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OPTIMAL Theory-Based Interactive Image Making to Improve Gait and Quality of Life in Parkinson Disease

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Parkinson Disease
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Abstract

Purpose: Parkinson disease (PD) is characterized by aberrant control of movement resulting in impaired gait. Physical therapy plays a critical role in symptom management; however, sustained improvements require continued practice of gait. This pilot feasibility study aimed to evaluate the feasibility, safety, acceptability, and initial efficacy of gait training with interactive image making based on OPTIMAL theory in people with PD.

Methods: 11 participants were randomized into the experimental or control group and underwent 16, 50-minute sessions with a licensed physical therapist during the 8-week training period. The experimental group (n=6) engaged in gait training with interactive image making informed by the OPTIMAL theory, while the control group (n=5) engaged in gait training plus observation of landscape images not constructed using the OPTIMAL theory. Feasibility, acceptability, and appropriateness were assessed by recruitment, attendance, retention rates, and safety and by participant-reported outcome measures (Acceptability of Intervention Measure (AIM), Intervention Appropriateness Measure (IAM), and Feasibility of Intervention Measure (FIM). Secondary outcomes assessed gait speed, gait endurance, physical activity, motivation, and quality of life (QoL).

Results: Primary outcomes all exceeded the criterion levels (FIM, AIM, and IAM (criterion 75%; 76%, 89%, and 88% of agreement, respectively), attendance (criterion 70%; 98.86%), retention (criterion 90%; 100%). Secondary outcomes demonstrated improvement at the individual and group level.

Conclusion: These findings suggest that gait training through interactive image making is a safe, feasible, and acceptable intervention that may improve gait, mobility, and QoL in people with PD. Future research is needed to explore this effect and its mechanisms further within larger randomized controlled trials.

Introduction

Parkinson's disease (PD) is the second most common neurodegenerative disorder[1]. It is characterized by loss of dopaminergic neurons in the substantia nigra[2]. The cardinal motor symptoms include tremors, rigidity, bradykinesia, and postural instability[3]. Resulting mobility problems, such as gait disturbances, instability, and frequent falls, impact both physical functioning and mental well-being[4,5]. Additionally, nonmotor symptoms of PD include decreased motivation and mood disorders. Together, these symptoms can lead to disruptions in daily function, roles, and activities, causing an overall decrease in quality of life (QoL)[4].

Recent research has highlighted the positive effects of physical exercise on both motor and non-motor symptoms of PD, suggesting that exercise-based interventions, including gait training, can improve overall QoL by enhancing mobility and alleviating psychological symptoms such as depression[6–8]. However, adherence to gait training programs may be difficult for patients with PD, as they have difficulties with motor learning[9] and experience decreased overall motivation[10]. To address this issue, incorporating the principles of Optimizing Performance Through Intrinsic Motivation & Attention for Learning (OPTIMAL) theory into gait training interventions may be beneficial[11].

OPTIMAL theory posits that motor learning cannot be understood without considering the motivational and attentional influences on behavior[11]. Three core factors of the OPTIMAL theory include: enhanced expectancies, autonomy, and external focus. Enhanced expectancies refers to the anticipation of a reward or positive outcome[12]. For instance, belief in one's ability to succeed directly influences the quality of the movements[11,13]. Autonomy refers to having control over practice conditions or the environment[7]. Giving the learner control over certain aspects of the practice conditions enhances motor skill learning[14]. Research on self-controlled practice in young, healthy adults indicated that this factor has a strong positive effect on learning[15]. Chiviacowski et al. (2012) looked at the effects of different types of instructions on complex motor skill learning in people with PD. The study indicated that participants demonstrated more effective learning and were more motivated to learn a motor task when they were given a choice compared to those who were given instructions regarding the task[16]. Finally, external focus of attention directs attention away from one's body parts or self and to the intended movement effect[17]. Wulf et al. (2009) examined the impact of attentional focus on balance in older adults with PD[18]. Their findings indicated that wording distinctions that direct attention to movement effects external to the mover reduce postural instability during standing relative to an internal focus[18]. To conclude, the multifaceted approach of the OPTIMAL theory in addressing the motor and motivational impairments associated with PD, offers promising methods for optimizing gait rehabilitation strategies in this population[6].

