The effect of a home-based exercise program on gait characteristics in an individual with Parkinson's disease over a one-year period: A case study

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Abstract

Background: The COVID-19 pandemic has placed a restriction on physiotherapy clinical visits for supervised exercise. It is important that individuals with Parkinson's Disease (PD) continue an exercise regime at home during the pandemic and also in normal situations.

Objective: The purpose of this study was to explore the case history of an individual with PD who used a developed home-based exercise programme for one year during the COVID-19 pandemic.

Methods: A 67 year-old married woman was diagnosed with PD stage 2.5 on the modified Hoehn and Yahr (HY) scale. Gait characteristics and the Movement Disorders Society-Unified Parkinson's Disease Rating Scale (MDS-UPDRS) motor scores were assessed at baseline, 10 weeks, and 12 months. The home-based exercise program included breathing exercises, posture correction, stretching exercises, rotation of the axial segments, balance training, and task-specific gait training.

Results: After 12 months, her MDS-UPDRS motor scores decreased when compared to baseline and 10 weeks, and gait characteristics at 12 months showed an increase in the degree of foot rotation, step length, cadence, and gait speed when compared to baseline and 10 weeks.

Conclusion: This case study showed that improvements in MDS-UPDRS and gait characteristics can continue over a 12 month period as a result of a home-based exercise programme. Therefore, home-based exercise programs should be encouraged with weekly monitoring, especially in individuals with gait disorders which show deterioration.

Keywords: Home-based exercise; Parkinson's disease; Gait characteristics

1. Introduction

Parkinson's Disease (PD) is the second most common movement disorder worldwide (de Araújo et al., 2021). PD is recognized as being a chronic neurodegenerative disease of the extrapyramidal system affecting the progressive alteration of motor and non-motor function (de

Araújo et al., 2021). A combination of pharmacotherapy and rehabilitation is recommended for the control of symptoms, improving quality of life and impeding deterioration of the disease (Abbruzzese et al., 2016; Hirsch et al., 2016). Several studies have shown that supervised exercise programmes by a physiotherapist or exercise specialist have beneficial effects regarding all aspects in individuals with PD (Goodwin et al., 2008; Dereli &Yaliman, 2010; Khalil et al., 2017; Choi et al., 2020). For example, physiotherapy using exercises for correct posture, relaxation training, balance training and movement training e.g. gait aims to improve posture, rigidity, balance, and gait (Goodwin et al., 2008; Dereli &Yaliman, 2010; Tomlinson et al., 2014). However, the COVID-19 pandemic imposed restrictions on clinical visits for supervised exercise. It is important that individuals with PD should continue an exercise regime during the pandemic at home. A study 10-week home-based exercise programme for gait characteristics has shown positive effects in individuals with PD (Khobkhun et al., 2021). This study aimed to report on an individual with PD who continued to carry out the home-based exercise programme with daily activities over a year. We hypothesize that a home-based exercise programme would offer continued improvements in clinical presentation using the Movement Disorders Society-Unified Parkinson's Disease Rating Scale (MDS-UPDRS) which was used to evaluate the severity and specific symptoms of PD and gait characteristics over a 12 months period.

2. Case description

A 67 year-old married woman who had been diagnosed with PD in 2008 and stage 2 on the modified Hoehn and Yahr score. The progression of motor and non-motor symptoms were controlled satisfactorily by pharmacotherapy (Madopar 250 mg and COMTAN 200 mg) until 2014, with normal cognitive function (MMSE 30/30). In 2015 she reported increased difficulties with gait, especially with gait initiation and was told by the neurologist that she was showing an increase in fluctuations which were present only in OFF phases, and her Hoehn and Yahr stage was modified to 2.5. The neurologist adjusted the medication (REQuip 2 mg) for these symptoms leading to improvement in fluctuations and the patient could move better until 2019. The patient joined a 10 week home-based exercise programme on 10th September 2020 which aimed to reduce axial rigidity and improve balance and gait, facilitating the performance of ADLs independently, and was invited to continue with the program for a further 12 months. She gave additional written consent to release information relating to demographics and medical history prior to the start of the initial assessment. She started performing the exercises from the first week and continued for over a year, as noted in the booklet (Supplementary file). In addition, the researcher telephoned to ask about any problems and to remind her and her husband to carry out the exercise regime every week. Her husband reported that she had gone shopping and was doing a lot more housework than she did before participating in the exercise programme. The local Ethics Committee on Human Experimentation approved the study (COA No. MU-CIRB 2020/040.1803), and the clinical trial was registered on clinicaltrials.gov (NCT04810897).

