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A Randomized Controlled Trial of Movement Strategies Compared with Exercise for People with Parkinson's Disease

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Abstract: This randomized controlled clinical trial was conducted to compare the effects of movement rehabilitation strategies and exercise therapy in hospitalized patients with idiopathic Parkinson's disease. Participants were randomly assigned to a group that received movement strategy training or musculoskeletal exercises during 2 consecutive weeks of hospitalization. The primary outcome was disability as measured by the Unified Parkinson's Disease Rating Scale, UPDRS (motor and ADL components). Secondary outcomes were balance, walking speed, endurance, and quality of life. Assessments were carried out by blinded testers at baseline, after the 2 weeks of treatment and 3 months after discharge. The movement strategy group showed improvements on several outcome measures from admission to discharge, including the UPDRS, 10 m walk, 2 minute walk, balance, and PDQ39. However, from discharge to follow up there was significant regression in performance on the 2 minute walk and PDQ39. For the exercise group, quality of life improved significantly during inpatient hospitalization and this was retained at follow-up. Inpatient rehabilitation produces short term reductions in disability and improvements in quality of life in people with Parkinson's disease. © 2008 Movement Disorder Society
Key words: Parkinson's disease; gait; exercise; rehabilitation

Parkinson's disease (PD) occurs frequently in older adults with a prevalence of around 780 per 100,000 people.[1] Because of a progressive loss of dopamine producing cells in the basal ganglia, movements become slow and reduced in amplitude.[2] Although PD medications such as levodopa initially provide relief of symptoms, with disease progression motor fluctuations eventually recur.[3,4] Rehabilitation is often prescribed as an adjunct to medication to improve mobility and prevent falls.[2,5,6]

Two major rehabilitation approaches have been advocated for PD. Movement strategy training teaches people with PD to use their frontal cortex to move more quickly, easily, and safely using cognitive control.[6] People are trained in how to improve mobility using focused attention,[7] part-practice,[7] mental rehearsal,[8] visualization,[7] visual cues,[9] or auditory cues.[10,11] In contrast, musculoskeletal exercises aim to improve strength, joint range of movement, muscle length, endurance, and aerobic capacity.[12–14]

The benefits of movement strategy training and musculoskeletal exercises for people with PD have not previously been compared. Moreover, no trial has reported the outcomes of in-patient hospital rehabilitation for people with PD. There have been a small number of studies of home based exercises for people with PD and classes delivered in outpatient clinics, showing short term benefits.[5,15–17] The aims of the current investigation were to assess the outcomes of an intensive burst of in-patient rehabilitation in ambulant people with mild-moderate PD and to compare the effects of movement strategy training and exercise therapy. The primary outcome measure was disability as measured by the motor and ADL sections of the UPDRS. Secondary measures included walking speed, endur-

Additional Supporting Information may be found in the online version of this article.

This trial has been registered with the Australian Clinical Trials Register, number 8221.