Building on these findings, we hypothesize that incorporating interactive image making into a gait training program, grounded in the OPTIMAL theory, will enhance motor learning by enhancing expectancies with explanations of expected outcomes, increasing autonomy during the creative process of interactive image making during gait training, and providing an external focus of control through the image making. This feasibility study aims to improve current approaches by integrating creativity through interactive image making based on OPTIMAL theory. The primary goal is to determine the feasibility, safety, acceptability, and initial efficacy of this novel gait training intervention that incorporates facets of the OPTIMAL theory to enhance motivation and motor learning and ultimately improve gait and QoL in people with PD.

Methods

This study was a randomized controlled feasibility trial to assess the feasibility, acceptability, and appropriateness of gait training with interactive image making based on OPTIMAL theory[11] for individuals with PD. The University of Connecticut's Institutional Review Board (IRB) approved this study (HR21-0142).

Participants

Potential participants were recruited via recruitment flyers posted in community centers, healthcare facilities, and PD organization newsletters and websites. Recruitment flyers were also shared by health care providers, fitness professionals, support group leaders, word of mouth, and community events.

Inclusion Criteria

Inclusion criteria were: 1. Diagnosis of idiopathic PD;2. Hoehn and Yahr stage 1-3; 3. Age ≥ 30 years old; 4. Able to walk without the assistance of another person (may use an assistive device); 5. Stable PD medication for 6 weeks without a plan for change in the coming 3 months; 6. Willingness to wear an activity tracker.

Exclusion Criteria

Exclusion criteria were: 1. Any unstable cardiopulmonary, orthopedic, metabolic, or psychological conditions; 2. Pain that was increased with walking; 3.Cognitive impairment (Telephone Interview for Cognitive Status[19] (TICS) ≤ 29); 4. Additional neurological diagnosis other than PD; 5. History of a fall within the last 3 months; 6. Daily episodes of freezing of gait.

Study Procedure

Interested individuals underwent a phone screening to assess initial eligibility and an in-person screening to assess baseline vital signs and disease severity. Medical clearance was required for participants using hypertension medication. All eligible participants provided written informed consent prior to participation. A computer-generated random sequence was created prior to participant enrollment by the PI. The PI generated this permuted block (block size = 2) randomization sequence and was not involved in recruitment, enrollment, or assessments. A research assistant (P.D.) enrolled participants and assigned them to the intervention or control group according to the predetermined sequence. The research assistant could not manipulate assignments, as participants were assigned to a group sequentially according to this pre-determined order, after consenting to the study.

Baseline Assessments

Demographic data were collected to describe the characteristics of the study population through a participant interview conducted by the research assistant. Medical history was collected through a participant interview conducted by a licensed physical therapist to document relevant clinical diagnoses, comorbid conditions, and medication use. This information was used to characterize baseline health status. Data were collected at the University of Connecticut, Storrs, CT, USA.

Outcome Measures

1. The Behavioral Regulation in Exercise Questionnaire-2[20] (BREQ-2): This is the most commonly used measure of motivators for exercise. It is a 19-item survey that evaluates the stages of motivation to exercise. This includes subscales such as amotivation, external regulation, introjected regulation, identified regulation, and intrinsic regulation. The Relative Autonomy Index (RAI) is a composite score that reflects the extent to which respondents feel self-determined. Higher RAI scores indicate more autonomous motivation, whereas lower scores reflect more controlled regulation. BREQ-2 has good test-retest reliability (0.84) and excellent content validity when assessing older adults[21].

2. Movement Disorder Society-Unified Parkinson Disease Rating Scale (MDS-UPDRS Part III)[22]: This scale is the gold standard for evaluating motor symptoms in individuals with PD. Part III focuses specifically on motor examination, including assessments of rigidity, bradykinesia, tremor, and postural instability. Higher MDS-UPDRS Part III scores indicate greater motor symptom severity and worse motor function, whereas lower scores reflect milder motor impairment and better motor performance.

3. Six-Minute Walk Test (6MWT)[23]: The 6MWT is a test of aerobic capacity and gait endurance. It measures the total distance an individual can walk in six minutes. It is a widely used test in people with chronic conditions, including PD, and it has demonstrated strong test-retest reliability (0.96)[24].

