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Does Group, Individual or Home Exercise Best Improve Mobility for People With Parkinson's Disease?

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Abstract

Background and Purpose—Comparative studies of exercise interventions for people with Parkinson Disease (PD) rarely considered *how* one should deliver the intervention. The objective of this study was to compare the success of exercise when administered by 1) home exercise program, 2) individualized physical therapy, or 3) a group class. We examined if common comorbidities associated with PD impacted success of each intervention.

Methods—Fifty-eight people (age 63.9 ± 8) with PD participated. People were randomized into: 1) home exercise program 2) individual physical therapy or 3) group class intervention. All arms were standardized and based on the Agility Boot Camp exercise program for PD, 3 times per week for 4 weeks. The primary outcome measure was the 7-item Physical Performance Test (PPT). Other measures of balance, gait, mobility, quality of life, balance confidence, depressions, apathy, self-efficacy and UPDRS motor and ADL scores were included.

Results—Only the individual group significantly improved in PPT. The individual exercise showed the most improvements in functional and balance measures, while the group class showed the most improvements in gait. The home exercise program improved the least across all outcomes. Several factors effected success, particularly for the home group.

Discussion and Conclusions—An unsupervised, home exercise program is the least effective way to deliver exercise to people with PD and individual and group exercises have differing benefits. Furthermore, people with PD who also have other comorbidities did better in a program directly supervised by a physical therapist. **Video Abstract available** for additional insights from the authors (See Supplemental Digital Content 1, http://links.lww.com/JNPT/A112).

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List of supplemental digital content

Supplemental Digital Content 1 (Video Abstract): JNR_abstract.mp4

Supplemental Digital Content 2 (Online only):

INTRODUCTION

Parkinson's Disease (PD) is a progressive neurodegenerative disease that results in significant mobility decline that can be partially remediated with exercise.[1-13] Although medications and surgery may improve some aspects of movement, exercise is gaining attention as another option that may also improve mobility and other non-motor symptoms related to cognition and emotion over and above the benefits of either medications or surgery.[6,14] There is evidence that many types of exercise can improve aspects of mobility in people with PD.[14] A recent meta-analysis examined differences between types of exercise by sub-grouping studies according to intervention and found no difference but caution readers about the limited number of studies and the indirect comparison of interventions.[9]

Often overlooked in exercise trials is *how* exercise intervention is administered. Most studies use either 1) group intervention or 2) individual physical therapy. However, current standard-of-care is often limited to 3) an unsupervised, home exercise program in which the patient is seen 1-2 times individually and then provided instruction on exercises to be done at home. Insurance coverage of group classes is unreliable and those interested in community group classes often must pay out-of-pocket.

Home exercise programs have reportedly low compliance rates and this could be even worse in a person with greater balance problems and/or other medical complications.[15-18] One study found that important barriers such as cognition made execution of a home exercise program difficult for people with PD.[19] Nonetheless, home exercise programs remain standard-of-care for mobility deficits in PD.

A second, often-overlooked challenge to exercise rehabilitation is that people with PD have a high number of comorbidities that may impact the success of therapy. People with PD have greater rates of depression, apathy, musculoskeletal problems, and mild cognitive impairment than their peers without PD.[20-25] These comorbidities may limit people's ability to participate in exercise programs.[26]

Our group recently published a paper providing evidence that a sensorimotor-based Agility Boot Camp (ABC) was successful at improving multiple aspects of mobility in people with mild PD when administered in an individual outpatient setting of more frequent time allotment than is considered standard.[27] This study prompted the question of whether similar results could be achieved in other settings, such as a group class or home exercise program. The purpose of the current study was to determine if this program would be equally successful when provided as a home exercise program, in a group class, or in individualized physical therapy sessions. We hypothesized that individual therapy would be more successful than a group class or home exercise using the sensorimotor ABC program for PD. Further, we sought to determine if common comorbidities associated with PD impacted the success of each type of exercise intervention.

METHODS

Design Overview

Participants with PD were randomized into either: 1) home exercise 2) individual physical therapy or 3) a group class intervention. All arms were standardized and based on the ABC exercise program for PD.[28] The study was designed in waves of 12 participants; 4 people per arm. Each wave occurred over a six-week period; pretesting (week 1), exercise intervention 3x/week 60 minutes per session (weeks 2-5) and post testing (week 6). Testing was performed in the same order and with rest breaks as needed by a blinded research assistant. All participants were tested and all exercise was performed in the ON state as defined subjectively by the participant having recently taken their medications.

