Effects of dance on gait and dual-task gait in Parkinson's disease

Nadeesha Kalyani Hewa Haputhanthirige

Queensland University

Karen Sullivan

Queensland University of Technology

Gene Moyle

Queensland University of Technology

Sandy Brauer

University of Queensland

Erica Rose Jeffrey

Queensland University of Technology

Graham Kerr (✉ g.kerr@qut.edu.au)

Queensland University of Technology <https://orcid.org/0000-0002-1008-256X>

Research article

Keywords: Parkinson's disease, Dance, Gait, Dual-tasking

Posted Date: October 2nd, 2019

DOI: <https://doi.org/10.21203/rs.2.15431/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Background Gait impairments in Parkinson's disease (PD) limit independence and quality of life. While dance based interventions could improve gait, further studies are needed to determine if the benefits generalise to different terrains and when dual-tasking. The aim was to perform a feasibility study of the effects of a dance intervention, based on the Dance for PD® (DfPD®) program, on gait under different dual-tasks (verbal fluency, serial subtraction) and surfaces (even, uneven), and to determine if a larger scale follow-up RCT is warranted.

Methods A dance group (DG; n = 17; age = 65.8 ± 11.7 years) and a control group (CG; n = 16; age = 67.0 ± 7.7 years) comprised of non-cognitively impaired (Addenbrooke's score: DG = 93.2 ± 3.6, CG = 92.6 ± 4.3) independently locomoting people with PD (Hoehn & Yahr I-III) participated in the study. The DG undertook a one-hour DfPD® based class, twice weekly for 12 weeks. The CG had treatment as usual. Gait analysis was performed at baseline and post-intervention while walking on two surfaces (even, uneven) under three conditions (regular walking; dual-task: verbal-fluency, serial-subtraction). The data was analysed by means of a linear mixed model.

Results The DG improved significantly compared to the CG in gait velocity, cadence, step-length, and stride-length when even surface walking, with and without a dual-task. On the uneven surface the DG walked more cautiously during regular walking but had improved gait velocity, cadence and step-length when performing serial-subtractions.

Conclusions DfPD®-based classes produced clinically significant improvement on spatiotemporal gait parameters under dual-task conditions and on uneven surfaces. This could arise from improved movement confidence and coordination; emotional expression; cognitive skills (planning, multitasking), and; utilisation of external movement cues. A large-scale RCT of this program is warranted. Trial registration A protocol for this study has been registered retrospectively at Australian New Zealand Clinical Trials Registry on 12.11.2018. Identifier: ACTRN12618001834246.

Background

Improving gait is of fundamental importance for people with PD as it is associated with independence and quality of life [1–4]. Amidst many debilitating symptoms, gait disturbances are a frequent cause of disability, and are characterised by reduced gait velocity, cadence, stride length, swing time and arm swing and a consequent increase in the double support phase [1, 3, 4]. Increased muscle rigidity reduces body rotation and encourages abnormal head-trunk intersegmental coordination during walking, thereby affecting gait velocity and turning [5, 6]. Stride time variability, which is a marker for impaired mobility [7], is increased. Given the wide range of potential PD-related gait disturbances and associated functional impairments, it is vital to find effective gait improvement programs.

An effective gait improvement program for people with PD should show benefits in a variety of real-world conditions. For example, improvements should be evident when walking *and* talking (dual-task gait) and when walking on different terrains (e.g. on an uneven surface). People with PD are known to have dual-task gait deficits [8]. This is thought to be because dual-tasking relies on executive function and the ability to divide attention [9], both of which are affected by basal ganglia pathology even in early PD [10]. The additional attentional demands of walking on uneven surfaces could also explain why this ability is compromised in many people living with PD [7]. [11]. Therefore, a gait intervention that improves walking on varied terrains and under dual-task conditions should facilitate ambulation for people with PD.

