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ORIGINAL RESEARCH

Randomized Controlled Trial of a Home-Based Action Observation Intervention to Improve Walking in Parkinson Disease



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Abstract

Objective: To examine the feasibility and efficacy of a home-based gait observation intervention for improving walking in Parkinson disease (PD).

Design: Participants were randomly assigned to an intervention or control condition. A baseline walking assessment, a training period at home, and a posttraining assessment were conducted.

Setting: The laboratory and participants' home and community environments.

Participants: Nondemented individuals with PD (N=23) experiencing walking difficulty.

Intervention: In the gait observation (intervention) condition, participants viewed videos of healthy and parkinsonian gait. In the landscape observation (control) condition, participants viewed videos of moving water. These tasks were completed daily for 8 days.

Main Outcome Measures: Spatiotemporal walking variables were assessed using accelerometers in the laboratory (baseline and posttraining assessments) and continuously at home during the training period. Variables included daily activity, walking speed, stride length, stride frequency, leg swing time, and gait asymmetry. Questionnaires including the 39-item Parkinson Disease Questionnaire (PDQ-39) were administered to determine self-reported change in walking, as well as feasibility.

Results: At posttraining assessment, only the gait observation group reported significantly improved mobility (PDQ-39). No improvements were seen in accelerometer-derived walking data. Participants found the at-home training tasks and accelerometer feasible to use.

Conclusions: Participants found procedures feasible and reported improved mobility, suggesting that observational training holds promise in the rehabilitation of walking in PD. Observational training alone, however, may not be sufficient to enhance walking in PD. A more challenging and adaptive task, and the use of explicit perceptual learning and practice of actions, may be required to effect change.

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Parkinson disease (PD) causes dysfunction in walking and gait.¹⁻³ Physical interventions (eg, treadmill walking) as well as sensory approaches (eg, metronomes) are effective in improving gait in PD,⁴⁻⁸ although deficits often persist. Action observation training,

in addition to physical practice, may be an effective adjunctive treatment. This training consists of repetitive visual perception of biological motion (the movement of human bodies). Biological motion perception depends on activity in the superior temporal sulcus and the mirror neuron system (premotor cortex, supplementary motor area),⁹ regions that are dysfunctional in PD.¹⁰⁻¹³ Previous data from our group¹⁴ have shown that perception of walking from biological motion is impaired in PD, which may contribute to walking impairments in this disorder.¹⁵ If

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individuals with PD can improve their perception of biological motion through repeated observations, motor aspects of gait and walking may improve via neuroplastic changes in motor/mirror neuron regions.

There is preliminary evidence for the usefulness of action observation in PD. A single session of observing finger movements reduced bradykinesia and enhanced spontaneous finger movement rate.¹⁶ Observation and practice of everyday actions improved functional independence.¹⁷ Observation of actors depicting strategies to overcome freezing of gait (and practicing those strategies) led to fewer self-reported episodes of freezing in comparison to a control condition, an effect that persisted at 4 weeks' follow-up.¹⁸ While these studies suggest that action observation training is beneficial in PD, several questions remain. First, it is unknown whether observation of biological motion alone is sufficient for improving motor function (as in Pelosin et al¹⁶), or if practice of the observed movements is required (as in Buccino¹⁷ and Pelosin¹⁸ and colleagues). Second, previous studies have used control conditions such as sequences of static landscape images¹⁷ that make it difficult to isolate treatment effects to the observation of biological motion rather than nonbiological motion. Third, it is unknown whether the effects of action observation training lead to objective changes in spatiotemporal aspects of walking that generalize to naturalistic settings.

The goal of the current study was to examine the efficacy and feasibility of a home-based action observation (gait observation) intervention for walking in PD. We sought to determine the effect of observing biological motion alone, without physical practice. We also used a stringent control condition with videos of nonhuman motion (moving water) in a natural environment, which allowed us to isolate treatment effects to biological motion (processed in posterior superior temporal sulcus and premotor cortex⁹) and eliminate nonbiological motion (processed in middle/inferior temporal cortex^{19,20}) or other visual features of the scene as drivers of any intervention effect. We assessed self-reported mobility and objectively measured spatiotemporal walking in the laboratory and at home, to determine whether training effects generalized to a natural setting. We predicted that the home-based action observation intervention would be feasible and would result in self-reported and objective changes in walking.

