVLIM scores. Group 1 did show a numerically higher effect size, which may correspond to greater independence in ADLs; studies combining exercise with motor imagery or virtual reality have reported similar patterns (Kashif et al., 2022). The numerically greater ADL change in Group 1 may reflect improved axial postural control, anticipatory postural adjustments, and head–neck alignment facilitated by CSE, all of which bear directly on the performance of daily functional tasks (Demircan et al., 2023; Norasteh et al., 2025).

Limitations

Blinding was not implemented in the present study. Outcome assessments were performed by the treating physiotherapist, who was aware of each participant's group allocation, and this introduces a potential for assessment bias. Remote administration of the UPDRS motor section, particularly items requiring hands-on examination such as rigidity and postural stability, may not fully replicate the validity of in-person assessment, despite family member assistance under visual guidance. For the SST and the 30s-CST, administration was similarly remote with caregiver assistance, so camera positioning and home environmental variability may have influenced measurement accuracy.

The sampling strategy was unconventional in that only individuals already familiar with the exercise protocols were included, thus it resulted in a small sample and potential selection bias. A control group was not feasible given disease progression and the inability to replicate baseline assessments from three years prior. Group 2 generally had poorer baseline clinical status; although the use of symmetrical percent change (SPC) may have partially reduced the influence of baseline differences, potential baseline imbalances and regression toward the mean should be considered when interpreting the results. No a priori power calculation was conducted, as the sample was predetermined by participant availability from the original study. The study was therefore likely underpowered to detect between-group differences, and non-significant findings should not be interpreted as evidence of no effect. Large effect sizes in small samples may overestimate true intervention effects. Multiple outcomes within distinct clinical domains were analyzed without formal adjustment for multiplicity. Although these outcomes may reflect complementary and clinically relevant aspects of Parkinson's disease instead of redundant testing of a single endpoint, the absence of correction for multiple comparisons increases the risk of type I error. Statistically significant findings reported here should accordingly be treated as exploratory and hypothesis-generating until they have been supported by further studies with pre-specified primary endpoints. Long-term adherence could not be reliably monitored, and limited data suggest slightly better adherence in Group 2.

On the practical side, technology literacy limitations, motor symptoms such as tremor and bradykinesia, and variable internet connectivity may have affected session quality and engagement. Without physical proximity, the therapist cannot provide manual correction, and because family members were present during all sessions, the intervention may not be equally feasible for patients who lack caregiver support. Future studies should include larger samples, control groups, and extended follow-up periods, and should compare different exercise modalities in order to better evaluate the long-term feasibility, sustainability and potential benefits of tele-rehabilitation in PD.

Conclusion

In this pilot, a previously face-to-face program was reimplemented through tele-rehabilitation, and its feasibility together with its preliminary effects was examined. CEP alone and CEP+CSE were each associated with pre-to-post improvements in motor, functional, and psychological measures when the programs were delivered remotely. For static and dynamic balance, the effect sizes were numerically larger in the arm that added CSE; in the other domains, CEP alone was associated with broader changes. Our preliminary findings support tele-rehabilitation as a feasible and well-tolerated mode of exercise delivery for individuals with PD. Larger, controlled trials are needed to confirm and extend these observations in this population.

Acknowledgements

The authors would like to thank all participants for their time and cooperation throughout the study.

Author Contributions

Idea/concept: END, NK; Design: END, NK, ÖB; Supervision/consulting: END, NK; Resources: END, GYÇ; Materials: END; Data collection and/or processing: END; Analysis and/or interpretation: END, HYZ; Literature review: END; Article writing: END, NK; Critical review: END, NK.

Ethical Approval

This study was carried out with the approval of the Ethics Committee of Istanbul Rumeli University, dated 31/03/2021 and numbered 2021/02-08. A signed subject consent form in accordance with the Declaration of Helsinki was obtained from each participant.

Funding

The authors declare that the study received no funding.

Conflict of Interest

The authors hereby declare that there was no conflict of interest in conducting this research.

References

Barboza, N. M., Laskovski, L., Volpe, R. P., Silva, T., Pereira, L. A., Silva, P., & Smaili, S. M. (2024). Perceptions of individuals with Parkinson's disease about a telerehabilitation protocol performed during the COVID-19 pandemic: a qualitative study. *Disabil Rehabil*, *46*(23), 5511-5520. doi: 10.1080/09638288.2024.2305687

Berry, D. A., & Ayers, G. D. (2006). Symmetrized percent change for treatment comparisons. *The American Statistician*, *60*(1), 27-31.