In a recent systematic review and meta-analysis we found promising findings for gait improvement in people with PD following dance-based interventions [12]. Improvements were shown on measures of functional mobility including the Timed Up and Go Test (TUG) [13–19] and the Six-Minute Walk Test (6MWT) [13–15, 20]. Eight studies looked for dual-task gait improvement from a dance-based intervention [14, 16, 18–23]. Only one dance-style (Argentine Tango) showed a dual-task gait benefit on the TUG [14, 19, 20]. Further, a limited number of studies, mostly using Argentine Tango [14, 16, 20, 24–28], have examined effects using *spatiotemporal gait variables* such as velocity, cadence, and swing, stride and double support percentage [14, 16, 20, 23–29], and only one of these parameters (gait velocity) has been tested whilst dual-tasking [16, 20]. There have been mixed findings from dance-based interventions with these finer-grained gait measures; however, three studies demonstrated a benefit on selected parameters [cadence, backward stride length, swing and stance percentage; [15, 22, 29]]. Further exploration of the potential benefits on gait of dance-based interventions for people with PD are required because there has been not yet been a detailed spatiotemporal gait analysis under dual-task conditions following these dance interventions [12], and it has yet to be established if the benefits extend to uneven surfaces.

This study investigated the effects on spatiotemporal measures of gait (regular and dual-task) of an intervention modeled on an internationally adopted program called Dance for PD (DfPD®). The DfPD® methodology produces a complex multifaceted intervention. It includes music, movement, social and artistic elements, and it has a central component that draws on different dance styles. These program attributes theoretically enable it to produce more benefits than simpler programs or those based on a single dance-style. Empirical studies of the DfPD® approach have already shown that it benefits a wide range of outcomes, including quality of life [30] and functional gait [31, 32]. It remains to be determined if this approach produces measurable benefits on spatiotemporal gait parameters, under dual-task conditions and on different

surfaces. Spatiotemporal measurement of gait provides a direct measure of the *components* of walking, and this could provide insight into the mechanism for change on the functional measures. This study will also establish the feasibility of undertaking a large-scale multi-centre RCT to assess whether the DfPD[®] approach benefits gait when comprehensively assessed. We hypothesized that, compared to a control condition, there would be an improvement in regular and dual-task gait on even and uneven surfaces following a dance-based intervention.

Methods

This feasibility study incorporated a quasi-experimental parallel group pre-test post-test design and was carried out at the Institute of Health and Biomedical Innovation, Queensland University of Technology (QUT). Participants gave written informed consent in accordance with the Declaration of Helsinki [33] and the experimental protocol was approved by the Human Research Ethics Committee at QUT (#1700000005). The study was registered in the Australian New Zealand Clinical Trials Registry (ANZCTR) (#ACTRN12618001834246).

Participants

A sample size of 16 participants per group was estimated based on parameters drawn from a previous pilot study [34] ($\alpha = 0.05$, power = 0.8, effect size = 0.75). Participants were recruited from PD support groups in Queensland, advertising on the Parkinson's Queensland website, distributing flyers to participants in the existing DfPD[®] class at Queensland Ballet (QB), through the "Radio Parkies" radio show, and via the QUT email system.

Forty-nine people with PD expressed interest in the study and were interviewed by phone to determine their eligibility. Eligible participants: 1) required a clinical diagnosis of idiopathic PD, using the published diagnostic criteria for clinically defined *definite PD* [35]; 2) were aged between 40–85 years; 3) had mild to moderate stage disease (Hoehn and Yahr I–III) [36]; 4) were free from dementia (Addenbrooke's Cognitive Examination: ACE) > 82) [37]; 5) had no medical, neurological (other than PD), musculoskeletal, cardiovascular or respiratory abnormalities, and; 6) could walk independently for ≥ 3 m without an assistive device. Participants were on stable medication regimens and were tested in the "ON" medication phase (within three hours post-PD medication).

Following initial screening, 38 people were deemed eligible. Due to difficulties in the recruitment process, limited time duration and participant availability, group allocation was pseudo random (dance group: DG = 19 and control group: CG = 19). During baseline assessment, two DG participants and three CG participants discontinued, leaving 17 and 16 participants in the DG and CG, respectively (see Figure 1).

Spatiotemporal gait analysis

The spatiotemporal gait assessment used a 12-camera Vicon data capturing system (Cameras: Vantage 5, 200Hz; Software: Nexus 2.5). The data were captured from forty-one retro-reflective markers worn by the participant while they walked from start to finish along a 12m walkway. Marker positions were tracked within a central six-meter length for four complete gait cycles. Data processing included marker labelling, reconstructing, gap filling, modelling and inserting the events (heel strike, toe off) for each walking trial [38]. Marker trajectories were filtered using a Woltring generalized cross validatory interpolating spline (5th order) [39].

Gait velocity (ms^{-1}) was the primary outcome. Secondary outcomes were cadence (steps/second), step length (metres), stride length (metres), double support % (percent of gait cycle with both feet on the ground), stance phase %, swing phase %, single support %, and stride time variability (standard deviation of stride period [40]). Some of these variables were directly exported from the software and a custom software was used to calculate the remaining variables.