Methods

Participants

Twenty-three individuals with PD were enrolled from January 2014 to February 2015 (fig 1). For analyses to yield a medium size effect with a power of 80% and $\alpha = .05$, a sample of 18 was required. Participants were recruited through Boston Medical Center, Boston University's Center for Neurorehabilitation, and the Fox Foundation Trial Finder. Inclusion criteria included the following: (1) diagnosis of idiopathic PD (Hoehn & Yahr stage 1–3; UK Parkinson Disease Society Brain Bank diagnostic criteria²¹); (2) score ≥ 1 on the Unified Parkinson Disease Rating Scale gait item (item number 42); (3) native speaker of English; (4) ≥ 12 years of education; and (5) living independently at home.

List of abbreviations:

PD Parkinson disease
PDQ-39 39-item Parkinson Disease Questionnaire

Exclusion criteria included the following: (1) presence of orthopedic injuries affecting walking; (2) use of an assistive device for walking; (3) previous intracranial surgery; (4) traumatic brain injury with loss of consciousness greater than a few seconds; (5) substance abuse; and (6) eye pathologies that impaired vision. This study was approved by the Boston University Institutional Review Board. All participants provided informed consent.

Random assignment of participants

After initial telephone screening, a staff member randomly assigned participants to the gait observation (intervention) condition or the landscape observation (control) condition using a computer-generated block randomization procedure (block size of 4). An independent examiner was blind to group assignment for the baseline walking assessment (assignment kept in a sealed envelope), but was unblinded for the at-home and posttraining assessment. Participants in both groups were naive to the focus on improving walking.

Training conditions

Gait observation (intervention)

Participants viewed videos of actors with and without PD. We filmed novel videos of actors walking in a hallway from lateral and anterior/posterior views, which allowed observation from multiple perspectives to facilitate motor learning. Eight to 10 walking trials were filmed and edited for each actor and entered into a perceptual experiment using SuperLab 5.0 presentation software.⁴ A total of 112 videos were created: 56 of PD actors with unhealthy gait patterns, and 56 of actors without PD with healthy gait patterns. Study participants judged whether the walking in each video appeared healthy or resembled a PD-like gait pattern.

Landscape observation (control)

Participants viewed videos (freely available at www.mothernaturevideos.com) of landscapes with moving water in oceans, rivers, lakes, and waterfalls. To our knowledge, these videos have not previously been used as a control condition in an action observation study. Motion was isolated to water moving with different speeds and strengths, with no biological motion. A total of 112 video clips (56 with water moving roughly, and 56 with water moving calmly) were taken from several different landscapes. Participants judged whether the water was moving "roughly" or "calmly."

For both conditions, participants took home a laptop computer. They judged the videos via keyboard press. Feedback ("correct" or "incorrect") was presented on the computer screen after each trial. The same videos appeared daily in a randomized order.

Procedure

Figure 1 provides a flowchart of the study procedures. Participants were in the "on" medication state for assessments and training. One participant was not on antiparkinsonian medication.

Laboratory-based walking assessment

This assessment was administered at baseline and repeated 7 days after completion of the home-based training. Participants wore triaxial accelerometers^b on each ankle while walking in the