Bloem, B. R., Okun, M. S., & Klein, C. (2021). Parkinson's disease. *Lancet*, *397*(10291), 2284-2303. doi: 10.1016/s0140-6736(21)00218-x

Chen, C., & Nakagawa, S. (2023). Recent advances in the study of the neurobiological mechanisms behind the effects of physical activity on mood, resilience and emotional disorders. *Adv Clin Exp Med*, *32*(9), 937-942. doi: 10.17219/acem/171565

Chuquilín-Arista, F., Álvarez-Avellón, T., & Menéndez-González, M. (2020). Prevalence of Depression and Anxiety in Parkinson Disease and Impact on Quality of Life: A Community-Based Study in Spain. *J Geriatr Psychiatry Neurol*, *33*(4), 207-213. doi: 10.1177/0891988719874130

Cohen, J. (1992). A power primer. *Psychol Bull*, *112*(1), 155-159. doi: 10.1037//0033-2909.112.1.155

Demircan, E. N., Köse, N., Çakmaklı, G. Y., Aksoy, S., Göçmen, R., Zengin, H. Y., & Elibol, B. (2023). Do cervical stabilization exercises change the effects of conventional exercises in patients with Parkinson's disease? *Neurol Res*, *45*(10), 936-946. doi: 10.1080/01616412.2023.2249699

Díez-Cirarda, M., Ibarretxe-Bilbao, N., Peña, J., & Ojeda, N. (2018). Neurorehabilitation in Parkinson's Disease: A Critical Review of Cognitive Rehabilitation Effects on Cognition and Brain. *Neural Plast*, *2018*, 2651918. doi: 10.1155/2018/2651918

Fang, Z., Qian, Y., Sun, S., Qin, H., Zhu, Y., Tang, J., Chen, S., & Luo, Z. (2026). Mechanisms of exercise against anxiety disorder: A review of the research progress. *Sports Med Health Sci*, *8*(2), 145-152. doi: 10.1016/j.smhs.2025.09.005

Ferreira, R. M., Alves, W., de Lima, T. A., Alves, T. G. G., Alves Filho, P. A. M., Pimentel, C. P., Sousa, E. C., & Cortinhas-Alves, E. A. (2018). The effect of resistance training on the anxiety symptoms and quality of life in elderly people with Parkinson's disease: a randomized controlled trial. *Arq Neuropsiquiatr*, *76*(8), 499-506. doi: 10.1590/0004-282x20180071

Fırat, N., Bek, N., Kaya, A. D., & Bozkurt, M. (2024). Investigation of the effects of the telerehabilitation program after total knee prosthesis surgery: a randomized controlled trial. *Turk J Physiother Rehabil*, *35*(2), 236-245. doi: 10.21653/tjpr.1318066

Flynn, A., Allen, N. E., Dennis, S., Canning, C. G., & Preston, E. (2019). Home-based prescribed exercise improves balance-related activities in people with Parkinson's disease and has benefits similar to centre-based exercise: a systematic review. *J Physiother*, *65*(4), 189-199. doi: 10.1016/j.jphys.2019.08.003

Flynn, A., Preston, E., Dennis, S., Canning, C. G., & Allen, N. E. (2021). Home-based exercise monitored with telehealth is feasible and acceptable compared to centre-based exercise in Parkinson's disease: A randomised pilot study. *Clin Rehabil*, *35*(5), 728-739. doi: 10.1177/0269215520976265

Gandolfi, M., Geroin, C., Dimitrova, E., Boldrini, P., Waldner, A., Bonadiman, S., Picelli, A., Regazzo, S., Stirbu, E., Primon, D., Bosello, C., Gravina, A. R., Peron, L., Trevisan, M., Garcia, A. C., Menel, A., Bloccari, L., Valè, N., Saltuari, L., . . . Smania, N. (2017). Virtual reality telerehabilitation for postural instability in parkinson's disease: a multicenter, single-blind, randomized, controlled trial. *Biomed Res Int*, *2017*, 7962826. doi: 10.1155/2017/7962826

Ge, Y., Zhao, W., Zhang, L., Zhao, X., Shu, X., Li, J., Qiao, L., Liu, Y., & Wang, H. (2024). Home physical therapy versus telerehabilitation in improving motor function and quality of life in Parkinson's disease: a randomized controlled trial. *BMC Geriatr*, *24*(1), 968. doi: 10.1186/s12877-024-05529-6

Goffredo, M., Baglio, F., R, D. E. I., Proietti, S., Maggioni, G., Turolla, A., Pournajaf, S., Jonsdottir, J., Zeni, F., Federico, S., Cacciante, L., Cioeta, M., Tassorelli, C., Franceschini, M., & Calabrò, R. S. (2023). Efficacy of non-immersive virtual reality-based telerehabilitation on postural stability in Parkinson's disease: a multicenter randomized controlled trial. *Eur J Phys Rehabil Med*, *59*(6), 689-696. doi: 10.23736/s1973-9087.23.07954-6