4. Ten-Meter Walk Test (10MWT)[25–27]: 10MWT assesses fast and comfortable gait speed over a short distance. It demonstrates excellent test-retest reliability for comfortable gait speed (0.96) and fast gait speed (0.97)[24].

5. Average Step Length (ASL): This test was used to measure the distance covered per step at a comfortable pace. Participants were instructed to walk 20 steps at a comfortable pace over a level surface. Then, the distance walked was measured with a measuring wheel and divided by 20 to calculate the step length.

6. Parkinson Disease Questionnaire-39 (PDQ-39)[28]: This 39-item self-report survey assesses QoL. It covers an assessment of mobility, activities of daily living, emotional well-being, stigma, social support, cognition, communication, and bodily discomfort. Higher scores on the PDQ-39 indicate greater impairment in health-related quality of life. Its internal consistency is acceptable (0.51- 0.96) with high reliability (0.86-0.96)[28].

Outcome assessments were conducted by an independent assessor who was blinded to group allocation for all testing at baseline and follow-up. This assessor was not involved in the delivery of the intervention or control interventions. Participants were reminded to refrain from discussing their group allocation with the blinded assessor prior to assessments. Additionally, participants wore an activity monitor, ActiGraph GT9X accelerometer (ActiGraph LLC, Pensacola, FL, USA), for one week prior and one week after the intervention to measure their physical activity levels. Data was averaged over 7 days and included days with 54% or more wear time[29].

Gait Training

All participants (experimental and control groups) engaged in gait training twice a week for 8 weeks. Standard gait training involved verbal, visual, and tactile cues to increase trunk extension and step length during both overground (OG) (15 minutes) and treadmill (TM) training (15 minutes). Throughout the gait training, participants were encouraged to reach 70% to 85% of their maximum heart rate by increasing their walking speed (OG and TM), increasing their arm swing, reducing external support (assistive device or TM rails), and/or advancing the percent incline (TM). Participants' heart rate was continuously monitored using a heart rate monitor, Polar H10 (Polar Electro, Oy, Kempele, Finland), and the Borg Rating of Perceived Exertion scale[30] to encourage participants to remain within their target heart rate zone during gait training.

Both groups received home exercises tailored to their baseline activity levels and their individual needs as prescribed by a licensed physical therapist.

Experimental Group

After completing gait training, participants engaged in a 15–25-minute photography session once per week that was focused on participants creating abstract images of their movements. Participants walked across a "runway" while being photographed by a photographer with long-exposure photography and were instructed to use large amplitude and high-velocity movements to create the abstract image (Supplementary Material). Participants self-selected props (e.g. finger lights, flashlights, reflective clothing, etc.) and the direction (forward, backward, side-stepping, turning) of their movement during the photography sessions. After walking one length of the walkway, participants would stop to look at the images they had created for 30 seconds to 1 minute. A licensed physical therapist monitored participant safety and response during these sessions.

Control Group

After completing gait training, the control group participants walked the same "runway" and then viewed standardized landscape pictures for 15-25 minute sessions once per week. After walking the length of the walkway, participants were instructed to pause and view the image (30 seconds to 1 minute). Participants did not have the autonomy to choose the direction of their movement or select the image.

The intervention and control groups were matched on time and interaction with the research team.

Post-Assessment

Post-assessments included the same measures as baseline (6MWT, 10MWT, ASL, PDQ-39, MDS-UPDRS, BREQ-2) plus feasibility, acceptability, and appropriateness measures.

Feasibility, Acceptability, and Appropriateness Measures

Objectively-measured Feasibility Outcomes

Recruitment, retention, attendance, and safety were measured as objective determinants of feasibility. Recruitment was assessed through interest in the study, as well as the inclusion and exclusion rates. Interest in the study was measured by the number of individuals who expressed interest in the study (call or email to study team) over time. The inclusion rate, or the ratio of the total number of participants who were eligible and consented in the study to the total number of participants screened, was assessed. In addition, the exclusion rate, or the ratio between the total number of participants that failed the screening, and the total number of participants screened, was assessed. These measures were used to determine if the set of inclusion and exclusion criteria were feasible for the population of interest.

The retention rate, or the ratio of the number of consented participants that completed the pre-assessment to the number at post-assessment, was assessed to determine the percentage of participants that remained in the study for the full study duration (8 weeks).