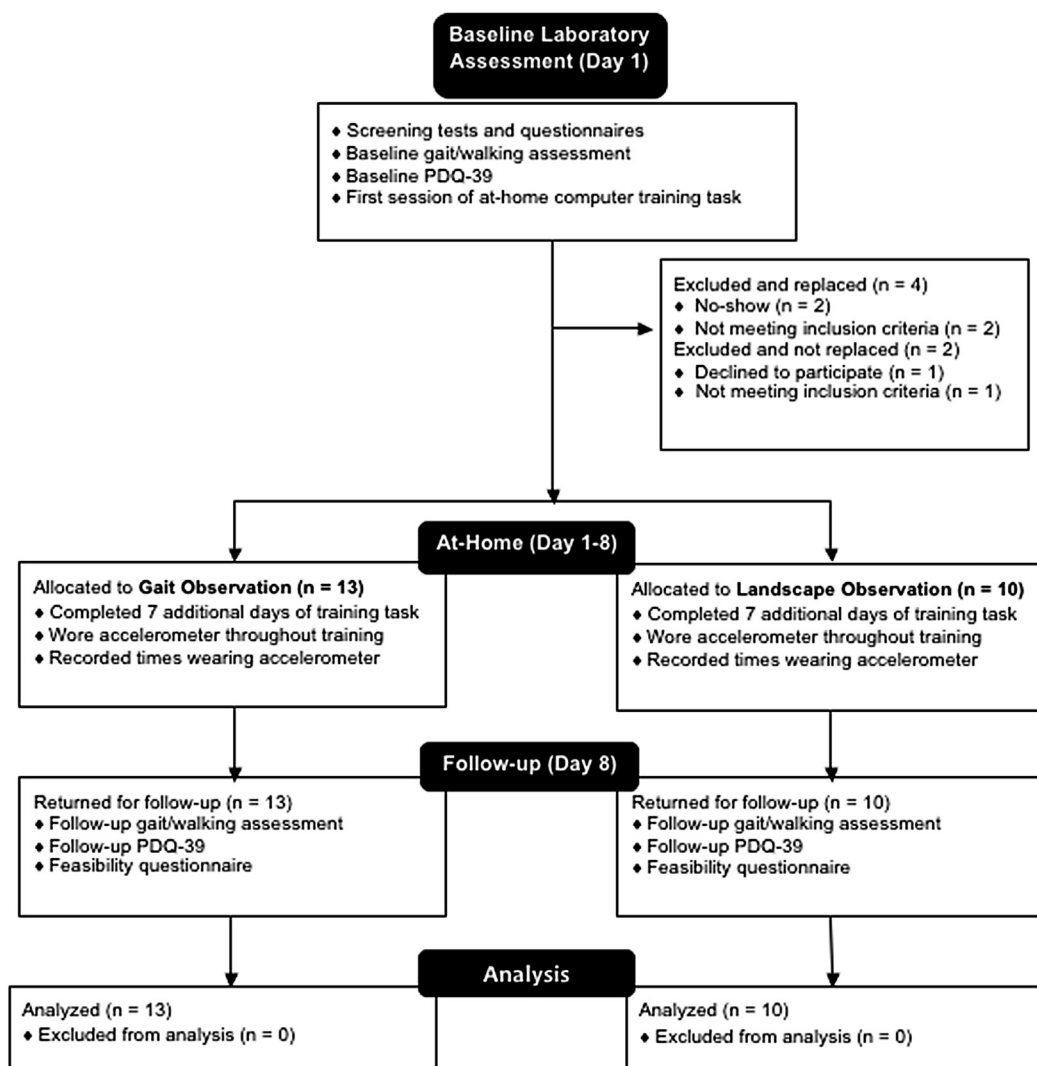


Fig 1 Flow diagram of study procedures.

laboratory. Data were collected at a sampling frequency of 100Hz (dynamic range, $\pm 8g$; resolution, 12 bit [3.9mg]). Walking trials included the following: (1) straight line walking (2 trials each of 10m and 20m); (2) walking with turns (1 trial to walk up to a cabinet [16m], 2 trials of walking to sit in a chair [18.8m and 13.8m], 1 trial walking up to a water cooler and drinking a glass of water [13.8m]); and (3) dual-task walking (1 trial of walking while holding a mug [16m]). Straight line walking trials closely matched the videos in the gait observation training task. Walking with turns and dual-task walking conditions were included to determine whether potential intervention effects would generalize to more complex walking. Participants were familiarized with the environment and tasks before performing the walking trials. They were instructed to walk at their natural, comfortable walking pace.

Acceleration data were extracted using EMG Works software.^c Spatiotemporal gait parameters were calculated using automatic peak detection functions that identified maximal (heel strike) and secondary (toe-off) peaks from the accelerometer,²²⁻²⁵ using the x-axis oriented in the sagittal plane of the right ankle. One stride was defined as 2 successive heel strikes of the same foot. Swing time was quantified as the time between the initial toe-off and

subsequent heel strike for each stride. The spatiotemporal walking variables included walking speed (distance of the walking trial/time to complete the trial), stride length (distance of the walking trial/number of strides to complete the trial), stride frequency (number of strides/time to complete the walking trial), and percent leg swing time ($100 \times [\text{swing time}/\text{stride time}]$ for each stride).