Participants

People of either gender with an idiopathic PD diagnosis were recruited from the Movement Disorders Clinic at Oregon Health Sciences University (OHSU) and the local community. To be included, people were required to: 1) have a diagnosis of idiopathic PD, 2) be between 40-80 years old, 3) have a least one co-morbidity associated with PD or aging, 4) walk unassisted. People were excluded if they: 1) needed assistance with ADL's, 2) did not speak or read English, 3) participated in a different exercise study within the year, 4) engaged in >10 hours of exercise/week, 5) participated in a conflicting research study, 6) had a moderate-severe cognitive impairment, 7) lacked transportation to come to OHSU 3X/week.

Eligible subjects completed the Cumulative Illness Rating Scale for Geriatrics (CIRS-G) over the phone to assess medical system comorbidities.[29] Based on the results, participants were stratified into either a *mild* or *severe* cycle of the study to enhance safety and control the skill level of the exercise class. If a participant scored a 3 (severe) in more than one section, a 3 in the neurologic section, or a 4 in any section, their impairment was deemed *severe*. If a participant scored a 3 in only one section (not including neurologic) or if they scored lower than 3 their impairment was categorized as *mild*. This information was used to stratify participants according to severity so that would groups would be equal on the numbers of participants with severe versus mild comorbidities.

Ethical Review

All participants signed informed consent approved by OHSU's Institutional Review Board. All work was conducted in accordance with the declaration of Helsinki (1964). This clinical trial (NCT01361724) was registered on clinical trials.gov and took place between March 2011 and August 2012.

Twenty-four people were ineligible due to lack of transportation, age, cognitive impairment, inability to stand unassisted, conflicting research study, or exercising more than 10 hours a week. Twelve participants dropped out after pre-testing due to inability to commit to exercise 3X/week, and one due to injury. One participant dropped out after completing the exercise intervention due to a family emergency (Fig 1). Patient baseline characteristics are outlined in Table 1.

This study was powered on data from 9 individuals with PD undergoing individualized ABC training with a physical therapist 4 X/week for 4 weeks. Using the 7-item PPT, we determined that at least 12 subjects per group would be required to show an improvement after exercise with α of 0.05 and Power $(1 - \beta)$ of 0.80.

Randomization

The statistician provided a computer-generated randomization list, stratified by comorbidity level, for blocks of 12 people (4 in each group). Sealed envelopes were prepared for each wave. Participants received their randomization letter after pre-testing had been completed. The person responsible for pre/post testing remained blinded to group assignment. Exercise and pre/post testing took place in different buildings to ensure continued blinding.

Intervention

The exercise intervention was based on the sensorimotor ABC Program.[27,28] The program targets basic postural systems in a 'boot camp' model to target biomechanical constraints, kinesthesia, limits of stability, anticipatory postural adjustments, bradykinesia, and coordination during gait. There were 6 stations: Tai chi, Boxing, Lunges, Kayaking, Agility course and Pilates. Each activity was systematically progressed for 3 levels by (1) challenging sensory integration via alteration of visual and surface conditions, (2) restricting availability of external cues, (3) increasing speed, (4) increasing resistance and (5) adding secondary tasks. Regardless of assignment, the exercise program was designed for 3X/week for 4 weeks with 60 minute sessions (See Appendix [Supplemental Digital Content 2]).

Home Exercise Program: The participants assigned to home exercise met with the physical therapist once to receive their individualized ABC home exercise program. The physical therapist assigned the exercise level based on the participant's ability to safely conduct the exercises in the home. Handouts were provided. *Individual Exercise Program:* The participants in the individual exercise program met one-on-one with the physical therapist 3X/week for an hour at the outpatient rehabilitation center. The physical therapist progressed the participant through the exercise program based on their ability to complete the exercises safely. *Group Exercise Program:* The participants randomized to the group class came to the wellness center at the University 3X/week for an hour. The physical therapist leading the class progressed people across the levels as appropriate. Missed sessions were not rescheduled. The 3 physical therapists were highly experienced, had strong backgrounds in PD, and were trained extensively in the ABC Program. Each physical therapist rotated equally with the cycles to avoid bias or effect of therapist.