Attendance was recorded as the percentage of sessions attended out of the 16 planned sessions. Safety was continuously monitored throughout the study duration through documentation of adverse events; the physical therapist and research assistant queried participants at each study visit about any changes in their status or any adverse events that occurred outside of the session. Participants were asked to contact the research team in the event of an incident or change in their symptoms outside of the session.

Self-reported Feasibility Outcome Measures

The Participant Satisfaction with Walking Program (PSWWP) was created by the research team to evaluate participant satisfaction, identify strengths and weaknesses of the novel intervention, and gather recommendations for future improvements.

Acceptability of Intervention Measure (AIM), Intervention Appropriateness Measure (IAM), and Feasibility of Intervention Measure (FIM)[31] were administered during the post-intervention assessment by an assessor who did not deliver the intervention. The AIM was used to determine participants' perceptions of the interactive image making including their approval, appeal, whether they liked it, and whether they welcomed it. The FIM was used to determine if gait interactive image making was implementable, possible, doable, and easy to use. Lastly, the IAM, was used to determine if the experimental intervention was approved by the participants[31]. Responses were collected on a 5-point (1-5) Likert scale, where higher scores indicated greater feasibility, acceptability, or appropriateness. The mean scores for each measure were calculated and converted to percentage scores (range 20%-100%, with 100% indicating total agreement), with a criterion of ≥ 75% agreement at the group level to determine feasibility, acceptability, and appropriateness of this intervention[31]. This threshold is in line with guidelines for assessing feasibility and progression as an acceptable cutoff for determining satisfactory outcomes in pilot trials[32].

Data Analysis

Study data were collected and managed using REDCap (Research Electronic Data Capture) electronic data capture tools hosted at the University of Connecticut[33]. REDCap is a secure, web-based application designed to support data capture for research studies, providing: 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources[33]. Descriptive statistics summarize feasibility, acceptability, and appropriateness results, while group means, standard deviations (SD), and frequencies described within-group differences. Minimally clinically important differences are reported, when available, to assist with interpretation of results.

Results

Recruitment

A total of 41 individuals expressed interest in the study. Upon learning about the details of the study, 14 individuals had scheduling conflicts or could not participate due to transportation barriers. The inclusion rate was 40.7% (11/27) and the exclusion rate was 59.3% (16/27). One individual passed the screening but was not consented because medical clearance could not be obtained before the start of the intervention period. Participants' flow diagram is presented (Fig-1). Eleven individuals passed the screening and participated in the study (Table1).

Attendance

The overall attendance was 98.8% when assessing the 16 intervention sessions across the control and experimental groups. Attendance was 97.9% assessing the 16 intervention sessions across the experimental group. 90.9% (10/11) of participants attended all intervention sessions. Only one individual in the experimental group missed 2 sessions due to adverse events outside of the study session and unrelated to the study.

Table 1. Participant Characteristics.

Patient Characteristics	Experimental group (n = 6)	Control group (n = 5)
Age (years)	67 (9.8)	69 (7.5)
Male	4 (66.7%)	3 (60%)
Disease Duration (Years)	9.2 (6.0)	6.2 (3.3)

Values are reported as mean (SD) or frequency (%).

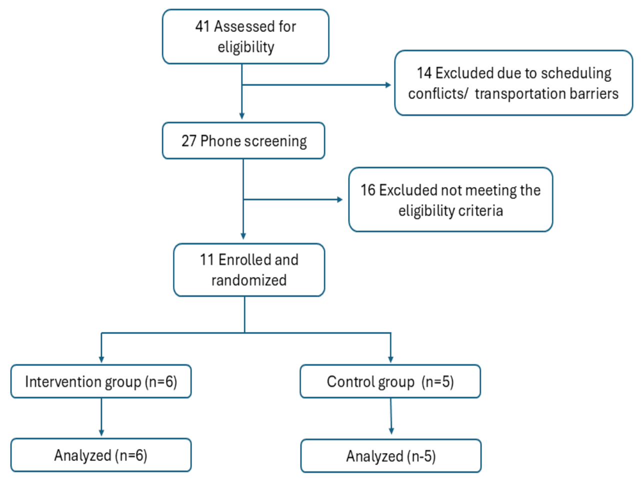

Figure 1. Participant Flow Chart

Retention

Retention was 100% with all 11 consented participants completing the baseline assessment, 8 weeks of the intervention, and the post-assessment.