3. Clinical assessments

The participant was assessed at three time points: baseline (week 0), 10 weeks, and 1 year. Gait characteristics were recorded using a 3-metre Zebris FDM force distribution platform (Zebris Medical GmbH, Isny, Germany) at a sampling frequency of 100 Hz. The participant was asked to stand at the edge of the platform and walk barefoot at a comfortable speed to the other end of the platform. This was repeated a total of three times. The average of three completed strides was calculated to the gait characteristics, including foot rotation, step width, step length, step time, cadence, and gait speed. In addition, Functional axial rotation – physical (FAR-p), was used to measure axial rotation, an average of the data from two trials were used to report for this test (Schenkman et al., 1998; Khobkhun et al., 2021).

Clinical scores included the Movement Disorders Society-Unified Parkinson's Disease Rating Scale (MDS-UPDRS) which was used to evaluate the severity of PD. The motor score total ranges from 0 to 132, a higher score corresponding to a more severe disability. In addition, the MDS-UPDRS rigidity, gait, postural stability and posture scores were also reported separately from the motor section. In addition, the Fall Efficacy Scale International (FES-I) questionnaire assessed self-reported fear of falling, with higher scores indicating a greater fear of falling. The raw data from all MDS-UPDRS sections and FES-I were used to complete the report on this case study.

Furthermore, the Functional reach test (FRT) was used to measure dynamic balance and spinal flexibility, the Time Up and Go test (TUG) was used to evaluate balance and mobility, the 10-metre walk test (10MWT) was used to measured gait speed. The average of 3 attempts of FRT (Schenkman et al., 1998), TUG (Zampieri et al., 2009) and 10MWT (Lang et al., 2016) were used in this report.

4. Home-based exercise for improve gait characteristics

The exercise program targeting improvement in symptoms of axial rigidity and gait in individuals with PD was described in the previous publication (Khobkhun et al., 2021), and we followed the same protocol as described in the previous methodology but over a 12-month period. The home-based exercise regimen included a warm-up period, followed by training and task-specific practice, and concluded with a cool-down (Table 1 and supplementary file). The details of the home-based exercise program are as follows:

1) A warm-up period for 10 minutes, including deep breathing, correct posture, and stretching of the neck, hamstrings, and calf muscles aimed at relaxation and enhancing flexibility.

2) A training period for 45 minutes, focusing on increased segmental rotation in various positions aimed at enhancing flexibility and mobility of the body segments.

3) A 10-minute gait-specific training aimed at improving gait characteristics in individuals with PD.

4) A cool-down period for 10 minutes, the same as the warm-up.

[insert Table 1]

5. Results

At the end of a year's participation in the exercise regime, the severity of her PD as represented by the MDS-UPDRS motor section decreased by 3.4% when compared to the baseline and by 6.9% compared with the end of the 10-week home-based exercise programme (Tables 2 and 3). However, the results for MDS-UPDRS rigidity, postural stability, posture, and freezing of gait showed no changes from the baseline indicating no improvements, but also no further deterioration (Tables 2 and 3).

Functional axial rotation was also increased following the 10-week home-based exercise and its results were increased still further after a year in comparison to baseline. In terms of gait characteristics; the degree of foot rotation, step length, cadence, and gait velocity showed an increase following the 10-week exercise regime, and those results increased still further following a year of the exercise in comparison to the baseline, with the exception of the step width result which did not change (Tables 2 and 3). In contrast, step time decreased following both the 10-week exercise regime (66.7%) and after a year (22.2%) (Table 2 and 3).