Exercise progression and compliance

Rate of Perceived Exertion (RPE) was collected after each session on a scale of 0-10. All scores were averaged over the course of the study. Progression level was determined by the physical therapist and recorded by the participants. For those exercising at home, the level of exercise was determined in the beginning and held constant. For those in the group and individual exercise, the level of exercise could change over time, based on the physical therapist's observations. Compliance was calculated by percentage of assigned exercise sessions in which exercise occurred.

Outcomes Measures

Our primary outcome measure was the 7-item PPT.[30] The PPT is designed to simulate common tasks including writing, simulated eating, putting a book on a shelf, donning and doffing a jacket, picking up a penny from the floor, performing a 360 degree turn, and walking 50 feet. This instrument has been well studied and validated for PD and does not have a floor or ceiling effect.[30,31]

Other Clinical Outcomes

The *Mini-BESTest* is a sensitive measure of balance in the PD population and includes 14 balance items.[32,33,34] *Timed up and go (TUG) test* is a test of mobility where the person is asked to stand, walk 3 meters at a comfortable pace, turn around, come back and sit down.[35] This test has excellent reliability for assessing people with PD.[36] *Timed up and go with dual task (TUG-D)* is performed as the TUG but simultaneously the person is asked to perform a secondary task, such as counting backwards by threes.[37,38] The test is timed and compared to the standard TUG. Slowing under the addition of a secondary task of greater than 10% is considered abnormal.[32] *Parkinson Disease Questionnaire-39 (PDQ-39)* is a questionnaire for measuring quality of life for individuals with PD. *Activities-Specific Balance Confidence Scale (ABC)* is a reliable 16-item questionnaire for detecting loss of balance confidence.[39,40] *The Exercise Self-Efficacy Scale (SES)* is an 18-item test that measures an individual's self-efficacy to participate in exercise when various barriers, social and physical are present.[41] *Lille Apathy Rating Scale (LARS)* is a 33-item test that measures apathy in persons with PD.[42] Unified Parkinson's Disease Rating Scale Activities of Daily Living (UPDRS-ADL Part II) is a 13-item questionnaire focused on symptomatic effects of PD on a variety of ADL's.[43] Unified Parkinson's Disease Rating Scale (UPDRS-Motor- Part III) is the most commonly used test for evaluating motor deficits in PD.[13,43,44]

All gait measures were derived using APDM system and software.[45] Participants wore 6 Opal sensors on the posterior trunk at L5, ankles, wrists and sternum. The sensors record 3D accelerations and angular velocity and wirelessly stream data to a laptop. The sensors on the ankles are used to detect basic gait events and temporal gait measures are calculated based on the time of gait events. Spatial gait measures are estimated using a biomechanical model.[46,47] All gait parameters were derived from a 2-minute walk. We calculated the following metrics based on previous studies suggesting sensitivity to early PD, good reliability and a comprehensive characterization of commonly impaired aspects of PD: 1) stride velocity, 2) arm swing velocity, 3) trunk velocity 4) stride time variability 5) turn duration. Turns were averaged out of the 2-minute walk. Freezing of gait was measured using the Freezing of gait questionnaire, a six item questionnaire to assess severity of freeing of gait.[48]

Comorbidities, possible confounders and effect modifiers

The Cumulative Illness Rating Score—Geriatric (CIRS-G) measures comorbidity in the geriatric population and measures medical problem severity on a scale from 0 to 4 (0=no problem; 4=extremely severe) for each organ-specific category (heart, vascular, hematopoietic, respiratory, eyes/ears/nose/throat/larynx, upper gastrointestinal, lower

gastrointestinal, liver, renal, genitourinary, musculoskeletal, neurological, endocrine/metabolic/breast and psychiatric illness).[49] The CIRS-G has good inter-rater reliability, face validity and been validated for use over the phone.[49] *Montreal Cognitive Assessment (MOCA)* assesses mild cognitive impairment by measuring attention and concentration, executive function, memory, language, visoconstructional skills, conceptual thinking, calculations and orientation.[50-52] It is valid and reliable for persons with PD.[51,53] *Geriatric Depression Scale (GDS)* is a self-reporting questionnaire for depression in the community-dwelling elderly and is both reliability and validity.[54] *Body Mass Index (BMI)* was calculated at their pretest visit.