Accelerometer data from both legs were used to determine gait asymmetry, following Yogeve et al.³ For each walking trial, mean swing time was calculated for the left and right leg. Gait asymmetry was calculated as the natural log (leg with longer swing time/leg with shorter swing time), where higher values reflect greater degrees of asymmetry. The mean and SD (as an index of variability) of gait parameters were computed separately for trials of straight line walking, walking with turns, and dual-task walking.

Home walking assessment

Participants wore an accelerometer (sampling rate, 75Hz) on the right leg during waking hours throughout each day of training. To calculate walking parameters, we used a well-established algorithm that reliably differentiates walking from other activities, and identifies stride frequency (mean and SD), number of walking

Table 1 Participant characteristics at baseline

Measure	Gait Observation (n=13)	Landscape Observation (n=10)	P
Age (y)	63.7±6.2 (51–74)	65.8±8.7 (52–80)	NS
Education (y)	17.2±1.4 (16–20)	16.0±2.4 (12–20)	NS
M/F ratio	6:7	4:6	NS
UPDRS motor score	18.8±4.9 (12–31)	19.5±8.2 (7–32)	NS
H&Y stage	2.0 (1.5–3)	2.0 (1–3)	NS
LED (mg/d)	519±293 (0–900)	447±268 (100–880)	NS
Acuity (logMAR)	0.08±0.11 (–0.1 to 0.2)	0.06±0.08 (–0.1 to 0.2)	NS
MMSE	28.6±0.8 (27.24–29.71)	28.5±1.0 (27.24–29.71)	NS
GDS	5.8±4.4 (0–15)	6.8±4.1 (3–14)	NS
BAI	6.4±6.3 (0–24)	3.6±3.5 (0–9)	NS

NOTE. Values are mean ± SD (range), median (range), or as otherwise indicated.

Abbreviations: BAI, Beck Anxiety Inventory; F, female; GDS, Geriatric Depression Scale; H&Y, Hoehn & Yahr; LED, levodopa equivalent dosage; logMAR, logarithm of mean angle of resolution; M, male; MMSE, Mini-Mental State Examination; NS, not significant; UPDRS, Unified Parkinson Disease Rating Scale.

periods, and duration of each walking period from an ankle-mounted triaxial accelerometer.²⁶ The algorithm defines a walking period as at least 3 strides occurring within 5 seconds.

Self-report questionnaires

The 39-item Parkinson Disease Questionnaire (PDQ-39) (modified to rate quality of life over the past week) was self-administered on day 1 (baseline) and on day 8 (posttraining assessment). Each question is scored on a 0-to-4 scale, for a maximum possible total of 156. The PDQ-39 has shown excellent psychometric properties.²⁷ We examined the total PDQ-39 score and the mobility subscale. At posttraining, participants were also administered a 10-item questionnaire to rate feasibility and self-perceived improvement.

Feasibility

We examined feasibility using participants' self-reported ability to understand instructions and to use the computer and accelerometer. We also assessed the number of computer training sessions completed, days in which the accelerometer was worn, and number of hours per day wearing the accelerometer.

Statistical analyses

Changes in walking based on group (gait observation, landscape observation), time (baseline, posttraining), and walking type

(straight line, walking with turns) were analyzed using a mixed-design analysis of variance. Primary outcome measures were walking speed, stride length, and stride frequency; secondary outcome measures were leg swing time and gait asymmetry. Ninety-five percent confidence intervals are presented in square brackets. For simple main effects and interaction effects, we report effect size using eta-squared (η^2), the proportion of the total variability in the data accounted for by that effect. To explore significant interaction effects, we conducted post hoc *t* tests. We report effect size using Cohen's *d* (.20, small effect; .50, medium effect; .80, large effect), with the pooled SD as the standardizer. Results of the training task and home walking assessment were analyzed using linear mixed-effects modeling with group, day (1–8), and group × day as fixed effects, and participants as a random effect.

Results

Demographic characteristics and feasibility

There were no group differences in age, education, male-to-female ratio, disease severity, medication dosage, visual acuity, cognitive status, depression, or anxiety (table 1). Participants found study procedures highly feasible and demonstrated a high rate of adherence to the study protocol (table 2). No adverse events were reported.