With regard to the secondary outcome measures, the distance of the functional reach test increased following the 10-week period (113.1%) and one year (63.1%) in comparison to the baseline. The TUG result following the 10-week home-based exercise programme was faster when compared to the baseline and showed further improvements between the end of the 10-week exercise (54.1%) and after one year (31.9%). In terms of normal gait speed, her results showed an increase (16.7%) following the 10-week exercise in comparison to baseline. Results after a year of home-base exercise indicated a return to near-baseline levels (13.3%). In contrast, her gait speed during performing at a fast speed showed a decrease (10%) following the 10-week exercise regime in comparison to the baseline. After one year, the results increased equally to the baseline. In addition, the self-reported fear of falling questionnaire as presented by the FES-I showed a slight decreased when compared to the baseline and both the 10-week exercise regime and after one year (Table 2 and 3).

[insert Table 2]

[insert Table 3]

6. Discussion

In this case study, we aimed to examine the effects of a 12-month home-based exercise program on gait characteristics in individuals with PD. Consistent with our hypotheses, we observed improvements in foot rotation, step length, cadence and gait speed, and MDS-UPDRS motor score at 12 months compared to baseline and 10 weeks.

The prolonged COVID-19 outbreak is affecting all levels of the public health system, as well as restricting access to other disease services due to the necessitation for keeping distance between individuals. This has had particular impact on individuals with PD, who are classified as a vulnerable group, in addition to the concerns about the risk of infection when leaving home. Individuals with PD are more likely to suffer from the impact of a prolonged lockdown that leads to a lack of exercise and a decrease in physical activity (Helmich &Bloem, 2020; Prasad et al., 2020). Additionally, recent studies reported that individuals with PD require the adjustment of medical management according to an inability to access health care (Flynn et al., 2019; Allen et al., 2012). A home-based programme is one of the recommended treatments that has been suggested for the maintenance of their symptoms and physical activities (Flynn et al., 2019).

Previously, recent study has shown the advantages of a home-based exercise group as regards assisting in the reduction of axial rigidity and improvement in gait characteristics in individuals with PD at Hoehn and Yahr stage 2 or 3 as represented by a statistically significant improvement in primary outcomes, including the MDS-UPDRS rigidity item, FAR-p, step length, and gait velocity, and also in secondary outcomes including FRT and FES-I following a 10-week home-based exercise programme (Khobkhun et al., 2021). The outcome of this previous research indicates that a home home-based exercise can encourage individuals with PD to exercise more easily and have a greater positive impact on their movements. Therefore, we aimed to follow-up a case who continue performing exercise over a year. To the best of our knowledge, this is the first case report on an individual who has performed a home-based exercise programme over a year which included breathing exercises, correction of posture, stretching exercises, rotation of the axial segments in supine, side lying, prone lying, sitting, and standing positions, balance training and task-specific gait training.

The participant was required to perform each exercise to her maximum potential and complete the perceptual feedback (i.e., how do you feel after exerting your maximum potential?). She performed exercises regularly which were monitored by written reporting and an activity diary, which were supported through phone calls and verbal confirmation from her husband. However, there was a time when it was a public holiday that she went visiting for 4 days in month 4 and 7, and didn't exercise when travelling. When she returned home she returned to her regular workout. Her husband said that before participating in this research, she was quite stressed, rarely smiling, but after getting into the workout program with regular calls from a researcher, she is happier and smiles more than ever before.

After 1 year, several variables in this case study showed results that were similar to those following the 10-week home based exercise programme. In particular, a decrease of the MDS-UPDRS motor section after carrying out the exercise for 1 year is comparable with both the baseline and after the 10-week home-based exercise programme. Also, the results in each item: MDS-UPDRS rigidity, postural stability, posture, and freezing of gait are similar to those following the 10-week exercise programme. Importantly, a decrease of the MDS-UPDRS motor section after 1 year is greater than the previously reported minimal clinically important difference (Table 2) (Horváth et al., 2015). It would be interesting to see if the functional performance could be maintained if the regime was continued after 1 year. However, the MCID is a measure used to determine the smallest change in a clinical outcome which is relevant to the intervention that is considered meaningful to patients (Jaeschke et al., 1989). It is typically established based on a certain patient population and disease duration. Given that the patient in our study the disease is of a long duration, it is possible that their response to treatment or interventions may differ from those in whom the disease is of shorter duration. This could potentially affect the relevance and applicability of the MCID determined by Horváth et al. in this particular case. We suggested that further research may be needed to determine if disease duration has a significant impact on the MCID. In addition, we have also suggested that it is advisable to consider multiple factors including the severity of the condition and also the variation in the individual treatment decisions based on the specific circumstances of each patient (Hauser et al., 2011).