Statistical analysis methods

Baseline characteristics among the three groups were compared using Kruskal-Wallis tests (for continuous variables) or Chi-square test (for categorical variables). Wilcoxon signed-rank tests were conducted to determine whether the outcome measures improved from baseline for each group. Standardized Response Mean (SRM) (= d/SDdiff, the mean score change divided by the standard deviation of change) was calculated for each outcome and a value of 0.20 represents a small change, of 0.50 a moderate, and 0.80 represents a large change.[55] Linear regression models were fitted to compare the changes in outcome measures from baseline among the three groups, after controlling for potential confounders and/or effect modifiers. For identified effect modifiers that interact with group, we assessed the association between the effect modifiers with the outcome variables within each group. Instead of the traditionally used 5% significance level, we set alpha to 10% for statistical significance in testing interaction terms. SAS 9.2 (Cary, NY) was used for data analysis.[56-58]

Results

There were no differences in exercise difficulty level among the groups at the end of the study (Home: 2.4 ± 0.61; Individual 2.5 ± 0.40; Group class: 2.4 ± 0.25). All 3 groups reported between moderate and somewhat heavy RPE (Home: 4.1 ±1.5; Individual: 4.1 ± 1.1; Group class: 3.4 ±1.2). The home group recorded 85% compliance, individual 97% and the group class 95%. The groups had roughly equivalent people who had freezing of gait as defined by a positive response to item 3 on the FOG questionnaire; home group had 60% people with FOG and both individual and group had 46% of people.[59]

The individual group was the only group to improve in our primary outcome measure, the PPT, on which the study was powered. Further, this group (individual) showed the most improvements in functional measures such as the PPT, UPDRS-ADL's, apathy, self-efficacy, depression, and balance. The group class showed the most improvements in gait measures such as freezing of gait, stride velocity, arm swing, trunk movement, gait variability and gait under dual task. The home exercise program improved the least across all outcomes. Table 2 reports statistics on outcomes for each group. The last column reports p-values of direct comparison of the pre/post changes among the 3 groups, while the individual p-value columns compare pre/post-values for each group separately.

We examined potential confounding variables (i.e. comorbidity scores, disease severity, age, BMI, number of medications, cognition, depression) and did not find any potential confounders related to both outcome variable and group assignment (i.e. no difference in results when controlling for each potential confounder). However, we found significant effect modifiers when examining the same comorbidities (i.e., several variables had a significant effect on certain outcome measures after exercise). Table 3 summarizes effect modifiers by providing p-values for comorbidities that had an effect on each outcome measure. In Table 3, statistically significant effect modifiers are bolded, and presented with the p-value for the interaction term in the linear regression model. The p-values represent significant interaction effects between the potential effect modifier and the outcome variable after exercise while “NS” means non-significant effect modifier.

Of the 7 effect modifiers, all, except age, were significantly associated with exercise effectiveness for the home group while only a few had significant associations with exercise effectiveness for the individual and group class. For example, the presence of depression, high comorbidities status and mild cognitive impairment only impacted success of people in the home program. In contrast, the number of medications, disease severity and BMI impacted success for all 3 groups (Table 4).

Discussion

Delivery method of rehabilitation and the presence of common comorbidities critically impact the success of rehabilitation for people with PD. Our main findings were that 1) home exercise – the standard-of-care for PD- is the least effective method to improve mobility, 2) individually-treated participants improved the most in balance and functional measures, 3) group class participants improved mainly in gait measures, and 4) the presence of certain comorbidities limited success of the therapeutic intervention primarily for participants in the home exercise assignment.