Hashemi, Y., Taghizadeh, G., Azad, A., & Behzadipour, S. (2022). The effects of supervised and non-supervised upper limb virtual reality exercises on upper limb sensory-motor functions in patients with idiopathic Parkinson's disease. *Hum Mov Sci*, *85*, 102977. doi: 10.1016/j.humov.2022.102977

Jenkinson, C., Coulter, A., & Wright, L. (1993). Short form 36 (SF36) health survey questionnaire: normative data for adults of working age. *BMJ*, *306*(6890), 1437-1440. doi: 10.1136/bmj.306.6890.1437

Jones, C. J., Rikli, R. E., & Beam, W. C. (1999). A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. *Res Q Exerc Sport*, *70*(2), 113-119. doi: 10.1080/02701367.1999.10608028

Kashif, M., Ahmad, A., Bandpei, M. A. M., Gilani, S. A., Hanif, A., & Iram, H. (2022). Combined effects of virtual reality techniques and motor imagery on balance, motor function and activities of daily living in patients with Parkinson's disease: a randomized controlled trial. *BMC Geriatr*, *22*(1), 381. doi: 10.1186/s12877-022-03035-1

Kim, R., Lee, T. L., Lee, H., Ko, D. K., Jeon, B., & Kang, N. (2023). Effects of Exercise on Depressive Symptoms in Patients With Parkinson Disease: A Meta-analysis. *Neurology*, *100*(4), e377-e387. doi: 10.1212/wnl.0000000000201453

Ladikli, N., Bahadir, E., Yumuşak, F. N., Akkuzu, H., Karaman, G., & Türkkan, Z. (2020). The reliability and validity of Turkish version of coronavirus anxiety scale. *International Journal of Social Sciences*, *3*(10), 71-80.

Magrinelli, F., Picelli, A., Tocco, P., Federico, A., Roncari, L., Smania, N., Zanette, G., & Tamburin, S. (2016). Pathophysiology of motor dysfunction in Parkinson's disease as the rationale for drug treatment and rehabilitation. *Parkinsons Dis*, *2016*, 9832839. doi: 10.1155/2016/9832839

Mollinedo-Cardalda, I., Cancela-Carral, J. M., & Vila-Suárez, M. H. (2018). Effect of a Mat Pilates Program with TheraBand on Dynamic Balance in Patients with Parkinson's Disease: Feasibility Study and Randomized Controlled Trial. *Rejuvenation Res*, *21*(5), 423-430. doi: 10.1089/rej.2017.2007

Muñoz-Tomás, M. T., Burillo-Lafuente, M., Vicente-Parra, A., Sanz-Rubio, M. C., Suarez-Serrano, C., Marcén-Román, Y., & Franco-Sierra, M. (2023). Telerehabilitation as a therapeutic exercise tool versus face-to-face physiotherapy: a systematic review. *Int J Environ Res Public Health*, *20*(5), 4358. doi: 10.3390/ijerph20054358

Norasteh, A. A., Karimi, K., Faraji, S., Ejlali, F., Alghosi, M., Alimoradi, M., & Zarei, H. (2025). Exercise therapy to improve cervical proprioception in individuals with asymptomatic forward head posture: A systematic review of randomized controlled trials. *PLoS One*, *20*(9), e0330665. doi: 10.1371/journal.pone.0330665

Núñez-Cortés, R., Salazar-Méndez, J., & Nijs, J. (2025). Physical activity as a central pillar of lifestyle modification in the management of chronic musculoskeletal pain: A narrative review. *J Funct Morphol Kinesiol*, *10*(2), 183. doi: 10.3390/jfmk10020183

Papa, S. M., Brundin, P., Fung, V. S. C., Kang, U. J., Burn, D. J., Colosimo, C., Chiang, H. L., Alcalay, R. N., & Trenkwalder, C. (2020). Impact of the COVID-19 Pandemic on Parkinson's disease and movement disorders. *Mov Disord Clin Pract*, *7*(4), 357-360. doi: 10.1002/mdc3.12953

Radder, D. L. M., Lígia Silva de Lima, A., Domingos, J., Keus, S. H. J., van Nimwegen, M., Bloem, B. R., & de Vries, N. M. (2020). Physiotherapy in Parkinson's Disease: A Meta-Analysis of Present Treatment Modalities. *Neurorehabil Neural Repair*, *34*(10), 871-880. doi: 10.1177/1545968320952799

Reed, M. D., & Van Nostran, W. (2014). Assessing pain intensity with the visual analog scale: a plea for uniformity. *J Clin Pharmacol*, *54*(3), 241-244. doi: 10.1002/jcph.250

Schootemeijer, S., van der Kolk, N. M., Ellis, T., Mirelman, A., Nieuwboer, A., Nieuwhof, F., Schwarzschild, M. A., de Vries, N. M., & Bloem, B. R. (2020). Barriers and Motivators to Engage in Exercise for Persons with Parkinson's Disease. *J Parkinsons Dis*, *10*(4), 1293-1299. doi: 10.3233/jpd-202247