Safety

No serious adverse events occurred related or unrelated to the intervention. Adverse events that occurred outside of the study session and were unrelated to the intervention were reported by 3 of the participants in the experimental group. These included a toe fracture due to a dropped object (1), a fall that occurred during vacation (1), and an exacerbation of symptoms that the participant reported occurred annually (1). Participants reported that these events led to a decline in their physical activity due to post-activity pain (toe fracture, fall), worsening of the symptoms that made it difficult to maintain their usual pace and incline (annual exacerbation of symptoms), or a doctor's instruction to reduce physical activity to promote healing of the fractured toe.

Feasibility, acceptability, and appropriateness of the intervention

The intervention was rated as acceptable (AIM = 76%), feasible (FIM = 84%), and appropriate (IAM = 88%), all exceeding the 75% criterion score. The PSWWP survey also indicated that participants benefited from the individualized gait training program, enjoyed the social support and connection they experienced, and believed that this program helped them improve their mobility. In the PSWWP survey, 83.3% (5/6) of participants in the experimental group rated the quality of the gait training program they received to be excellent. All participants in the experimental group reported that they would recommend the program to a friend in need of similar help. Additionally, 100% (6/6) of the participants in the experimental group stated that the program improved their walking to some extent. Regarding the overall satisfaction with the program, 83.3% (5/6) participants in the experimental group reported being very satisfied, and one participant indicated they were mostly satisfied. Lastly, 83.3% (5/6) of participants mentioned that they would participate in the program again if they needed help with their walking in the future.

Average Step Length

Both groups showed an increased average step length after the intervention (Fig.2). The mean individual level change score in step length was 21 cm (SD = 10.54) in the experimental group and 17 cm (SD = 37.8) in the control group. Sixty percent (3/5) of the individuals in the control group and 100% (6/6) of the individuals in the experimental group met the minimally clinically important difference (MCID) of 3.6 cm[34]. (Table 2)

Gait Measures

From baseline to post-intervention, 100% (6/6) of participants in the experimental group and 80% (4/5) of the participants in the control group improved their comfortable gait speed in 10MWT (Fig.2). The mean individual level change score for comfortable gait speed was 0.26 m/s (SD = 0.3) in the experimental group compared to 0.21m/s (SD = 0.26) in the control group (Table 2). Forty percent (2/5) of the individuals in the control group and 50% (3/6) of individuals in the experimental group met the MCID of .18 m/s[24]. 100% (6/6) of the participants in the experimental group and 60% (3/5) of the participants in the control group showed improvement in fast gait speed after 8 weeks (Fig.2). Forty percent (2/5) of the individuals in the control group and 33.3% (2/6) of individuals in the experimental group met the MCID of .25 m/s for fast gait speed[24]. The mean individual level change score of fast gait speed in 10MWT was 0.75 m/s (SD = 0.91) in the experimental group and 0.2 m/s (SD = 0.37) in the control. (Table 2)

Table 2: Group level scores for baseline and post intervention outcome measures.

Outcome measures	Pre-Intervention	Post-Intervention	Pre-Control	Post-Control
10MWT (Comfortable gait speed, m/s)	1 (0.4) [0.58 - 1.42]	1.27 (0.53) [0.71 - 1.82]	1.11 (0.18) [0.88 - 1.33]	1.33 (0.42) [0.81 - 1.84]
10MWT (Fast gait speed, m/s)	1.21 (0.64) [0.53 - 1.88]	1.96 (1.1) [0.81 - 3.11]	1.57 (0.23) [1.29 - 1.85]	1.77 (0.47) [1.18 - 2.36]
6MWT (m)	372.82 (154.29) [210.91 - 534.75]	442.97 (181.98) [252 - 634]	413.65 (78.61) [316 - 511.25]	449.78 (114.82) [307.22- 592.36]
ASL (cm)	2.02 (0.37) [1.64 – 2.41]	2.24 (0.32) [1.9 – 2.6]	1.84 (0.49) [1.24 – 2.45]	2.02 (0.26) [1.7 – 2.34]

10MWT: 10 meter walk test; 6MWT: 6 minute walk test; ASL: average step Length.
Values are reported as mean (standard deviation),[95% confidence interval].