Only those receiving individual physical therapy improved significantly in the PPT. The average change was 1.8 points, close to the 2.5 Minimal Detectable Change (MDC) for people with PD and the 2 point improvement after exercise found after exercise in people without PD.[31,60] It should be noted that we used the 7-item PPT while MDC is based on the 9-item test. Although the people who received individual therapy improved the most in balance measures, the group class had the largest improvement in balance confidence. It has been reported that balance confidence changes do not always correlate with balance ability in people with PD and that balance ability can be improved without associated increase in balance confidence.[61,62] In our study, both the home and individual exercise (but not the group class) improved significantly in balance as measured by the Mini-BESTest. Both mean changes were below the published MDC but roughly one quarter of the people in each group achieved at or above the level of clinically important change (24% home, 19% individual and 25% class) suggesting that the ABC program is helpful for balance in a subset of people regardless of delivery. In a group class, the instructor may not be able to safely challenge balance, but the overall movement and interaction involved in a class may improve perception of balance control. The UPDRS-ADL subscore measures the impact of PD on ADL's and function and had been suggested to be a stable measure of disease

progression since it is less affected by drug and motor fluctuations.[63] ADL's changed only in the individual group and this change averaged 1.6, similar to changes found in other exercise interventions for PD and approximated the MDC of 2 points.[64-66] Participants averaged 1.4 to 1.9 points of changed improvement in UPDRS Motor subscore, lower than the published MDC of 3.5 to 5.[64,65] The UPDRS-Motor change was not significant in any group.

Surprisingly, the group class improved the most in gait. While the ABC program does not specifically target gait, many exercises emphasize big movements, trunk flexibility and arm swing, all of which may improve gait. There is increasing evidence of a relationship between cognition and gait that may naturally be emphasized more in a group setting.[67,68] A class involves more interaction, which could result in a greater emphasis on divided attention and cognitive function when compared to exercising alone. Gait variability improved only in the group class, which may relate to cognition. In cognitively impaired adults and in persons with PD, gait variability increases under dual task conditions.[67,69] Furthermore, PD with FOG results in even more gait variability under dual task conditions.[70] Gait variability is reportedly associated with falls and is increased in people with FOG.[67,70-72]

Although it is commonly believed that exercise improves quality of life, findings for the PD population have been mixed.[9,73] In our study, quality of life improved across all groups, although the largest improvement was in the class. Reportedly, quality of life is correlated with depression and apathy, both which improved in the individual therapy group as well.[74] Self-efficacy is a major determinant in successful continuation of exercise participation.[75,76] Again, we found that the individual group was the only one group to significantly improve in self-efficacy, after oneon-one sessions with a physical therapist.

Results from this study suggest that exercise led by a physical therapist, either individually or in a group setting, may be critical to overcoming obstacles associated with comorbidities such as mild cognitive impairment, disease severity, BMI, number of medications and depression. People who had higher levels of comorbidities did not improve with home exercises like they did in the physical therapist-led programs. These comorbidities should be factored in to determine if a home exercise program is appropriate.

There are several limitations to this study. The lack of a non-exercising control group does not allow direct comparison of exercise versus no exercise. Furthermore, 4 weeks of exercise may not be long enough to see significant improvements in all groups and outcomes. Since we were unable to progress the intensity and complexity of the home exercise group as we did the other groups, we do not know if a progressive home exercise program would have shown differences. Finally, we did not have a follow-up period to determine whether the effects of exercise lasted over time. It should be noted that all of our interventions were led entirely by highly experienced physical therapists. Further research should consider if similar results would be obtained using less experienced physical therapists, physical therapist assistants or exercise trainers.

Our results suggest that an unsupervised home exercise program is the least effective way to deliver therapeutic exercise to people with PD. In addition, individual and group exercise

has differing benefits. Group class may be most effective for improving gait, particularly those associated with cognitive challenges. In contrast, individual physical therapy may be the best method to improve function and balance. A combination of both group and one-on-one administered physical therapy may be the most effective way to treat mobility disability for people with PD. Furthermore, people with PD who have depression, high number of comorbidities, mild cognitive impairment, high BMI and advance disease severity should be seen in a physical therapist-supervised program. Taken together, the findings from this study call into question the usefulness of an unsupervised home exercise program to improve mobility in people with PD and other accompanying comorbidities.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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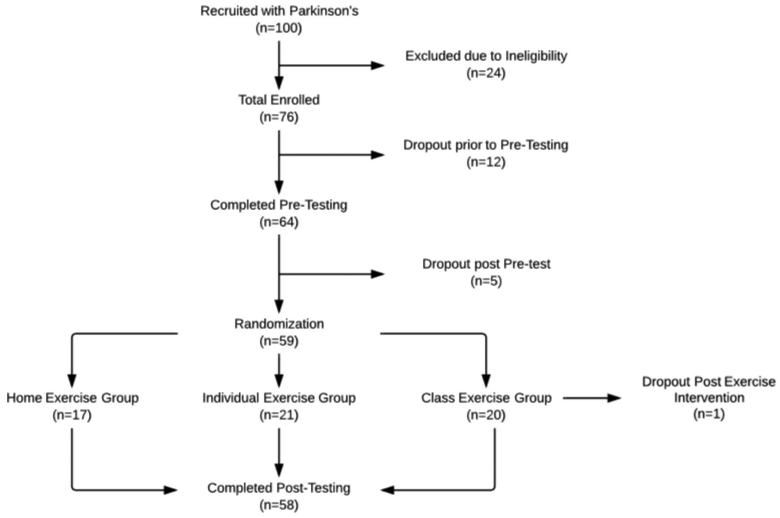