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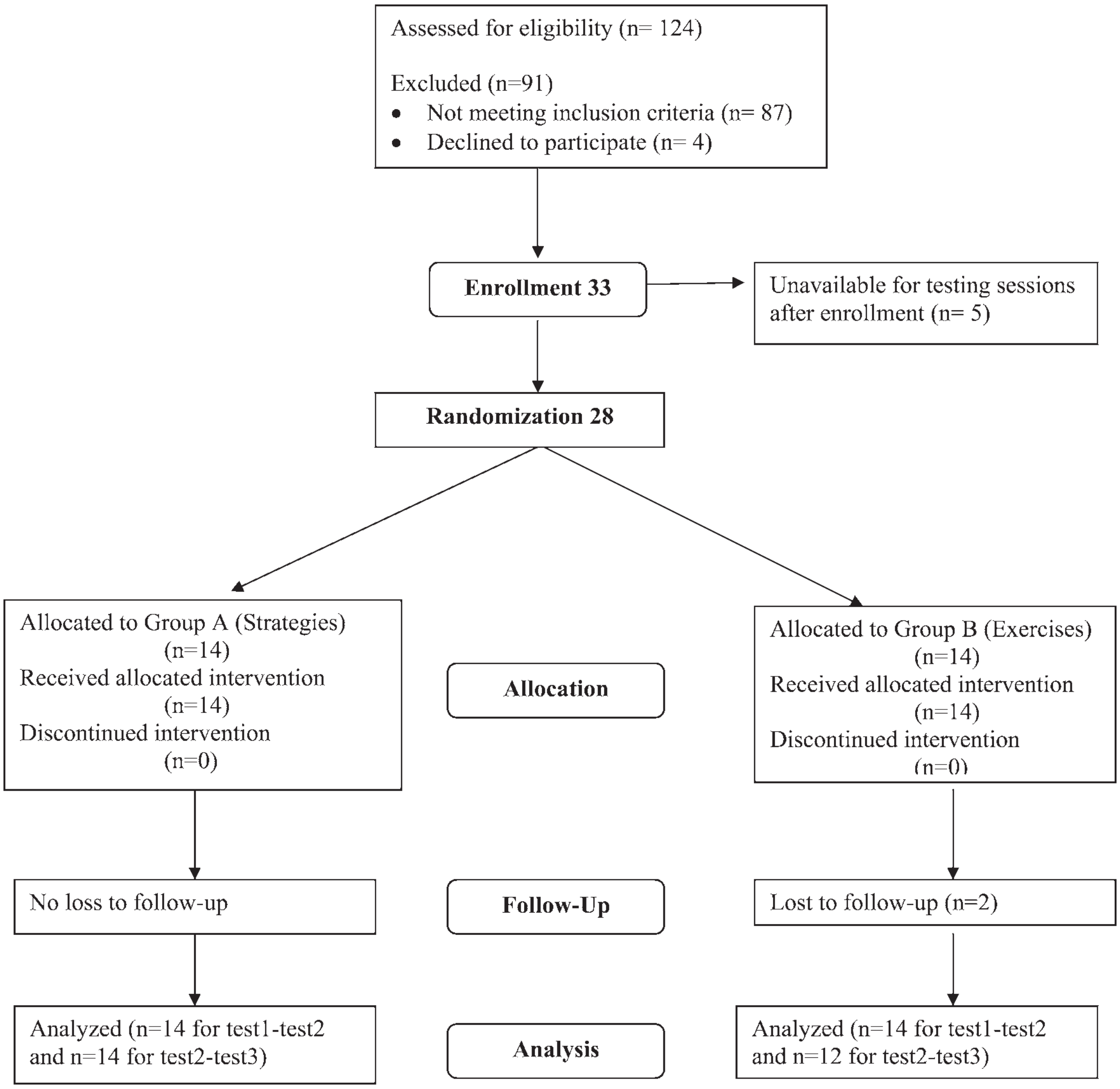

FIG. 1. Sampling and group allocation.

ance, balance, and quality of life. We also measured retention of training for the two approaches, 3 months after hospitalization.

PATIENTS AND METHODS

Participants

Twenty-eight people with idiopathic PD were tested. All had been admitted for therapy and medical management to a private rehabilitation hospital which specialized in the management of neurological conditions, including PD. As shown in Figure 1, 124 PD patients were initially screened for eligibility for the trial and 28 were included (14 in each group). The remaining 96 were excluded for one or more of the following reasons: because they did not have idiopathic PD, were unsafe to participate in the therapy programs, had other neurological conditions in addition to PD, had musculoskeletal, visual, or cardiopulmonary conditions that affected mobility, had cognitive impairment, were not in hospital for 2 weeks or were unable or unwilling to consent to participate in the study. To be included in the study, participants were required to be 21 to 80 years of age and medically stable, with a diagnosis of idiopathic PD confirmed by a neurologist. A large age range was permitted to enhance the generalizability of findings. They needed to score more than 23 out of 30 on the Mini-Mental Status Examination[18] with a minimum of two of three on the recall question (Q 4). They also needed to have disease severity of Hoehn and Yahr stage II or III[19] and be able to walk 10 m three times without assistance. In the final sample the ages ranged from 52 to 79 years, with a mean age of 68 years in the movement strategy group and 66 years in the exercise group. The mean height for the movement strategy group was 1.71 m compared to 1.74 m in the exercise group. The study conformed to the CONSORT guidelines, and was approved by the Southern Health Ethics Committee, Melbourne, Australia

A single-blind randomized controlled clinical trial design was used to assess the effects of movement strategies and exercises. Participants were randomly allocated to one of the groups using computer generated random number sequences by an independent University source. A hospital liaison person then scheduled the intervention for each participant and advised the therapists about group allocation. The researchers, referring neurologist, and the research physiotherapist conducting the assessments were kept blind to group allocation.