The results showed improvements after routinely performing a home-based exercise programme including an increase in the distance in functional axial rotation and an increase in the degree of foot rotation, step width, step length, cadence, and gait velocity (Lim et al., 2005; Serrao et al., 2019). As long as the patients persist regularly with this home based exercise programme this seems to further improve severity and functional outcomes, and could be a feasible treatment during the COVID-19 lockdown period as patients are enabled to continue their prescribed physiotherapy exercises. Interestingly, as for the increase in gait speed, our results are consistent with a previous study which showed an increase in gait speed of 30% on average following 12-months of weekly telerehabilitation with treadmill-virtual reality training. However, the home-based exercise programme requires a higher degree of self-control and motivation due to their being no tele-rehabilitation component (Cornejo Thumm et al., 2021).

The increase of gait speed in this study was greater than the previously reported minimal clinically important difference (0.25 m/sec) which reflects a meaningful improvement (Perera et al., 2006). In addition, the TUG which reflects the perception regarding the risk of falls was also improved more than the minimal clinically important difference (11 seconds) (Steffen &Seney, 2008b). The possible explanation for these results may be that stretching, segment rotational training, balance training and task-specific gait and turning in this exercise programme contributed to reduced axial rigidity, increased mobility, and enhanced coordination and postural stability, resulting in greater improvements in the primary and secondary outcomes. This is supported by the findings of previous studies (Ni et al., 2018; Rawson et al., 2019), which reported that stretching of the hamstrings, calf muscles, and neck muscles may improve muscular readiness and flexibility, as well as the promotion of movement initiation (Rawson et al., 2019). It is also reasonable to postulate that the improvement in step length may be due to the stretching exercise. Research suggests that regular stretching also affects mechanical output, muscle responses, and proprioception, which can positively impact stability and adaptability (Behm et al., 2004). It may also enhance anticipatory postural adjustments and voluntary responses, improving postural control and balance during walking, particularly important aspects in individuals with PD (Cristopoliski et al., 2009). Moreover, stretching the hip and calf muscles have been shown to improve gait and increase the range of motion (Rawson et al., 2019; Cristopoliski et al., 2009). Adding weight to this, the results of this study demonstrate that stretching exercises not only improve gait speed but also may improve spatiotemporal variables such as step length, cadence and balance, hence enhancing the improvement in gait speed during walking.

In addition to the improvements in gait characteristics and TUG, the home-based exercise programme is sufficient to improve the self-reported fear of falling questionnaire as reflected by an improvement of FES-I. The FES-I showed a slight decreased when compared to the baseline and both the 10-week exercise regime and after a year (Tables 1 and 2). Compared to the previous study (Khobkhun et al., 2021), this case study showed a reduction of FES-I which showed a trend towards a significant difference. In addition, the basal ganglia circuits, limbic structures, cortical motor circuits, thalamus, and dopaminergic neuronal pathways are all implicated in the creation of movements in PD. Improvements in functional scores could be due to the facilitation of dopaminergic neuron activity in motor regions as a result of the exercise, which would improve motor function, balance, gait and reduce motor symptoms including stiffness and bradykinesia (Khobkhun et al., 2021).

Based on a survey study, the medical care, exercise, and social activities in individuals with PD were interrupted due to the Covid-19 outbreak and additional evidence pointed out that those interruptions were associated with the exacerbation of PD symptoms (Brown et al., 2020). Consequently, the home-based exercise programme may be suggested as a means of decelerating the worsening of their symptoms. The findings in this report might be insufficient to generalize to a population level as they are based on a single individual, however, the positive results of the case study indicate the longer term potential of such a home-based exercise programme. Further research is needed to explore the long-term effects of home-based exercise in a larger sample of individuals with PD. Additionally, it is important to document any abnormal symptoms that may impact exercising at home, such as pain, the risk of falls, and the frequency of falls.