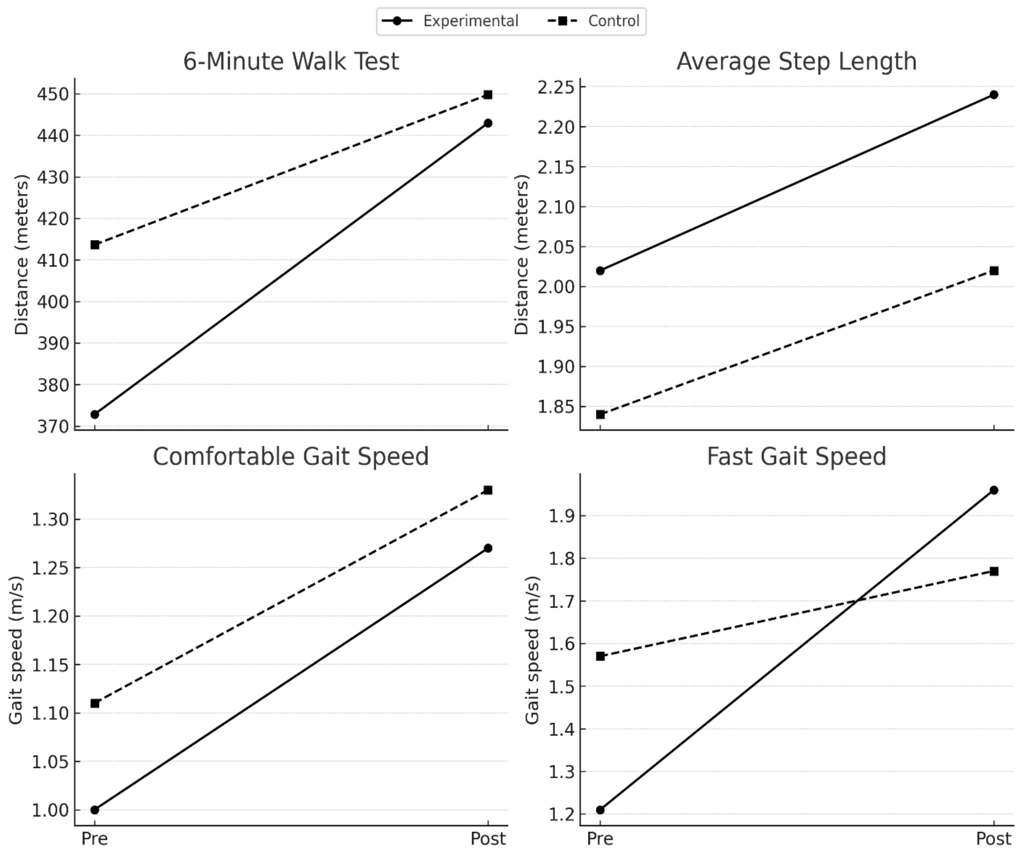

Figure 2: Gait measures

Regarding the 6MWT, 100% (6/6) of the participants in the experimental group and 60% (3/5) of the participants in the control group improved their endurance (Fig.2). The mean individual level change score in distance was 70.14 m (SD = 45.16) for the experimental group and 36.14 m (SD = 70) for the control group. Twenty percent (1/5) of the participants in the control group and 50% (3/6) in the experimental group met the Minimal Detectable Change (MDC) of 82 meters[24].

Motivation

In the BREQ-2 questionnaire, the group mean change scores showed improvements in RAI scores from baseline to post-intervention, from 10.05 (SD = 6.64) to 11.76 (SD = 6.81) in the experimental group and from 14.73 (SD = 1.96) to 15.66 (SD = 1.34) in the control group (increased scores indicate increased relative autonomy/increased motivation, Table 3). In the experimental group, mean intrinsic regulation and identified regulation scores increased from pre- to post-intervention, whereas these subscales remained essentially unchanged in the control group. MDC or MCID has not yet been established for this measure.