Figure 1.
Consort Diagram

Table 1

Characteristics of the Participants

Characteristic	All (n=58)		Home (n=17)		Individual (n=21)		Class (n=20)		P-Value
	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	Mean (SD)	Median	
Age (y)	64.2 (7.3)	63.9	64.6 (6.8)	63.8	64.2 (6.7)	64.7	63.9 (8.5)	64.5	0.88
Male (%)	41.0	NA	10.0	NA	17.0	NA	14.0	NA	0.33
H & Y	2.4 (0.5)	2.0	2.5 (0.5)	3.0	2.4 (0.5)	2.0	2.4 (0.5)	2.0	0.51
Disease Duration (y)	6.2 (6.1)	5.3	5.2 (5.8)	1.9	7.9 (7.9)	5.3	5.4 (3.6)	6.0	0.36
UPDRS - Motor	36.8 (12.8)	37.0	35.2 (13.7)	32.0	39.4 (11.1)	38.0	35.4 (14.1)	37.5	0.43
BMI	27.6 (4.7)	26.5	27.6 (5.0)	25.9	28.0 (4.8)	25.7	27.2 (4.5)	28.6	0.45
MOCA	26.0 (3.8)	27.0	25.8 (4.0)	27.0	26.1 (2.5)	26.0	25.8 (3.1)	27.0	0.90
Total Cirs-G	12.4 (4.2)	12.0	12.0 (4.0)	13.0	12.0 (4.0)	11.0	13.2 (4.5)	11.5	0.65

Table 2

Estimated means, standard deviation (SD), Standardized Response Mean (SRM), and P-Value differences before and after exercise for each group.