Table 2 Feasibility and adherence to study protocol

Parameter	Gait Observation	Landscape Observation	P
Ability to understand study instructions*	8.5±0.5	8.4±0.7	NS
Ability to use computer equipment*	8.3±0.9	8.4±0.7	NS
Ability to use/wear accelerometer while going about daily life*	8.5±.52	8.6±1.0	NS
Participants who completed all computer training sessions†	10/13	7/10	NA
Participants who wore the accelerometer on all training days‡	11/13	9/10	NA
Hours wearing accelerometer per day	12.4±2.0	13.7±1.4	NS

NOTE. Values are mean ± SD, n, or as otherwise indicated.

Abbreviations: NA, not applicable; NS, not significant.

* Participants answered the questions by circling a number on a 0-to-9 visual analog scale (0, very difficult; 9, very easy).

† The remaining 3 participants in the gait observation group and the landscape observation group each missed 1 training session.

‡ Two participants in the gait observation group and 1 participant in the landscape observation group missed 1 day of wearing the accelerometer.

Table 3 Results of linear mixed-effects modeling for computer training task

Effect	df	F	P		
Tests of fixed effects					
Intercept	1, 44.4	13630.1	<.001		
Group	1, 44.4	46.7	<.001		
Day	1, 44.7	94.0	<.001		
Group × day	1, 44.7	20.0	<.001		
		β	95% CI	t P	
Estimates of fixed effects					
Intercept*		85.1	82.8 to 87.4	73.0	<.001
Group = gait observation		10.6	7.5 to 13.7	6.8	<.001
Day*		1.4	1.1 to 1.7	9.4	<.001
Group = gait observation		-0.9	-0.5 to -1.3	-4.5	<.001

NOTE. The dependent variable is accuracy (percent correct).

Abbreviations: CI, confidence interval; df, degrees of freedom.

* Intercept and Day refer to the reference group (landscape observation).

Performance on training task

There were significant effects of group, day, and group × day (table 3). Baseline performance on the computer task was better for gait observation than landscape observation by 10.6%. Both groups showed significant improvement in training task performance across days (fig 2), although the rate of improvement was significantly less for gait observation (.89% less gain per day) than landscape observation.

Laboratory-based walking assessment

Primary outcome measures

Means and SDs of walking variables are displayed in table 4. No main or interaction effects emerged for walking speed (mean and

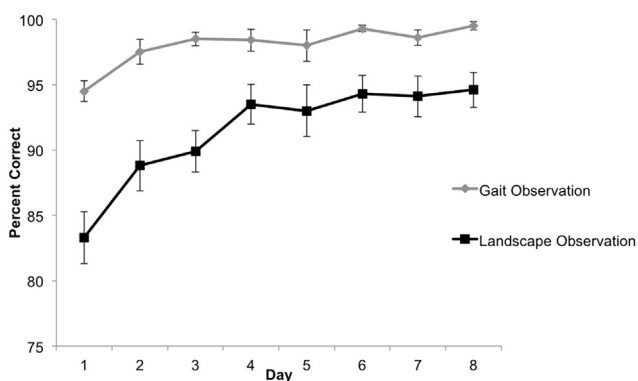


Fig 2 Performance on the at-home computer training task for the gait observation and landscape observation groups. The task in the gait observation condition was to discriminate between healthy and parkinsonian gait/walking. The task in the landscape observation group was to discriminate between water moving roughly and calmly. The outcome variable is accuracy (percent correct). Both groups improved significantly over subsequent days, although the rate of change (slope) was smaller in the gait observation group. Error bars represent standard error of the mean.

SD) or mean stride length (all $F_{1,21}$ values <2.74 , P values $>.05$). For stride length (SD), only a significant main effect of walking type emerged ($F_{1,21}=7.72$, $P<.05$, $\eta^2=.11$), with stride length being more variable in trials of walking with turns than trials of straight line walking (mean difference = .02 [.01, .03], $P<.05$, $d=.63$).