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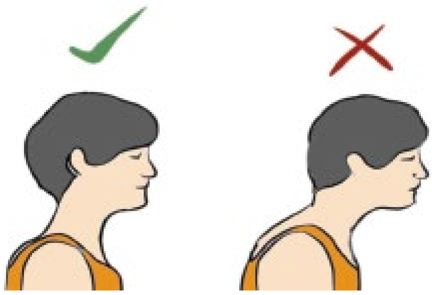
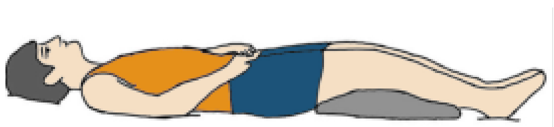
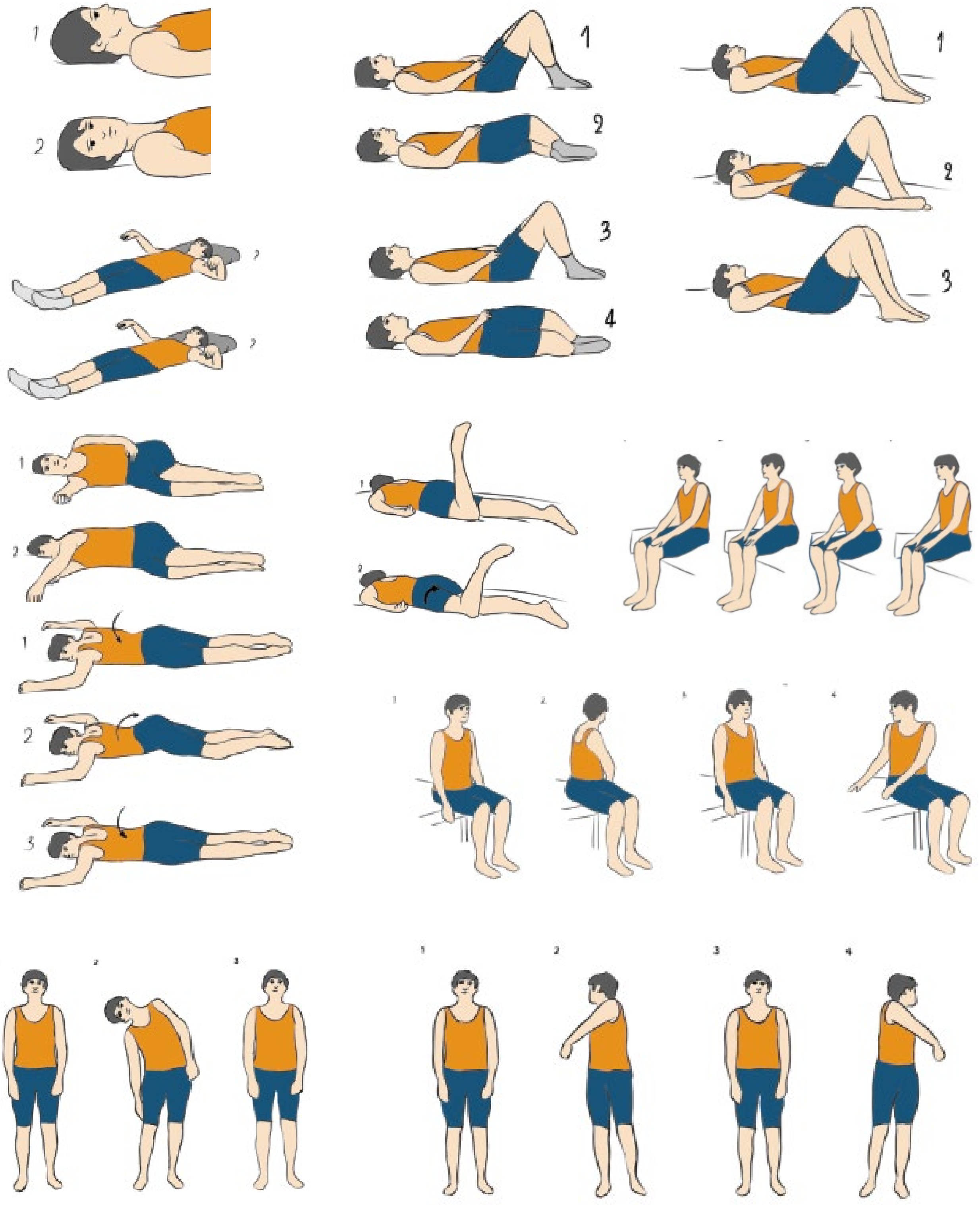
Tables

