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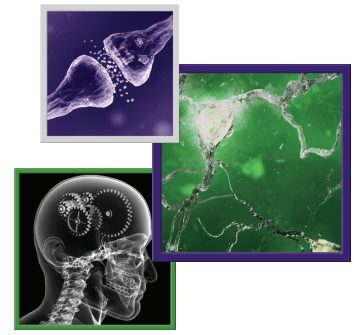
Neurodegenerative Disease Management



A walking dance to improve gait speed for people with Parkinson disease: a pilot study

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Practice points

- A 6-week contemporary dance class was feasible and elicited significant increases in walking speed for people with Parkinson disease (PD).
- Reductions in gait variability were also seen after the intervention.
- Motor motivation may play an important role in treating gait bradykinesia.
- Key elements of dance interventions may include active engagement and collaboration in movement generation.
- Targeted physical interventions for PD may directly counter the motor control abnormalities caused by PD.

Aim: To determine the effectiveness of a targeted dance intervention to improve walking speed for people with Parkinson disease (PD) by increasing motor motivation. **Materials & methods:** 11 participants with PD participated in a 6-week pilot study in which they learned a contemporary dance composed of walking steps and designed to mimic everyday walking. 1 h classes occurred twice-weekly. **Results:** Pre- and post-intervention assessments revealed a significant increase in gait speed (t_9 = 3.30; p = 0.009), cadence (t_9 = 2.345; p = 0.044), and stride length (t_9 = 3.757; p = 0.005), and a significant decrease (improvement) in single support time variability (t_9 = -2.744; p = 0.022). There were no significant changes in other measures of gait variability nor in motor symptoms, mood and anxiety, extent of life-space mobility, or quality of life. No adverse events were reported. **Conclusion:** Joywalk provides preliminary evidence that a targeted physical intervention for people with PD may specifically counter bradykinesia.

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Keywords: bradykinesia • dance • gait speed • motivation • Parkinson disease • reward

Parkinson disease (PD) is the second most common neurodegenerative disorder affecting nearly one million people in the USA [1]. One of the most debilitating symptoms for people with PD is gait bradykinesia, or slowness of walking, primarily caused by depletion of dopaminergic neurons in the substantia nigra [2]. Slow walking can lead to increases in gait variability, which can contribute to instability and falls [3]. Reductions in gait speed are predictive of overall health and precipitate further disability [4]. For people with PD, reduced speed may be linked to 'motor motivation', a form of motivation that guides the automatic selection of a preferred movement speed because it is experienced as more comfortable or rewarding than other speeds [5]. Motor motivation, presumed to be encoded by tonic levels of dopamine in the dorsolateral striatum, may lead people with PD to move slowly because they subconsciously experience slower speeds as normal [6]. Thus, a reduction of motor motivation may manifest as bradykinesia [5,7].

Bradykinesia is particularly difficult to treat because it may reflect an unconscious global alteration in speed preference, or in what speed feels normal [8]. Previous work suggests that the speed of our daily movements is tightly regulated and impervious to change [9]. While movement vigor can be altered volitionally, it quickly reverts

Table 1. Participant demographics.

n (male)	**10 (7)**
Age, years	69 (8)
Years since dx	6 (3)
LEDD, mg	803 (370)
H&Y stage (n)	II (6)
	II.5 (3)
	III (1)
MDS-UPDRS III	29 (12)
MMSE, median (range)	28 (26, 29)
NFOG-Q	6 (0, 9)

Values represent mean ± standard deviation, except where noted. Table shows total participants included in final analyses.
H&Y: Hoehn and Yahr; LEDD: Levodopa-equivalent daily dose; MDS-UPDRS-III: Movement Disorders Society Unified Parkinson Disease Rating Scale Part 3; MMSE: Mini Mental State Exam; NFOG-Q: New Freezing of Gait Questionnaire.

to preferred speed [10,11]. An intervention aimed at increasing motor motivation, on the other hand, might be particularly effective for bradykinesia. Dance might be just such an intervention.