Quality of life

After the intervention, both groups improved in PDQ-39 summary index, with lower scores indicating better QoL. The experimental group's mean PDQ-39 summary index decreased to 13.2 (SD = 8.8), while the control group's overall score decreased to 12.7 (SD = 11.8) (Table 4). Of the participants in the experimental group, 33.3% (2/6) and 40% (2/5) of the participants in the control group met the MCID of –4.72 for the overall mean score indicating an improvement. Only one participant in the experimental group and one participant in the control group met the MCID of +4.22 indicating a worsening score[35].

Physical Activity

At baseline, participants in the experimental group averaged 7384.54 (SD = 3905.31) steps/day and 50.44 (SD = 57.92) minutes/day of moderate to vigorous physical activity (MVPA). Post-intervention, these values decreased to 7254.57 (SD = 3261.33) steps/day and 38.37 (SD = 48.68) minutes/day of MVPA. In the control group, participants averaged 7331.17 (SD = 2673.2) steps/day and 40.06 (SD = 39.02) minutes/day of MVPA at baseline. Post-intervention, these values increased to 7472.62 (SD = 3038.78) steps/

Table 3: BREQ-2 items and scores.

BREQ-2 factors	BREQ-2 items	Pre intervention (n=6)	Post Intervention (n=6)	Pre Control (n=5)	Post Control (n=5)
External Regulation	1. I exercise because other people say I should 6. I take part in exercise because my friends/family/ partner say I should 11. I exercise because others will not be pleased with me if I don't 16. I feel under pressure from my friends/family to exercise	0.54 (0.87)	0.62 (0.74)	0.7(0.54)	0.1(0.22)
Introjected Regulation	2. I feel guilty when I don't exercise 7. I feel ashamed when I miss an exercise session 13. I feel like a failure when I haven't exercised in a while	1.44 (0.78)	1.28(0.8)	1.46(1.6)	1.53(1.4)
Intrinsic Regulation	4. I exercise because it's fun 10. I enjoy my exercise sessions 15. I find exercise a pleasurable activity 18. I get pleasure and satisfaction from participating in exercise	2.5(1.04)	2.8(1.27)	3.6(0.28)	3.5(0.17)
Identified Regulation	3. I value the benefits of exercise 8. It's important to me to exercise regularly 14. I think it is important to make the effort to exercise regularly 17. I get restless if I don't exercise regularly	2.9(0.47)	3.2(0.71)	3.7(0.32)	3.75(0.43)
Amotivation	5. I don't see why I should exercise 9. I can't see why I should bother exercising 12. I don't see the point in exercising 19. I think exercising is a waste of time	0.25(0.42)	0.17(0.41)	0.2(0.45)	0.2(0.45)
Relative autonomy index	NA	10.05(6.64)	11.76(6.81)	14.73(1.69)	15.66 (1.34)

BREQ-2: The Behavioral Regulation in Exercise Questionnaire-2.
Values are reported as mean (standard deviation).

Table 4. Descriptive statistics of group-level PDQ-39 scores by domain at baseline and post-intervention.

PDQ-39 Domain	Pre Intervention	Post Intervention	Pre Control	Post Control
Mobility	28.8 (25.5)	15.4 (12.1)	24 (19.1)	21 (23.1)
Activities of Daily Life	20.8 (23.0)	15.3 (21.7)	7.5 (5.4)	5 (3.5)
Emotional Well- Being	16.0 (13.5)	15.3 (24.0)	15.8 (13.0)	16.7 (18.4)
Stigma	19.1 (26.0)	6.3 (4.0)	15 (17.5)	13.8 (14.9)
Social Support	9.0 (10.7)	4.2 (10.2)	0 (0)	5 (11.1)
Cognition	17.7 (12.1)	14.6 (12.3)	13.8 (11.2)	13.8 (19.0)
Communication	19.4 (26.7)	22.2 (19.5)	6.7 (9.1)	11.7 (16.2)
Bodily Discomfort	18.1 (17.0)	12.5 (8.7)	15.0 (10.9)	15.0 (7.0)
Overall Score	18.6 (11.8)	13.2 (8.8)	15.3 (8.2)	12.7 (11.8)

PDQ-39: Parkinson Disease Questionnaire.
Values are reported as mean (standard deviation).

day and 43.14 (SD = 42) minutes/day of MVPA. The mean individual-level change score was -76.48 steps per day and -12 minutes per day of MVPA in the experimental group, and 141.45 steps per day and 2.3 minutes per day of MVPA in the control group. Based on the MCID threshold of 581 steps, 16.6% (1/6) of the participants in the experimental group and 40% (2/5) of the participants in control group surpassed the MCID[36].