Seron, P., Oliveros, M. J., Gutierrez-Arias, R., Fuentes-Aspe, R., Torres-Castro, R. C., Merino-Osorio, C., Nahuelhual, P., Inostroza, J., Jalil, Y., Solano, R., Marzuca-Nassr, G. N., Aguilera-Eguía, R., Lavados-Romo, P., Soto-Rodríguez, F. J., Sabelle, C., Villarroel-Silva, G., Gomolán, P., Huaiquilaf, S., & Sanchez, P. (2021). Effectiveness of telerehabilitation in physical therapy: a rapid overview. *Phys Ther*, *101*(6), pzab053. doi: 10.1093/ptj/pzab053

Smithson, F., Morris, M. E., & Iansek, R. (1998). Performance on clinical tests of balance in Parkinson's disease. *Phys Ther*, *78*(6), 577-592. doi: 10.1093/ptj/78.6.577

Song, H., Ge, S., Li, J., Jiao, C., & Ran, L. (2025). Effects of aerobic and resistance training on walking and balance abilities in older adults with Parkinson's disease: A systematic review and meta-analysis. *PLoS One*, *20*(1), e0314539. doi: 10.1371/journal.pone.0314539

Tabei, K. I., Ogawa, J. I., Kamikawa, C., Abe, M., Ota, Y., & Satoh, M. (2023). Online physical exercise program with music improves working memory. *Front Aging Neurosci*, *15*, 1146060. doi: 10.3389/fnagi.2023.1146060

Torriani-Pasin, C., Domingues, V. L., de Freitas, T. B., Silva, T. A. D., Caldeira, M. F., Júnior, R. P. A., Lara, A. R. F., Antonio, B. A., Palma, G., Makhoul, M. P., & Mochizuki, L. (2022). Adherence rate, barriers to attend, safety and overall experience of a physical exercise program via telemonitoring during COVID-19 pandemic for individuals with Parkinson's disease: A feasibility study. *Physiother Res Int*, *27*(4), e1959. doi: 10.1002/pri.1959

Truijen, S., Abdullahi, A., Bijsterbosch, D., van Zoest, E., Conijn, M., Wang, Y., Struyf, N., & Saeys, W. (2022). Effect of home-based virtual reality training and telerehabilitation on balance in individuals with Parkinson disease, multiple sclerosis, and stroke: a systematic review and meta-analysis. *Neurol Sci*, *43*(5), 2995-3006. doi: 10.1007/s10072-021-05855-2

Türkmen, C., Köse, N., Bal, E., Bilgin, S., Çetin, H., Zengin, H. Y., Gümeler, E., & Mut, M. (2023). Effects of two exercise regimes on patients with chiari malformation type 1: a randomized controlled trial. *Cerebellum*, *22*(2), 305-315. doi: 10.1007/s12311-022-01397-1

The Unified Parkinson's Disease Rating Scale (UPDRS): status and recommendations. (2003). *Mov Disord*, *18*(7), 738-750. doi: 10.1002/mds.10473

Vandervelde, L., Van den Bergh, P. Y., Goemans, N., & Thonnard, J. L. (2007). ACTIVLIM: a Rasch-built measure of activity limitations in children and adults with neuromuscular disorders. *Neuromuscul Disord*, *17*(6), 459-469. doi: 10.1016/j.nmd.2007.02.013

Vellata, C., Belli, S., Balsamo, F., Giordano, A., Colombo, R., & Maggioni, G. (2021). Effectiveness of Telerehabilitation on Motor Impairments, Non-motor Symptoms and Compliance in Patients With Parkinson's Disease: A Systematic Review. *Front Neurol*, *12*, 627999. doi: 10.3389/fneur.2021.627999

Wilke, J., Mohr, L., Yuki, G., Bhundoo, A. K., Jiménez-Pavón, D., Laiño, F., Murphy, N., Novak, B., Nuccio, S., Ortega-Gómez, S., Pillay, J. D., Richter, F., Rum, L., Sanchez-Ramírez, C., Url, D., Vogt, L., & Hespanhol, L. (2022). Train at home, but not alone: a randomised controlled multicentre trial assessing the effects of live-streamed tele-exercise during COVID-19-related lockdowns. *Br J Sports Med*, *56*(12), 667-675. doi: 10.1136/bjsports-2021-104994

Yang, Y., Fu, X., Zhang, H., Ouyang, G., & Lin, S. C. (2023). The effect of home-based exercise on motor symptoms, quality of life and functional performance in Parkinson's disease: a systematic review and meta-analysis. *BMC Geriatr*, *23*(1), 873. doi: 10.1186/s12877-023-04595-6