Dance is well-established as a highly motivating therapeutic technique that improves functional mobility for people with PD [12–15]. Previous studies of tango suggest that dance forms that involve stepping as the primary dance step are highly effective at promoting gait improvement [16]. Studies of contemporary dance, including the well-known Dance for PD® (DfPD) model, suggest that creative movement that allows for self-expression also benefits a range of motor and non-motor symptoms [17–19]. In spite of a wealth of evidence supporting dance therapy for PD, improvements in gait velocity specifically are not reported for all dance interventions suggesting that a targeted approach to the specific symptom of bradykinesia may show greater improvements [14,15].

According to our reinforcement-based account of gait speed [5], in which PD-related bradykinesia makes moving at normal speeds intrinsically less rewarding, making walking feel like a dance might replace the lost sense of reward and compete with the tendency to move slowly. Thus, a dance intervention could be tailored to co-opt the rewarding aspects of dancing in the space of the studio that could potentially translate to other domains of daily life such as everyday walking. Contemporary dance lends itself uniquely to this goal due to the broadness of expressive movements that fall under its scope as well as its known positive effects on quality of life measures [17]. While many dance forms involve highly stylized variations of stepping, our dance intervention uses natural walking steps as the primary dance step. Joywalk is the only dance intervention to our knowledge to turn everyday walking into a dance and make it the primary component of the therapy. In doing so, we hoped that practicing walking in the context of a dance class might, in turn, make walking become more rewarding. If our assumption that bradykinesia is reward-mediated is true, then making walking more rewarding might also make it faster. In this approach, dance is chosen as an instrument to increase motor motivation and thereby counter the motor control abnormality that gives rise to bradykinesia.

In this pilot study, we examined the effects of a 6-week contemporary dance intervention on gait performance among people with PD. This intervention is novel in its use of set choreography consisting primarily of walking to specifically target the presumed underlying motor impairment leading to bradykinesia in PD. We hypothesized that learning walking as a dance would increase motor motivation for walking in people with PD and thus increase their spontaneous walking speed. By emphasizing these principles in our classes, we hoped to harness the motivational capacity of dance while increasing the likelihood of inducing targeted improvements in gait speed.

Materials & methods

Participants

Participants were recruited from the Movement Disorders Center at Washington University School of Medicine. Inclusion criteria included: age above 30 years; a diagnosis of 'definite PD' [20]; absence of other neurological diagnoses, orthostatic hypotension, or history of deep brain stimulation surgery; ability to stand independently for at least 30 min; and absence of evidence of dementia (Mini Mental State Exam ≥24) [21]. Fourteen participants were enrolled in the study (Table 1). Three participants dropped out due to unexpected changes in schedules and inability to travel. 11 participants completed the classes and both assessments. t-tests confirmed there were no significant differences in baseline demographic characteristics between those included in the analysis and those

who dropped out. There were no adverse events. All participants provided informed consent prior to testing and were compensated for their time. Participants were blinded to the purpose of the study and told only that they would undergo a series of assessments before and after the intervention. The protocol was approved by the Human Research Protection Office at Washington University School of Medicine.

Experimental protocol

The study was conducted over the course of 8 weeks and included gait tests, assessments, and dance classes described below. Gait tests and assessments were both conducted at pre- and post-intervention, while the dance classes occurred for 6 weeks in between.

Gait test

Participants with PD were tested in the 'on' state as determined by self-report during the Movement Disorders Society Unified Parkinson Disease Rating Scale (MDS-UPDRS) evaluation to capture their typical walking. Walking trials were collected on a 5-m instrumented, computerized GAITRite walkway (CIR Systems, Inc., NJ, USA). Participants were instructed to "*walk down the mat at your comfortable pace*". Three trials were used to assess each participant's comfortable walking characteristics at each assessment time point.