Discussion

This pilot feasibility study was safe and resulted in high levels of feasibility, acceptability, and appropriateness. High ratings across all three measures suggest strong participant satisfaction and alignment with the intervention's goals. Additionally, the results provided preliminary evidence of improvements in motor control, motivation, and QoL in people with PD. While there is evidence that visual feedback combined with balance training is feasible for people with PD[37], our study has the novelty of testing the feasibility and effectiveness of visually enhanced gait training by integrating the OPTIMAL theory with interactive image making on movement, motivation, and QoL in people with PD.

The improvements observed in motor parameters in both groups could be related to the individualized gait training sessions with a physical therapist. According to the clinical practice guideline from the American Physical Therapy Association[38], gait training under the supervision of a physical therapist can help to improve motor symptoms in people with PD[38]. Additionally, the mean and individual change scores increased in the experimental group, beyond the increases of the control group, in gait endurance, ASL, and gait speed, that may be attributed to increased motor control resulting from the intervention. These greater improvements in gait parameters observed in the experimental group may be related to the application of OPTIMAL theory, with an emphasis on external focus. As previous evidence has shown, impaired perception of movement is a common problem in people with PD[39] and can heavily influence movement execution. Adopting an external focus may be the mechanism that leads to improved balance and gait parameters[18].

All participants had improvements in QoL and this finding is in concordance with other walking programs that have led to improved QoL in patients with PD[40]. However, the experimental group showed larger improvements across most PDQ-39 domains than the control group. This could be explained by the intervention's emphasis on the autonomy component of OPTIMAL theory. As previous evidence shows, lower autonomy is associated with poor QOL in PD[41]; therefore, the stronger focus on autonomy in the experimental group may have helped drive the larger QoL gains.

Unexpectedly MVPA and step counts per day increased in the control group at higher levels compared to the experimental group. However, this difference could be related to the adverse events experienced by 3/6 participants in the experimental group over the eight-week period. Although these were not related to the intervention itself, they limited their physical activity capacity.

Evidence suggests that decreased dopaminergic transmission in people with PD contributes to reduced creativity[42]. Interventions that target creative expression like music, dance, and visual arts can address this reduction and potentially benefit both motor and non-motor symptoms[42]. In this study, while overall motivation improved in both groups, the experimental group demonstrated improvements across more self-determined BREQ-2 subscales, intrinsic regulation and identified regulation, whereas the control group showed little to no change in these domains. Higher intrinsic and identified regulation suggests that participants in the experimental group were not only engaging in the gait training program because they found it interesting and enjoyable, but also because they viewed it as personally meaningful and aligned with their goals. This may be related to the intervention's emphasis on principles of OPTIMAL theory (autonomy, enhanced expectancies, and external focus) as well as opportunities for creative expression.

Limitations

This feasibility trial was limited to descriptive statistical analyses. Additionally, the short intervention period may not have been sufficient to capture long-term effects or the sustainability of observed changes. With feasibility established, future studies should employ randomized controlled trial designs, with sufficient sample sizes, to detect statistically meaningful differences.

Conclusions

Interactive image making grounded in OPTIMAL theory is safe, feasible and acceptable and may improve motor control, motivation, and QoL in people with PD. Given that the intervention has met the criteria for feasibility, an efficacy trial is warranted to determine the effect of interactive image making on motor control, motivation, and QoL in people with PD.

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Authors' contributions

(1) Research project: A. Conception, B. Organization, C. Execution; (2) Statistical Analysis: A. Design, B. Execution, C. Review and Critique; (3) Manuscript: A. Writing of the First Draft, B. Review and Critique.

PD: 1B,1C,2B,3A; CB: 1A,2C,3B; JC: 1C,2B,3A; CG:1A,2C,3B; TO:1C,2B,3A; NS:1C,2B,3A; EM:1C,2B,3A; CCS:1A,1B,1C,2A, 2C,3B.

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Supplementary Material

Figure S1: A participant walking across a designated runway while performing large-amplitude, high-velocity movements to create an abstract image, captured in long exposure. Participants selected their own props (e.g., finger lights, flashlights, reflective clothing).