A significant group × time × walking type interaction emerged for mean stride frequency ($F_{1,21}=5.62$, $P<.05$, $\eta^2=.04$); however, post hoc t tests showed no significant between-group or within-group differences (all P values $>.05$). For stride frequency (SD), there was only a significant interaction between time and walking type ($F_{1,21}=7.7$, $P<.05$, $\eta^2=.09$). Regardless of group, stride frequency (SD) decreased from baseline to posttraining assessment for straight line walking (mean difference = .006 [.001, .01], $t_{22}=2.65$, $P<.05$, $d=.42$), but did not change for walking with turns (mean difference = .004 [−.002, .01], $t_{22}=1.53$, $P>.05$, $d=.38$).

The dual-task walking trial was analyzed separately. A significant main effect of time emerged for mean walking speed ($F_{1,21}=8.48$, $P<.01$), which increased from baseline to posttraining assessment (mean difference = .06 [.02, .1], $P<.05$, $d=.38$) regardless of group, suggesting a possible practice effect. A significant main effect of time emerged for mean stride length ($F_{1,21}=8.75$, $P<.01$, $\eta^2=.29$), which increased after training (mean difference = .06 [.02, .1], $P<.05$, $d=.33$) regardless of group, again suggesting a practice effect. No main or interaction effects emerged for mean stride frequency.

Secondary outcome measures

No main or interaction effects emerged for mean percent swing time (all $F_{1,21}$ values <3.41 , P values $>.05$). For percent swing time (SD), a significant group × time × walking type interaction emerged ($F_{1,21}=11.25$, $P<.05$, $\eta^2=.06$). In straight line walking only, there was no change from baseline to posttraining assessment in the gait observation group (mean difference = .25 [−0.1, .60], $t_{12}=1.56$, $P>.05$, $d=.63$), while there was a trend toward decreased percent swing time (SD) in the landscape observation group (mean difference = .35 [−.03, .72], $t_9=2.09$, $P=.07$, $d=.92$). For gait asymmetry, the only significant effect was a main effect of group ($F_{1,21}=4.94$, $P<.05$), where regardless of time and walking type, the gait observation group had more gait asymmetry than the landscape observation group (mean difference = .01 [.001, .02], $P<.05$, $d=.64$). On the dual-task walking trial, no main or interaction effects emerged for percent swing time (mean or SD) or gait asymmetry.

Home walking assessment

No significant main or interaction effects emerged for walking periods per hour, mean duration of each walking period, or stride frequency (all F values <3.44 , P values $>.05$).

Self-report questionnaires

There was a significant group × time interaction on the PDQ-39 mobility subscale ($F_{1,21}=9.44$, $P<.01$, $\eta^2=.31$) (fig 3). Post hoc t tests revealed that although there was no significant difference between gait observation and landscape observation at baseline (mean difference = .75 [−5.5, 6.99], $t_{21}=.54$, $P>.05$, $d=.11$) or posttraining (mean difference = 3.08 [−2.97, 9.12], $t_{21}=1.06$, $P>.05$, $d=.45$), the gait observation group had a significant

Table 4 Gait characteristics by group (gait observation, landscape observation) and time (baseline, follow-up)

Walking Parameter	Gait Observation (n=13)		Landscape Observation (n=10)	
	Baseline	Follow-up	Baseline	Follow-up
Straight line walking trials				
Walking speed (m/s)	1.19±.15	1.19±.15	1.13±.14	1.18±.08
Walking speed variability	.07±.04	.07±.04	.07±.04	.05±.03
Stride length (m)	1.34±.18	1.35±.21	1.30±.15	1.34±.12
Stride length variability	.06±.04	.07±.03	.06±.04	.05±.03
Stride frequency (strides/s)	.86±.06	.89±.06	.87±.08	.89±.06
Stride frequency variability	.04±.02	.03±.01	.03±.01	.03±.01
Swing time (% of stride)	46.0±1.6	45.6±1.6	44.5±1.4	44.8±1.7
Swing time % variability	1.7±0.4	1.9±0.4	1.8±0.5	1.5±0.2
Gait asymmetry	.03±.02	.03±.02	.02±.01	.02±.01
Walking with turns trials				
Walking speed (m/s)	1.18±.15	1.19±.13	1.16±.12	1.19±.08
Walking speed variability	.08±.04	.06±.03	.07±.03	.06±.04
Stride length (m)	1.35±.20	1.36±.20	1.33±.15	1.35±.11
Stride length variability	.09±.04	.07±.03	.08±.03	.07±.04
Stride frequency (strides/s)	.88±.06	.89±.07	.88±.08	.88±.06
Stride frequency variability	.02±.01	.03±.01	.02±.01	.02±.02
Swing time (% of stride)	45.8±1.5	45.3±1.3	44.6±1.5	44.7±1.6
Swing time % variability	2.1±0.4	1.9±0.4	2.0±0.5	1.9±0.3
Gait asymmetry	.03±.02	.03±.01	.02±.01	.03±.01
Dual-task trial				
Walking speed (m/s)	1.13±.14	1.17±.18	1.10±.10	1.17±.15
Stride length (m)	1.30±.19	1.34±.23	1.26±.13	1.34±.14
Stride frequency (strides/s)	.88±.07	.88±.07	.87±.09	.88±.08
Swing time (% of stride)	45.4±1.8	45.3±1.7	44.4±1.4	44.6±1.9
Swing time % variability	2.0±0.7	2.0±1.0	2.1±0.9	1.7±0.5
Gait asymmetry	.03±.02	.03±.03	.02±.02	.03±.02