Assessments

The MDS-UPDRS was used to assess disease severity. Sub-section III (motor sign severity) was administered and scored through video review by a certified staff member blinded to time point (except for item 3, rigidity, which was entered by the staff member who administered the test). Additional questionnaires included the New Freezing of Gait Questionnaire (nFOGq), the Fall History Questionnaire, the Life Space Questionnaire (LSQ), the Geriatric Depression Scale (GDS), and Parkinson Disease Questionnaire – 39 (PDQ-39). Freezing status was confirmed with a score ≥ 1 indicating they answered "*yes*" to the first question of the nFOGq, "*Did you experience freezing episodes in the past month?*" during the baseline testing visit.Medication dosage was determined by the levodopa-equivalent daily dose (LEDD) [22]. We quantified dance experience, defined as any form of dance training, practice and/or performance, in total number of years of participation. Participants completed the same battery of questionnaires and assessments at both time points, pre-intervention and post-intervention, and the same instructions were used each time. After the intervention, participants filled out an exit survey to give feedback about the class.

Dance classes

Participants met twice-weekly for 6 weeks for a total of 12 classes, and each class lasted 1 h. Classes were led by a professional contemporary dancer experienced in teaching people with PD. Several assistants from the dance community also participated in the classes and helped monitor participants for safety. A variety of teaching methods commonly used in contemporary dance were employed including visualization, mental imagery, verbal instructions and auditory cueing. Music accompanied all portions of the class and was administered from multiple speakers on the surrounding periphery of the room. Participants were challenged to play with their movement speed, direction, style and quality. Many walking activities were humorous and allowed participants to creatively interact with one another in a safe setting. For example, one exercise involved participants crossing in pairs from opposite sides of the room, meeting in the center and greeting each other with a silly dance move. The majority of the class period was spent standing or walking. Breaks were encouraged, though participants seldom sat down so as not to miss an activity. Two make-up classes took place for participants (n = 3) who missed a regularly scheduled class. The class structure was divided into a two-part format detailed below, each lasting approximately 30 min.

Part A: warm-up & center practice

Each class began with a 10-min seated warm-up meant to explore range of motion, moving synchronously with others, and musicality. The warm-up emphasized stretching of the ankles, wrists and shoulders, finger isolations, articulation of the neck and spine, and incorporation of breath and relaxation. 20 min of center work followed, which consisted of a variety of activities that all included walking. This portion of class included gathering in a circle and passing an imaginary ball, moving about the space according to varied task-based movement parameters, and doing partnered improvisations. These activities were all set to familiar popular music including jazz standards, show tunes, and generational pop that the participants mostly knew and enjoyed.

Part B: Joywalk dance

The second half of each class period was devoted to creating a 7-min piece of group choreography designed to teach the Joywalk dance. The choreography portion was set to an original digital musical score with a tempo of 112 bpm specifically designed for this dance that utilized a variety of moods allowing for different types of movement expression. This allowed participants to walk on the beat of the song throughout the choreography.

We designed Joywalk to consist as much as possible of typical walking. The dance consisted of segments of walking in five distinct moods (neutral, confident, groovy, hurried and suspicious). Movements consisted of typical walking with nuanced modulations to express each mood. For example, confident walking had a more erect trunk posture and larger arm swing, while groovy walking utilized bent knees with more bounce in the shoulders. Dancers were divided into A and B groups with home positions on rows of chairs arranged along the left and right edges of the studio. A and B dancers faced each other and executed each mood segments either by crossing the stage in parallel formation or by walking in single file in curved paths. The moods were encouraged with simple narratives and imagery (e.g., "*pretend you are wary of this person who is walking toward you*") and were meant to encourage self-expression rather than to alter the way in which a person walked. Thus, the choreography served to expand the repertoire that one might use to walk down the street, but all of the walking moods fell within the range of regular walking. Participants within each group performed the same movements, walking in parallel formations or in single file. This feature makes the choreography easily scalable to allow variable numbers of participants. During each class, we built on to the piece, adding more choreography each day, and ran each iteration several times to aid with memory. There was no performance of the piece during the intervention. Each class closed with passing a hand squeeze around the circle.

Data analysis

Our primary outcome measure was normalized gait velocity. In order to understand how changes in velocity were achieved from pre- to post-intervention, we also calculated cadence, stride length, and measures of gait variability (coefficients of variation [CV] for stride length, stride time, and single support time).