The variables that typically impact on outcome of movement rehabilitation in PD are advanced age, disease duration, and the type and dosage of PD medication. Random allocation of subjects to groups resulted in no significant differences between the movement strategy or exercise groups for these variables. For each sample size calculation, power was set at 80%, alpha set at 5%, and a drop-out rate of 15% was assumed. For disability, which was the primary dependent variable, a sample size of 28 was required to detect a 10% difference between the groups, assuming a mean (±SD) UPDRS score in the PD control group of 16.0 (8). [20]

Interventions

One physiotherapist and one occupational therapist trained in movement strategy training and musculoskeletal exercises provided the daily treatments. Therapists attended a training session to learn how to administer the different treatment techniques. They were also provided with an instruction booklet and guidelines on how to deliver the therapy. Therapists were required to document the frequency, duration and type of treatment daily using a standardized form. Summaries of the content of the therapy programs are provided in the Appendix (Tables A1 and A2).

A maximum of 16 sessions of up to 45 minutes of therapy per session was provided over the 2 week inpatient period. The number of sessions ranged from 5 to 16, with a mean of 14 sessions in the movement strategy group and 13 in the exercise group. The mean total therapy time per person in the movement strategies group was 526 (SD 110) minutes compared to 461 (SD 159) minutes in the exercise group. This difference was not statistically significant as shown by an independent samples *t*-test ($P = 0.91$). Therapists used their discretion to tailor treatment time to individual needs and to ensure safety. Patients also received usual care during their hospital stay. This included speech pathology, dietary advice, and consultations from the medical practitioner, neuropsychologist, or social worker, as well as occupational therapy for dressing, grooming, food preparation, and vocational training. None of these other interventions included gait training or exercise therapy and the extent to which these factors contributed to the results was not quantified.

Participants randomly assigned to the movement strategy training group learned how to use cognitive strategies such as focusing their attention on movement and responding to external cues to enhance walking, turning, standing up from a chair, and obstacle negotiation. This was also extended to ADL performances. Each person was given individualized therapy tailored to their needs. Strategy training was based on the principles of the Victorian Comprehensive Parkinson Disease Program (Australia), as documented in detail by Morris, Iansek, and Kirkwood.[6,8,21,22] Strategy training aimed to teach people how to use attention and to use the frontal cortical regions to compensate for movement disorders.[6,8] This included teaching people with PD to plan in advance for forthcoming movements, mentally rehearse complex actions before they were performed, consciously focus on movements while they were being performed, breaking long or complex movement sequences down into component parts, avoiding dual task performance and using external visual and auditory cues to guide movements.[6,8] External cues and attention strategies aimed to improve the size, speed, and sequencing of movements. Conventional musculoskeletal exercises aimed to improve strength, range of movement, posture, general fitness, and function, based on Schenkman's[13] protocols. This included lower limb and trunk strengthening exercises, spinal and lower limb flexibility exercises and receiving feedback on optimal postural alignment for a range of positions.

Testing Procedure

People with PD were tested by a physiotherapist blinded to the study aims and group allocation "on"

TABLE 1. *Means and standard deviations at admission, discharge and follow up*

	Admission mean, SD	Discharge mean, SD	3 Month follow-up mean, SD
UPDRS (Motor and ADL)			
Movement strategies	13.1 (7.5)	9.1 (4.5)	11.8 (7.1)
Exercises	16.2 (10.9)	14.4 (10.3)	15.1 (10.2)
10 m walk (s)			
Movement strategies	8.4 (1.8)	7.3 (1.7)	7.5 (1.5)
Exercises	7.7 (1.4)	7.3 (1.7)	7.7 (1.7)
Timed Up and Go (s)			
Movement strategies	10.7 (2.0)	9.8 (2.1)	10.9 (2.4)
Exercises	10.2 (2.3)	10.3 (3.2)	9.9 (2.5)
2 min walk (m)			
Movement strategies	139.1 (30.6)	159.8 (32.1)	133.6 (37.2)
Exercises	150.7 (33.7)	161.6 (37.9)	144.5 (34.2)
Balance pull test			
Movement strategies	2.1 (1.1)	1.0 (0.6)	1.4 (1.0)
Exercises	2.1 (0.8)	2.1 (0.9)	1.7 (1.4)
PDQ39			
Movement strategies	22.3 (13.0)	13.6 (9.4)	21.3 (12.0)
Exercises	28.5 (18.8)	13.5 (7.7)	19.5 (13.9)

their PD medication (at least 1.0 hour after taking their first morning dose of PD medication) before and after the therapy sessions as well as 3 months after the second test. The therapist administered the Hoehn and Yahr scale, the motor and ADL sections of the UPDRS,[23] the 10 m walk test,[20] the "Timed up and go,"[24] and the 2 min walk test. Balance was quantified using a selection of clinical tests validated by Smithson et al.[25] including the shoulder "tug," which measures the person's ability to regain postural stability after an unexpected external perturbation to their center of mass. Each participant also completed the PD Questionnaire 39 (PDQ39),[26] which rates their quality of life from excellent (zero) to very poor (100).