NOTE. Values are mean ± SD.

decrease in score (increase in self-reported mobility) posttraining (see fig 3) (mean difference = -1.92 [$-3.64, -.21$], $t_{12} = -2.44$, $P < .05$, $d = -.25$). The score decreased by 4.8%, which exceeded the threshold for a clinically meaningful change.²⁸ The landscape

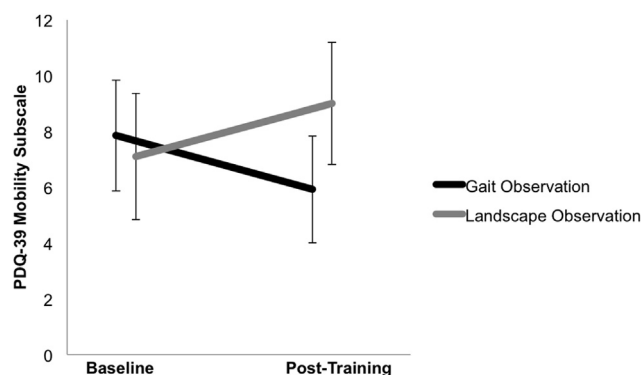


Fig 3 Change in self-reported mobility by group (gait observation, landscape observation) and time (baseline, posttraining). The outcome variable is score on the PDQ-39 mobility subscale. Higher scores indicate worse mobility. Error bars represent standard error of the mean. The gait observation group had significantly improved self-reported mobility (lower score) at posttraining compared with baseline ($t_{12} = -2.44$, $P < .05$, $d = -.25$). The score decreased by 4.8%, which exceeded the threshold for a clinically meaningful change. The landscape observation group's score did not significantly change from baseline to posttraining.

observation group's score did not change posttraining (mean difference = 1.9 [$-.32, 4.12$], $t_9 = 1.93$, $P > .05$, $d = .31$). No significant main or interaction effects emerged on the PDQ-39 total score (all $F_{1,21}$ values < 2.19 , P values $> .05$).

Participants in the gait observation group reported greater improvement in walking speed and stride length than those in the landscape observation group (table 5); although not statistically significant, the magnitude of the effects were medium. The gait observation group reported strategies they learned through the training, including increased attention to one's own gait, keeping one's head up, swinging the arms, and visualizing gait patterns of others while walking.

Discussion

The present study investigated the efficacy of home-based gait observation training to enhance walking in PD. With repeated perceptual training, PD participants in the gait observation group showed an improved ability to discriminate between healthy and parkinsonian gait (biological motion). This improvement did not result in objective changes in walking measured in the lab or home, but did result in increased self-perceived mobility (small effect) after the training.