		Home						Individual						Class					
	Primary Outcome	**Pre Mean (sd)**	**Post Mean (sd)**	**Diff (mean, med; 95% CI)**		**SRM**	**P-Value**	**Pre Mean (sd)**	**Post Mean (sd)**	**Diff (mean, med; 95% CI)**		**SRM**	**P-Value**	**Pre Mean (sd)**	**Post Mean (sd)**	**Diff (mean, med; 95% CI)**		**SRM**	**P-Value**	**P-Value ALL**
	PPT	21.4 (05.0)	22.6 (3.6)	0.71, 0.0;	−0.7, 2.2	0.28	0.371	20.0 (4.2)	21.9 (4.0)	1.81, 1.0;	0.69, 2.9	0.74	0.004	21.4 (3.5)	22.0 (2.9)	0.55, 0.5;	−0.4, 1.5	0.27	0.156	0.265
	Secondary Outcome																			
Functional	UPDRS- ADL	11.6 (05.1)	11.0 (7.10)	−0.65, −1.0;	−2.7, 1.4	0.00	0.489	13.5 (6.3)	11.9 (5.1)	−1.67, −1.0;	−2.9, −4.3	0.61	0.011	11.7 (5.0)	9.8 (4.9)	−1.90, −2.0;	−4.0, 0.2	0.43	0.061	0.691
	UPDRS- Motor	35.2 (13.7)	33.8 (14.0)	−1.47, −2.0;	−4.1, 1.2	0.29	0.308	39.4 (11.1)	38.0 (10.4)	−1.30, −1.0;	−4.3, 1.6	0.21	0.212	35.4 (14.1)	33.5 (12.7)	−1.90, −1.5;	−5.3, 1.5	0.26	0.191	0.990
	PDQ	33.1 (18.4)	26.5 (18.2)	−6.65, −9.0;	11.6, −1.7	0.69	0.015	40.7 (23.5)	33.8 (16.2)	−6.30, −5.5;	13.1, 0.5	0.43	0.068	34.8 (21.8)	21.1 (11.9)	−10.4, −9.0;	16.8, −4.0	0.81	0.002	0.448
	LARS	−24.1 (05.3)	−24.5 (3.8)	−0.41, 0.0;	−2.4, 1.6	0.11	0.683	−22.1 (5.3)	−24.3 (4.8)	−2.24, −2.0;	−4.4, −0.1	0.47	0.048	−23.9 (5.3)	−24.2 (7.0)	−0.25, −1.0;	−2.7, 2.2	0.05	0.745	0.377
	SES	60.4 (15.4)	62.8 (17.4)	2.41, 2.0;	−5.2, 10.0	0.16	0.524	68.0 (15.4)	73.2 (12.6)	5.24, 5.0;	0.8, 9.7	0.54	0.017	67.9 (15.1)	70.5 (14.1)	2.65, 0.5;	−1.2, 6.5	0.32	0.237	0.655
	GDS	7.4 (04.8)	6.8 (5.1)	0.07, 1.0;	−2.0, 2.1	0.01	0.669	9.5 (4.9)	8.1 (5.2)	−1.43, −2.0;	−2.5, −0.4	0.64	0.014	7.0 (5.9)	5.4 (5.8)	−1.11, 0.0;	−2.4, 0.2	0.40	0.138	0.142
	Mini- BESTest	20.5 (04.2)	22.3 (3.9)	1.82, 2.0;	0.4, 3.2	0.67	0.013	19.8 (5.0)	21.6 (5.2)	1.81, 2.0;	0.9, 2.8	0.86	0.001	21.7 (3.8)	22.3 (4.0)	0.06, (0.5);	−0.7, 1.9	0.21	0.347	0.293
	ABC	81.4 (15.5)	82.9 (15.3)	1.55, 1.9;	−2.8, 5.9	0.18	0.571	71.1 (14.5)	82.2 (12.2)	3.16, 3.1;	−0.1, 6.5	0.44	0.061	83.5 (17.6)	84.5 (17.9)	4.62, 3.0;	1.5, 7.7	0.75	0.001	0.429
	Freezing of Gait	5.1 (04.8)	5.4 (4.8)	0.35, 0.0;	−0.5, 1.2	0.20	0.413	6.3 (6.3)	5.7 (5.0)	−0.62, 2.0;	−1.9, 0.6	0.23	0.308	4.6 (4.4)	3.4 (3.7)	−1.20, −1.0;	−1.9, −0.5	0.83	0.001	0.038
Gait	Stride Velocity *(height/s%)*	76.4 (11.4)	76.7 (12.7)	0.37, 1.6;	−2.5, 3.2	0.06	0.790	72.3 (10.7)	73.1 (12.6)	0.81, 1.8;	−1.5, 3.1	0.16	0.476	74.6 (11.8)	78.4 (11.9)	3.80, 3.1;	1.6, 6.0	0.80	0.002	0.124
	Arm Velocity *(degrees/s)*	139.7 (64.5)	148.0 (75.1)	8.39, 18.4;	−3.1, 19.9	0.37	0.142	141.3 (67.2)	159.0 (79.9)	17.7, 13.9;	2.7, 32.8	0.54	0.024	134.2 (67.8)	166.3 (80.6)	32.1, 18.9;	15.6, 48.6	0.91	0.001	0.232
	Trunk Velocity *(degrees/s)*	23.2 (10.5)	23.4 (9.8)	0.18, −0.2;	−1.5, 1.9	0.05	0.824	22.1 (7.7)	25.0 (7.7)	3.0, 3.3;	−0.5, 5.5	0.54	0.023	19.7 (6.0)	23.1 (9.1)	3.50, 2.3;	1.2, 5.8	0.70	0.005	0.028
	Stride Time Variability *(%)*	0.02 (0.01)	0.03 (0.02)	−0.004, −0.002;	0.02, 0.03	0.25	0.318	0.03 (0.01)	0.03 (0.01)	0.001, 0.001;	0.02, 0.03	0.02	0.937	0.03 (0.01)	0.02 (0.01)	0.005, 0.001;	0.02, 0.03	0.50	0.049	0.051
	Turn Duration *(s)*	2.6 (0.8)	2.7 (1.3)	0.04, −0.09;	−0.3, 0.4	0.06	0.306	2.6 (0.7)	2.6 (0.8)	−0.01, −0.05;	−0.2, 0.2	0.04	0.567	2.6 (0.7)	2.4 (0.6)	−0.13, −0.01;	−0.3, 0.1	0.30	0.316	0.935
	TUG *(s)*	11.3 (0.9)	11.0 (1.3)	−0.35, 0.3;	−1.4, 0.5	0.23	0.487	10.9 (3.5)	10.2 (2.9)	−0.64, −0.05;	−1.5, 0.7	0.16	0.389	13.2 (8.9)	13.1 (7.7)	−0.16, −0.2;	−0.9, 0.02	0.29	0.234	0.979
	TUG-D *(s)*	13.7 (02.5)	13.7 (3.4)	0.05, 0.3;	−1.8, 0.9	0.20	0.890	14.9 (6.1)	13.2 (3.9)	1.90, −0.8;	−2.5, 2.0	0.05	0.547	15.6 (6.5)	16.2 (9.6)	−0.40, −0.9;	−3.3, −0.04	0.52	0.012	0.392