Statistical Methods

Descriptive statistics examined the distributions and range of scores for individuals within the two groups on admission, confirming that the groups were comparable for key dependent variables at the start of treatment. A series of planned comparisons using the *t*-statistic were used to investigate improvements from admission to discharge and from discharge to follow up in each group. Bonferroni adjustments were made to the alpha levels to control for accumulation of error associated with multiple comparisons. Because we were also interested in the between-group differences during hospitalization, a series of 2 (Groups) $\times$ 2 (types of therapy) analysis of covariance tests (ANCOVA) were used to measure changes over the episode of care. No adverse events were reported.

RESULTS

Baseline Data

There were no significant differences between groups for any of the dependent variables at baseline. As seen in Table 1, the 10 meter walk at baseline was moderately slow for the sample as a whole and per-

TABLE 2. *t*-Test Results for Differences from Admission to Discharge

	Mean difference	SD of difference	*t*-value	df	*P*
UPDRS (Motor and ADL)					
Movement strategies	4.0	4.7	3.158	13	0.008*
Exercises	1.9	5.7	1.226	13	0.242
10 m walk (s)					
Movement strategies	1.0	1.1	3.660	13	0.003*
Exercises	0.39	0.92	1.602	13	0.133
Timed Up and Go (s)					
Movement strategies	0.8	1.6	1.928	13	0.076
Exercises	0.01	1.8	0.030	13	0.976
2 min walk (m)					
Movement strategies	20.6	13.9	−5.541	13	0.000*
Exercises	10.9	14.1	−2.880	13	0.013
Balance pull test					
Movement strategies	1.1	1.1	3.741	13	0.002*
Exercises	0.1	0.8	0.322	13	0.752
PDQ39					
Movement strategies	9.8	9.7	3.652	12	0.003*
Exercises	15.4	16.3	3.278	11	0.007*

*Significant after Bonferroni adjustment.

TABLE 3. *t*-Test Results for Differences from Discharge to 3 Month Follow-Up

	Mean difference	SD of difference	*t* value	df	*P*
UPDRS (Motor and ADL)					
Movement strategies	−2.7	5.4	−1.896	13	0.080
Exercises	−0.58	6.4	−0.316	11	0.758
10 m walk (s)					
Movement strategies	−0.2	1.4	−0.549	13	0.592
Exercises	−0.5	1.3	−1.382	11	0.194
Timed Up and Go (s)					
Movement strategies	−1.1	1.5	−2.845	13	0.014
Exercises	0.4	1.3	0.970	11	0.353
2 min walk (m)					
Movement strategies	−26.1	18.6	5.272	13	0.000*
Exercises	−22.3	25.2	2.933	10	0.015
Balance Pull Test					
Movement strategies	−0.4	0.9	−1.710	13	0.111
Exercises	0.6	1.6	1.246	11	0.239
PDQ39					
Movement strategies	−7.7	7.6	−3.652	12	0.003*
Exercises	−6.2	13.9	−1.483	11	0.169

*Significant after Bonferonni adjustment.

formance on the timed up and go test was comparable to elderly PD samples.[25]

Disability

Bonferroni adjusted *t*-tests showed significant improvements in UPDRS (ADL and motor) scores for the movement strategy group from admission to discharge [$t(13) = 3.158$, $P = 0.008$] although we noted a trend towards regression in performance from discharge to follow up [$t(13) = -1.9$, $P = 0.08$]. The exercise group showed negligible improvement from admission to discharge and UPDRS (ADL and motor) score was marginally higher at the follow up, indicating greater disability (Tables 1–3). A one-way ANCOVA showed that, after adjusting for preintervention scores, there was a trend towards a significant difference between the two groups on postintervention scores for the UPDRS [$F(1, 25) = 3.176$, $P = 0.087$, partial eta squared = 0.113].