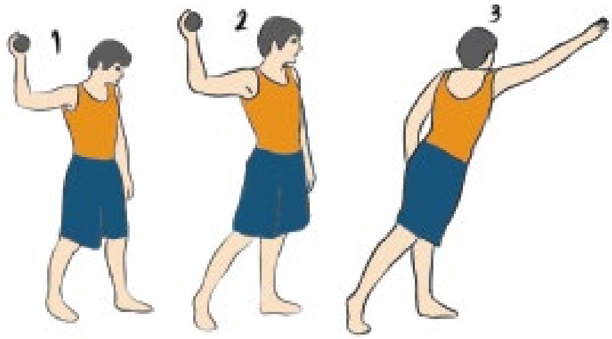
Table 1. Home-based exercise for improve gait characteristics.

1. Correct posture: 3 repetitions × 10-second hold 
2. Stretching exercise: 3 repetitions × 10-second hold - Hamstring muscles  - Calf muscles stretching  - Neck muscles stretching 
3. Deep breathing exercise: 3 repetitions 

4. Rotation of axial segments training: in supine 10 times in 5 positions, side lying 10 times per 1 position, prone lying 10 times per 2 positions, sitting 10 times per 4 positions, and standing positions 10 times per 2 positions.



5. Balance training: 10 times per 2 positions



5. Task-specific gait training: 5 rounds.

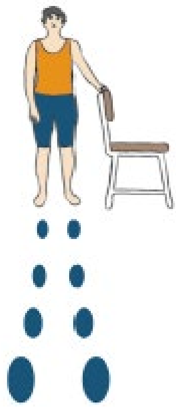


Table 2. Raw score of Movement Disorders Society-Unified Parkinson's Disease Rating Scale (MDS-UPDRS), and the mean and standard deviation (SD) for gait characteristics and secondary outcomes of one case study among the baseline, a 10-week and 1-year period.

Outcome measure	**Assessment**		
	Baseline	**10-week**	**1 year**
Primary outcomes			
MDS-UPDRS motor part (score)	29	28	27
MDS-UPDRS rigidity item (score)	2	2	2
MDS-UPDRS postural stability item (score)	2	1	2
MDS-UPDRS posture item (score)	2	1	2
MDS-UPDRS freezing of gait item (score)	2	1	1
Functional axial rotation – physical (cm)	103.5 (3.6)	139.4 (2.8)	116.9 (3.2)
Gait characteristics			
- Foot rotation (deg.)	5.2 (0.7)	6.9 (1.1)	7.1 (0.8)
- Step width (cm)	13.7 (1.5)	16 (1)	13.7 (0.6)
- Step length (cm)	32.8 (3.1)	38.7 (1.2)	40.7 (0.6)
- Step time (sec)	1.8 (0.6)	0.6 (0.02)	1.4 (0.4)
- Cadence (steps/min)	85.3 (2.5)	91.3 (2.5)	89.7 (3.1)
- Gait velocity (km/s)	0.7 (0.1)	1.8 (0.1)	1.0 (0.1)
Secondary outcomes			
Functional Reach Test (cm)	12.7 (0.9)	27 (0.7)	20.7 (0.8)
Time Up and Go (sec)	36.1 (0.9)	16.6 (0.2)	24.6 (0.4)