Table 3

Summary of interaction effects (represented as P-values) between potential effect modifiers and outcome variables after exercise.

		Effect Modifiers						
		UPDRS	**AGE**	**BMI**	**MEDICATION**	**MOCA**	**COMORBIDITY**	**DEPRESSION**
Outcome Measures	UPDRS-ADL	0.093	NS	NS	NS	NS	0.02	NS
	Physical Performance Test	NS	0.086	NS	NS	NS	NS	NS
	UPDRS - Motor	NS	NS	NS	NS	NS	NS	0.019
	PDQ-39	NS	NS	NS	NS	NS	NS	NS
	Apathy	NS	0.009	0.086	NS	NS	NS	NS
	Self Efficacy	NS	0.07	NS	NS	NS	NS	NS
	Mini Best	NS	NS	NS	NS	NS	NS	NS
	ABC	NS	NS	NS	NS	NS	NS	NS
	Freezing of Gait	NS	NS	NS	0.04	0.057	NS	NS
	Stride Velocity	NS	NS	NS	0.09	0.072	NS	NS
	Arm Velocity	0.07	NS	NS	NS	NS	NS	NS
	Trunk Velocity	NS	NS	NS	NS	NS	NS	NS
	Stride Time Variability	0.0004	NS	0.001	0.028	0.016	0.008	NS
	Turn Duration	NS	NS	0.001	NS	0.039	NS	NS
	Tug Time	NS	NS	0.026	0.038	NS	NS	NS
	Tug Dual Task Time	NS	NS	NS	0.032	NS	NS	NS

Table 4

Interaction effects separated by interventions to highlight group-specific interaction effects between effect modifiers and outcomes.

Effect Modifiers	Outcomes	Home	Group	Individual
Depression	UPDRS - Motor		0.49	0.56
Co-morbidity Score	UPDRS - ADL	0.04	0.28	0.12
	Stride Time Variability	0.02	0.29	0.59
Mild Cognitive Impairment	Freezing of Gait	0.006	0.49	0.04
	Stride Time Variability	0.02	0.37	0.86
Number of Medications	Freezing of Gait	0.55	0.37	0.01
	Stride Time Variability	0.04	0.35	0.46
	Stride Velocity	0.02	0.86	0.37
	Tug Time	0.32	0.4	0.02
	Dual Tug Time	0.0009	0.88	0.12
Disease Severity (UPDRS - Motor)	UPDRS - ADL	0.032	0.69	0.63
	Arm Velocity	0.13	0.45	0.05
	Stride Time Variability	0.02	0.008	0.58
Age	PPT	0.12	0.45	0.2
	LARS	0.55	0.07	0.02
BMI	Stride Time Variability	0.0012	0.6	0.93
	Turn Duration	0.0013	0.05	0.51
	Tug Time	0.0004	0.78	0.99
	LARS	0.16	0.73	0.04
MOCA	Freezing of Gait	0.0063	0.41	0.48
	Stride Velocity	0.04	0.35	0.83
	Stride Time Variability	0.07	0.2	0.25
	Turn Duration	0.05	0.68	0.52