We performed statistical tests in IBM SPSS Statistics for Windows, version 24 (IBM Corp., NY, USA). CV were calculated as the ([standard deviation/mean] $\times$ 100) for each person. Two-sided paired t-tests were used to assess group differences between pre-intervention and post-intervention. Due to the small sample size, we carefully assessed outliers for each paired t-test. The Kolmogorov–Smirnov test was used to assess normality and outliers were assessed for each paired t-test. Statistical significance was set at $\alpha = 0.05$.

Results

Adherence

Three participants dropped out of our initial sample size of 14, resulting in an adherence rate of 79%. Of the 11 participants who completed the intervention, they attended 95% of the class periods. One outlier was identified and excluded from the final analyses. One participant was also an outlier in stride time CV. The analysis was run with and without these data and did not alter the results.

Gait measures

There was a statistically significant increase in gait velocity between pre- and post-intervention ($t_9 = 3.30$; $p = 0.009$) (Figure 1). There were also significant increases in cadence ($t_9 = 2.345$; $p = 0.044$) and stride length ($t_9 = 3.757$; $p = 0.005$) and a significant decrease (improvement) in single support time variability ($t_9 = -2.744$; $p = 0.022$). There were no significant changes in stride-length variability ($t_9 = -1.496$; $p = 0.169$) or stride-time variability ($t_8 = -1.366$; $p = 0.209$) (Supplementary Table 1).

Clinical severity & non-motor measures

There were no significant changes between pre- and post-intervention assessments in measures of motor symptoms, MDS-UPDRS-III, mood and anxiety, extent of life-space mobility and quality of life (Table 2).

Discussion

We conducted a pilot study in which we created a dance composed of walking steps to specifically target the motor symptom of gait bradykinesia in people with PD. Joywalk is the first intervention to our knowledge to train people with PD to walk normally (i.e., at normal speeds) through the means of set choreographic structure. In line with