Outcome measure	Assessment		
	Baseline	10-week	1 year
Primary outcomes			
Gait speed (m/s)			
- Normal speed	0.6 (0.1)	0.7 (0.1)	0.5 (0.1)
- Fast speed	1.0 (0.1)	0.9 (0.1)	1.0 (0.2)
Fall Efficacy Scale-International (score)	26	22	24

MDS-UPDRS = Movement Disorders Society-Unified Parkinson's Disease Rating Scale

cm = centimetre, deg. = degree, m = metre, s = second, km = kilometre

Table 3. The percentage changes (% changes), the mean differences (Mean diff) and minimal clinical important differences (MCID) between a 10-week and 1-year home-based exercise period compared to baseline assessment.

Variables	At 10-week		At 1-year		MCID
	Mean Diff	% changes	Mean Diff	% changes	
Primary outcomes					
MDS-UPDRS motor part (score)	-1	-3.4	-2	-7.14	-3.25 [a]
MDS-UPDRS rigidity item (score)	0	0	0	0	N/A
MDS-UPDRS postural stability item (score)	-1	-50	0	0	N/A
MDS-UPDRS posture item (score)	-1	-50	0	0	N/A
MDS-UPDRS freezing of gait item (score)	-1	-50	-1	-50	N/A
Functional axial rotation – physical (cm)	35.9	34.7	13.4	12.9	N/A
Gait characteristics					
- Foot rotation (deg.)	1.7	32.7	1.9	36.5	0.5 [b]
- Step width (cm)	2	14.3	0	0	0.17 [b]
- Step length (cm)	6	18.2	8	24.2	N/A
- Step time (sec)	-1.2	-66.7	-0.4	-22.2	N/A
- Cadence (steps/min)	6	7.1	5	5.9	10 [b]

Variables	At 10-week		At 1-year		MCID
	Mean Diff	**% changes**	**Mean Diff**	**% changes**	
- Gait velocity (km/sec)	1.1	157.1	0.3	42.9	N/A
Secondary outcomes					
Functional Reach Test (cm)	14.3	112.6	8	63.1	12 [c]
Time Up and Go (sec)	19.5	54.1	11.5	31.9	3.5 [d]
Secondary outcomes (con.)					
Gait speed (m/sec)					
- Normal speed	0.1	16.7	-0.1	-13.3	0.19 [c]
- Fast speed	-0.1	-10	0	0	0.25 [e]
Fall Efficacy Scale-International (score)	-4	-15.4	-2	-9.1	N/A

MDS-UPDRS = Movement Disorders Society-Unified Parkinson's Disease Rating Scale

cm = centimetre, deg. = degree, m = metre, s = second, km = kilometre, mean diff = mean differences

N/A = No evidence for minimal clinical important differences (MCID).

MCID = Minimal Clinical Important Differences

[a] = Horváth K, Aschermann Z, Ács P, Deli G, Janszky J, Komoly S, et al. Minimal clinically important difference on the Motor Examination part of MDS-UPDRS. Parkinsonism Relat Disord 2015; 21(12):1421-6.

[b] = Serrao M, Chini G, Caramanico G, Bartolo M, Castiglia SF, Ranavolo A, et al. Prediction of responsiveness of gait variables to rehabilitation training in Parkinson's disease. Front Neurol 2019; 10:826.

[c] = Lim LI, van Wegen EE, de Goede CJ, Jones D, Rochester L, Hetherington V, et al. Measuring gait and gait-related activities in Parkinson's patients own home environment: a reliability, responsiveness and feasibility study. Parkinsonism Relat Disord 2005;11(1):19-24.

[d] = Huang SL, Hsieh CL, Wu RM, Tai CH, Lin CH, Lu WS. Minimal detectable change of the timed "up & go" test and the dynamic gait index in people with Parkinson disease. Phys Ther 2011;91(1):114-21.

[e] = Steffen T, Seney M. Test-retest reliability and minimal detectable change on balance and ambulation tests, the 36-Item Short-Form Health Survey, and the Unified Parkinson Disease Rating Scale in people with Parkinsonism. Phys Ther 2008;88(6):733-46.