There are a number of possible reasons for the lack of change in objective walking results. First, individuals with PD have impaired perception of biological motion¹⁴ and may require

Table 5 Self-reported change in gait and walking

Parameter	Gait Observation	Landscape Observation	<i>P</i>	Cohen's <i>d</i>
Walking speed	3.6±3.0	1.7±1.9	.08	.76
Stride length	3.5±2.8	1.8±1.9	.11	.73
Arm swing and arm/leg coordination	3.2±2.8	2.2±2.5	NS	.39
Learning differences between PD-like and healthy walking	5.1±2.9	NA	NA	NA
Ability to perceive differences in PD-like and healthy walking	6.0±2.9	NA	NA	NA

NOTE. Values are mean ± SD or as otherwise indicated. Participants answered the questions by circling a number on a 0-to-9 visual analog scale (0, no improvement at all; 9, improved a lot). Higher values reflect greater improvement. Participants in the landscape observation group were not asked the last 2 questions.

Abbreviations: NA, not applicable; NS, not significant.

more practice than healthy adults^{29,30} to benefit from action observation training; therefore, it is possible that an insufficient dose of training was provided to see objective changes in gait. Second, our training task may not have been sufficiently challenging. Participants in the gait observation condition were 95% accurate in discriminating between healthy and PD gait on day 1 of training. Our training intervention used the same videos daily for 1 week. A perceptual training intervention that uses a wider range of stimuli, more than 2 response choices (ie, a broader array of gait types to discriminate between), or an adaptive procedure that increases in difficulty with participant improvement, may prove more efficacious than our intervention.

Third, the nature of our training task relied on implicit learning. We expected that participants with PD would implicitly perceive and discriminate between healthy and impaired aspects of gait during observational learning, resulting in the adoption of healthier gait patterns.³¹⁻³⁴ Observation-based training may require more explicit strategies, such as directing attention toward specific aspects of gait (eg, stride length, gait speed) or specific parts of the body (eg, feet), rather than observing the whole task with a general focus. Such directed attention could elicit stronger activity in the mirror neuron system (premotor cortex), because the premotor cortex activates in a somatotopic manner when observing actions.³⁵ Objective gait changes may also require directed practice of such strategies in combination with the training task (ie, by drawing conscious attention to one's own gait and implementing strategies repeatedly during training), similar to previous paradigms that have paired action observation with physical training.^{17,18}

Our results are in line with previous studies on action observation training that have shown self-reported improvement in motor function.^{18,36} The gait observation intervention led to a self-perceived increase in functional walking ability in natural environments (PDQ-39 mobility subscale) that was clinically meaningful,²⁸ even though participants were not told that the purpose of the training was to improve walking. It is possible that walking assessed with accelerometers did not capture the types of functional improvements represented on the PDQ-39 mobility subscale. Self-perceived improvement is important for participants to remain motivated to engage in such interventions, and may also increase participation in walking-based activities of daily living.

Participants found study procedures feasible; they reported the study instructions were easy to understand, and the computer equipment and accelerometer were easy to operate. Most

participants completed all training sessions and wore the accelerometer each day, for several hours during the day. All participants returned for posttraining assessment. These findings suggest that future studies of home-based interventions with continuous activity monitoring using accelerometers are feasible in the PD population.

Our landscape observation condition was a novel addition to an action observation paradigm, as we controlled for the effects of observing nonbiological motion while providing challenge (<85% correct performance at baseline) and motivation/engagement (of 10 participants, 7 completed all sessions; 3 missed only 1 session). We recommend such a control condition in future investigations because it will strengthen the claim that treatment effects are attributable to the perception of biological motion per se.

Study limitations

Limitations of the study included the small sample with consequent constraints on the generalizability of the results. This study also did not have a long-term follow-up to determine the maintenance of self-reported increased mobility over time. As mentioned above, the gait training discrimination task may have been insufficiently challenging to evaluate the full potential impact of this approach.

Conclusions

Despite the lack of objective change, the gait observation intervention holds promise in the rehabilitation of walking in PD, particularly given the self-reported increase in functional mobility. Participants found our home-based intervention to be highly feasible. Accelerometers allowed us to assess walking in a naturalistic setting at home, which is important in understanding treatment effects in real-world settings. Our data inform the design of future research investigating the benefits of action observation treatments to improve gait in PD.

Suppliers

- SuperLab 5.0 presentation software; Cedrus.
- Triaxial accelerometers; Activinsights Ltd.
- EMG Works software; Delsys Inc.

Keywords

Activities of daily living; Locomotion; Movement disorders; Neurodegenerative diseases; Rehabilitation; Visual perception

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