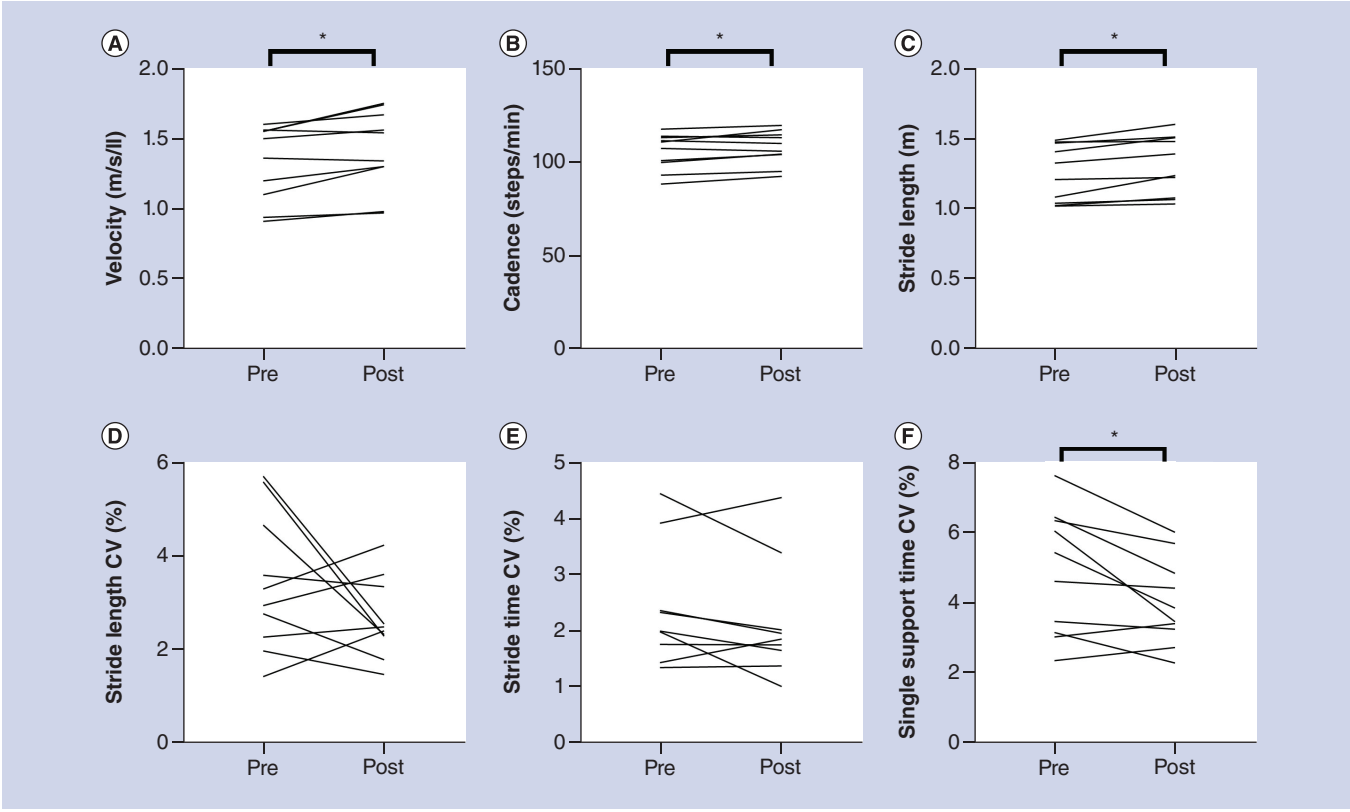

Figure 1. Gait characteristics. Group differences from pre- to post-intervention are shown; *$p < 0.05$.
CV: Coefficient of variation; ll: Leg length; m: Meters; s: Second.

Table 2. Secondary outcomes.

	Pre-intervention	Post-intervention	p-value
MDS-UPDRS-III	29 (13)	38 (14)	0.12
PDQ-39	23 (13)	23 (15)	0.84
LSQ	68 (35)	71 (31)	0.66
GDS	6 (2)	7 (2)	0.63
BAI	12 (8)	14 (7)	0.19

Values represent mean ± SD.
BAI: Beck Anxiety Inventory; GDS: Geriatric Disease Scale; LSQ: Life Space Questionnaire; MDS-UPDRS-III: Movement Disorders Society Unified Parkinson Disease Rating Scale Part 3; PDQ-39: Parkinson Disease Questionnaire – 39; SD: Standard deviation.

our hypotheses, 6 weeks of Joywalk dancing improved gait velocity and other markers of gait performance, without influencing measures of overall mobility, mood, or quality of life.

Improvements in gait speed are notable since our intervention was shorter in duration than most dance interventions for people with PD [13]. This suggests that a highly targeted intervention may require relatively few classes in order to significantly impact the targeted motor outcomes. Notably, our mean change of 0.08 m/s is relatively small, but may hold clinical relevance as it does fall above previously deemed minimal clinically important differences for people with PD [23]. Concurrently, we saw reductions in gait variability that may signify improved stability and reduced fall risk [24].

We did not see significant differences in any measures of mood or quality of life. This specificity of effect may be due to the highly targeted nature of our intervention, and suggests that the intervention acted directly on gait control mechanisms rather than through nonspecific influences on general mobility or mood. Other studies using dance have reported benefit on multiple motor domains, though the extent of this general benefit varied [25]. A more

general benefit may require a longer intervention duration or crafting dances that combine multiple movement elements, each specific to a type of symptom.

In designing a dance composed almost entirely of walking steps, one concern was whether participants would fatigue from walking. In fact, participants rarely took breaks, though some reported being tired by the end of class. In spite of a wide range of gait impairment among our participants, Joywalk choreography seemingly suited varied levels of ability. Our adherence rate of 79% was comparable with other dance therapy studies for PD [26]. Participants who completed the intervention attended 95% of the class periods. Exit surveys revealed that they enjoyed the socialization that dance enabled, the positive atmosphere, the music and the movement style. They reported feeling 'more energetic', 'less rigid', 'more alert' and 'happier' at the end of the intervention. Although these positive effects did not lead to a generalized improvement in self-reported mood or quality of life, 100% of participants said they would continue in the class if it was offered on an ongoing basis.