Balance

The mean score for the movement strategy training group at discharge (M = 1.0, SD = 0.6) was significantly less than their admission score (M = 2.1, SD = 1.1) [$t\ (13) = 3.741$ $P = 0.002$] yet not significantly different from test three (M = 1.4, SD = 1.0). The exercise group did not show significant changes in balance from admission to discharge or from discharge to follow up. A one-way ANCOVA showed that, after adjusting the pre-intervention scores, there was a statistically significant difference between the two groups on postintervention balance [$F(1, 25) = 15.0$, $P = 0.001$, partial eta squared = 0.375]. There was also a strong and significant relationship between the preintervention and postintervention scores on the shoulder pull test, as indicated by a partial eta squared value of 0.440.

10 Meter Walk

Comparisons using Bonferroni adjusted *t*-tests showed significant improvements on the 10 meter walk for the movement strategy group from admission (M = 8.4, SD = 1.8) to discharge (M = 7.3, SD = 1.7) [$t(13) = 3.66$, $P = 0.003$] (Tables 1 and 2). The improvements were maintained, and there was no significant change from discharge to the 3 month follow up (M = 7.5, SD = 1.5). The exercise group showed negligible and nonsignificant improvements in speed from admission (M = 7.7, SD = 1.4) to discharge (M = 7.3, SD = 1.7) and mean walking speed was marginally slower at the follow up (M = 7.7, SD = 1.7). A one-way ANCOVA showed that, after adjusting for preintervention scores, there was no significant difference between groups on postintervention 10 meter walk results.

Walking Function

Performance on the Timed Up and Go Test showed little change over time. Bonferroni adjusted *t*-tests did not show significant changes from admission to discharge in either group or marked changes from discharge to the 3 month follow up (Tables 1–3). A one-way between groups analysis of covariance showed that, after adjusting for preintervention scores, there was no significant difference between groups on post-intervention scores for the Timed Up and Go.

Walking Endurance

There were significant improvements in walking distance for the 2 minute walk for the movement strategy group from admission (M = 139.1 m, SD = 30.6) to discharge (M = 159.8 m, SD = 32.1) [$t(13) = -5.541$, $P = 0.000$] (Tables 1 and 2). Nevertheless performance had regressed significantly by the 3 month follow up (M = 133.6 m, SD = 37.2) [$t(13) = 5.272$, $P = 0.000$]. After Bonferroni corrections to the alpha level, the exercise group did not show significant changes from admission to discharge and from discharge to the follow up (Tables 1–3). A one-way ANCOVA showed that, after adjusting for preintervention scores, there was no statistically significant difference between the two groups on postintervention scores for the 2 minute walk test.

Quality of Life

There were significant improvements in quality of life for the movement strategy group from admission to discharge [$t(12) = 3.652$, $P = 0.003$]. There was also improvement in quality of life for the exercise group from admission to discharge [$t(11) = 3.278$, $P = 0.007$]. A one-way between groups ANCOVA showed that, after adjusting for preintervention scores, there was no significant difference that existed between groups on postintervention scores for the PDQ39. There was no significant change from discharge to the 3 month follow up in the exercise group whereas the PDQ39 results showed significant regression from discharge to the 3 month follow up in the movement strategy group.

DISCUSSION

Targeted inpatient rehabilitation as an adjunct to PD medication was associated with short term gains in addition to some longer term improvements in disability, walking, balance, and quality of life. Significant gains from admission to discharge were observed for the movement strategy training group for the motor and ADL UPDRS, 10 m walk, 2 minutes walk, balance "pull" test, and for the PDQ39. Although patients and clinicians have long reported the short term benefits of motor strategies[5,13,27] this is one of the first trials to objectively assess their effects within a controlled hospital-based trial.

In the exercise group, some gains were observed although these were not always large or sustained. Of note, quality of life, as measured by the PDQ39, improved over the episode of inpatient hospital care in the exercise group and regression at the 3 month follow up was not statistically significant. Whether the positive PDQ39 scores were directly attributed to the specific effects of exercises on strength,[12,28] endurance and range of movement or the nonspecific effects of receiving physiotherapy remains unclear.

Although participants in both groups made gains during their hospital stay, by the 3 month follow up, some regression in performance had occurred. These results are in agreement with other RCTs on the effects of PD rehabilitation.[15,17] For example, Wade et al.[17] noted that after 6 weeks of outpatient rehabilitation people with PD declined significantly over a 6 month period. They advised that short follow up treatments might be needed soon after discharge to maintain gains and prevent the progressive decline in motor performance that often occurs in people with PD. The short term effects of therapy observed in the current investigation are probably related to the dosage of intervention. Only 2 weeks of intensive rehabilitation was provided while patients were in hospital. It could be argued that 2 weeks of training is insufficient to enable long term changes in movement performance and that patients would benefit from a longer term therapeutic program that could be continued in the home or in an outpatient clinic.