In order to capitalize on the motivational components of dance, we utilized guiding principles of contemporary dance such as emotional expression, musical entrainment, social interaction, and joint movement, all of which may have played a role in eliciting faster gait. Positive emotional valence likely encouraged self-expression and creativity [27]. Musical entrainment could have played a role in enhancing motor control and facilitating higher cadences [28]. Although most movement in our dance was non-partnered, which has previously shown lower outcomes than partnered dance [29], social interactions were emphasized throughout the class, both in partnered improvisations and in the final choreography. As such, participants repeatedly reported feeling engaged and enlivened by moving together.

This is the first study to our knowledge that utilizes set choreographic structure as the main element of therapy. Though dance-based interventions generally include some instruction of choreographed sequences, our intervention differs in two ways. First, a substantial portion of class time was spent working on the group choreography. Thus, classes resembled a dance rehearsal, in which dancers warmed up and then reviewed material from the previous week before building on. Second, the choreography was not preset; instead, it emerged organically in collaboration with the dancers, effectively giving them a sense of ownership over the choreographic material. We propose that this ingredient – the actual generation of choreography – may further contribute to the motivational capacity of dance. By allowing participants to take part in the generative process of dance-making, participants may have felt a sense of agency over the steps they created and their individual roles in the piece. Ample rehearsal time over the course of the intervention may have further enabled a merging of practice and performance, thus allowing the act of walking to feel more dance-like. Though no audience was present, the goal of adding on each week and rehearsing the whole dance at the end of each class may have provided even greater motivation to learn the steps [7].

Joywalk also attempts to address a chasm that exists between the way dance is practiced in the studio and the way its outcomes are measured in the laboratory. A recent call for a new framework in dance highlighted a gap between the stated goals of the founders of Dance for PD® and the scientists who have provided the evidence that it works [12]. According to Westheimer's rationale, DfPD® was formed to provide an escape from the disease, something to do that was enjoyable and 'unrelated to PD' [30]. Dancing was meant as an aesthetic outlet for the sake of artistic beauty and storytelling, with any subsequent benefits being merely subsidiary. This is in stark contrast to the stated goals of many laboratory-based dance classes for PD – ours included – which target specific motor symptoms in order to see the greatest possible effect. In this pilot study, we attempted to merge these two schools of thought by developing a dance-based therapeutic technique that incorporates the holistic foundation of dance with an outcome-based focus on symptoms.

This study has several important limitations that should be addressed, including a small sample size, abbreviated duration of intervention, lack of a control group, and lack of follow-up. Our preliminary results should be interpreted cautiously as these factors could limit generalizability to other people with PD. Additionally, knowledge of the title of the dance piece Joywalk may have impacted our results as participants may have been unwittingly biased toward a particular emotional state during dancing. Given the preliminary nature of this study, we did not assess transferability of this intervention from the laboratory to the real world, which would necessarily create new variables to consider. In order to assess the translation of performative studio dancing to other domains of daily life, future work should test carryover benefits following the intervention.

Conclusion

In conclusion, preliminary results from this study show that participating in a 6-week contemporary dance class and learning Joywalk choreography is both feasible and safe. By co-opting the motivational components of dance,

we aimed to target the motor symptom at the root of bradykinesia and elicited significant improvements in gait speed. We propose that active engagement and collaboration in the generation of a piece of choreography may especially enable performative aspects of dance, thereby turning walking itself into a dance. This pilot study builds upon a steadily growing body of literature aimed at parsing out which elements of dance therapies may optimize outcomes and contributes fresh insights into how motor motivation may provide an active ingredient in improving gait speed.

Supplementary data

To view the supplementary data that accompany this paper please visit the journal website at: www.futuremedicine.com/doi/suppl/10.2217/nmt-2020-0028

Author contributions

All authors critically reviewed the manuscript and approved the final version. EC Harrison contributed toward study conception, study design, data acquisition and analysis, and manuscript preparation. GM Earhart and P Mazzoni contributed toward study conception, study design, data interpretation and review/revision of manuscript. D Leventhal and L Quinn contributed toward study conception, study design and review/revision of manuscript.

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No writing assistance was utilized in the production of this manuscript.

Ethical conduct of research

The authors state that they have obtained institutional review board approval. In addition, informed consent has been obtained from the participants involved.

Data sharing statement

The authors certify that this manuscript reports original clinical data. The data will be made publicly available according to IRB approval.

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