The results at follow up are counter to the findings of Marchese et al.[29] who found that 6 weeks of external sensory cue training resulted in much better retention in an intervention group than a control group who were not "cued". The difference in retention could have been associated with the greater duration and dosage of training provided in the study by Marchese, reinforcing the need for sustained physical therapy for people with PD.

The results of the current study can be generalized to people with idiopathic PD, and it is possible that the favorable effects of movement strategy training might not generalize to people with related conditions such as progressive supra-nuclear palsy, multiple systems atrophy or frontal gait apraxia. The sample in this inpatient study also excluded those with additional neurological conditions, back pain, musculoskeletal conditions such as arthritis, cardio-respiratory impairments, and cognitive impairment, leading to a homogenous group of people with few comorbidities. The extent to which movement strategy training and musculoskeletal exercises benefit people with PD who have multiple comorbidities or those seeking out-patient therapy remains open to question.

To conclude, hospital-based rehabilitation, particularly movement strategy training, is associated with improvements in disability and quality of life in the short term. These results support the use of physical therapy and occupational therapy as adjuncts to medical management for people with PD. Future research needs to examine how gains made during rehabilitation can be maintained over longer periods despite disease progression. The combined effect of movement strategy training and exercise therapy also awaits exploration.

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APPENDIX

TABLE A1. *Recommended Amount and Content of Therapy for Movement Strategy Training Group*

Elements of therapy	Treatment principle (based on Morris[6]).	Suggested dosage for each therapy session
1. External cures: visual, auditory or somato-sensory as detailed in Morris.[6]	Movement and the performance of functional tasks are enhanced when the person uses external cues.	Integrated into entire program, especially as specified in (3).
2. Attentional strategies: focusing attention on key parameters such as step length, turning in an arc, maintaining upright posture. Visualization. Mental rehearsal. Break long or complex tasks down into components and focus attention on performing each element as detailed in Morris.[6]	Movement and the performance of functional tasks are enhanced when the person uses conscious attention to compensate for PD movement disorders.	Integrated into entire program, especially as specified in (3).
3. Practice functional mobility tasks such as walking, turning, moving from sitting to standing, obstacle negotiation, walking on a variety of support surfaces indoors and outdoors.	Retention and transfer of training are enhanced by practice of functional activities that are frequently used in everyday life.	30 min
4. Aerobic training: treadmill walking incorporating visual cues and or cycling on stationary exercise bicycle. Walking on level ground and outdoors concentrating on walking with long steps.	People with PD have the capacity to improve general fitness and aerobic capacity with training.[14]	10 min
5. Health education regarding safe and beneficial physical activities. Learn home program that includes practice of functional tasks such as walking whilst performing strategies. Advice on falls prevention.	Retention of training may be optimized when patients and care-givers are educated about safe and effective performance of a home program to be used after discharge from hospital.	5 min

TABLE A2. *Recommended Amount and Content of Therapy for Exercise Group*

Elements of therapy	Treatment principle	Suggested dosage for each therapy session
1. Relaxation and breathing control.	Relaxation and breathing exercises help to reduce over activity of muscles and allow range of movement to be optimal.	10 min
2. Musculoskeletal exercises in supine, prone, side-lying, standing, and walking to increase strength and to reduce over-activity in some muscles; can include strength training.[27,28]	Weakness can be a problem in some individuals with PD, as can over-activity of some muscles[13]	10 min
3. Musculoskeletal exercises in supine, prone, side-lying, standing, and walking to optimize muscle length and range of movement. Can include exercises to activate axial structures commencing in supported positions, progressing to unsupported positions.[13]	Schenkman et al.[13] advise that relaxation and mobilization of axial segments precede extremity segment. Some people with PD have reduced range of movement and reduced muscle length.	10 min
4. Aerobic training: treadmill walking and or cycling on stationary exercise bicycle. Walking on level ground and outdoors.	People with PD have the capacity to improve general fitness and aerobic capacity with training.[14]	10 min
5. Health education regarding safe and beneficial physical activities. Learn home program that includes musculoskeletal exercises. Advice on falls prevention.	Retention of training may be optimized when patients and care-givers are educated about safe and effective performance of a home program to be used after discharge from hospital.	5 min