Surfaces

The even-surface walkway was flat, smooth and free from obstacles. The uneven-surface walkway constructed as per precedent [41] and consisted of randomly positioned small wooden blocks covered with layers of foam and artificial grass.

Dual-tasks

Two separate dual-tasks that involved working memory and attention [42, 43], and which are known to involve the prefrontal cortex [44], were used during walking. Each of these tests has previously been added to walking to create a dual-task in PD dance interventions [45].

The first cognitive task was an untimed verbal fluency test (DT_{VERB}). The participant was required to name as many words as possible that begin with a nominated letter. Eight letters were randomly selected from within the *relatively easy* category [46, 47] (B, R, L, S, T, P, C, and M). The same letters were used for all participants, and responses were recorded verbatim. A score of 1-point was awarded for each correct word. The total score was the sum of the correct responses across the eight trials, with higher scores indicating greater verbal fluency.

The second cognitive task was an untimed serial subtraction task (DT_{SUBT}). A randomly generated whole number to three-digits (e.g., 748) was given to the participant as a starting number [48]. The participant was required to subtract seven from the starting number, verbalise the result, and continue the process until no further subtractions could be made. One-point was awarded for each correct subtraction, with higher scores indicating greater working memory and attention.

For both dual-tasks, decrements in walking under dual-task conditions were also expressed as a percentage of single task performance, commonly referred to as the dual-task cost ($DTC = [\text{dual-task} - \text{single-task}] / \text{single-task} \times 100$) [45]. Gait velocity, stride length and double support percentage, which have been commonly used to measure gait-related changes in PD were rescored as DTC [4, 45]. A higher DTC score indicates a greater cost to walking (worse gait).

Intervention versus treatment as usual

The intervention, which was based on the DfPD[®] approach [49], was led by DfPD[®]-trained instructors. The intervention commenced on 21st Aug 2017 and continued for three months as a two-hourly twice weekly class. Each class was followed by a social tea/coffee break. Participants could attend with a family member, friend, or caregiver. Each class had 3–4 volunteer assistants who were paired with participants who demonstrated poor balance. Each class started with a 30-minute seated dance, followed by 10–15 minutes each of standing dance with support, then standing dance movement across the floor. The intervention was progressively advanced over time (intervention details: Appendix I). The intervention was added to each participant's usual PD care.

The CG participants received their PD treatment as usual. This comprised routine clinical care for each patient. After baseline assessment, the research team made minimal contact with the participants in this group, apart from to schedule post-intervention assessments.

- Procedure

For each surface type, the spatiotemporal gait analysis was performed under three conditions (regular walking, DT_{VERB} , DT_{SUBT}). Altogether there were six tests for each occasion (2 surfaces X 3 condition), the order of which was randomized across the participants. The six trials were performed on two occasions (baseline and post-intervention). Before each test, 42 retro-reflective markers were placed on the specific anatomic points of the subjects' body, according to the Vicon plug-in gait model [39]. To minimize errors, the same experienced investigator attached the markers, labelled and analyzed the spatiotemporal data, and administered and scored the cognitive tests. For each trial, the participant was instructed to walk barefoot from the start to the end of the walkway at a self-selected pace. One practice trial for each condition was allowed, before the tests commenced. For dual-task tests, the participant was requested to start walking while performing the cognitive task as soon as the starting number or letter was spoken to them.

- Statistical Analysis

A linear mixed model (LMM) with factors of group (dance, control) and condition (regular, dual-task-A, dual-task-B) was used. Separate analyses were performed for even and uneven surfaces. The dependent variable was a spatiotemporal gait parameter or its DTC derivative. Separate univariate analyses for each condition were used to compare the dance and control groups. Analyses were undertaken on the change (pre-post) scores. A preliminary analysis found that there were more females in the dance group (82.4%) than in the control group (37.5%; $\chi^2 (1, N = 33) = 6.94, p = 0.008$). Gender was therefore considered as covariate in subsequent analyses. Although disease severity (MDS-UPDRS score) of the groups was statistically comparable at baseline ($p > 0.05$), because there was large variability in these data (DG range: 36 to 116, CG range: 27 to 111) this variable was also included as a covariate. All statistical procedures were conducted using SPSS 25 and were evaluated using an alpha of 0.05.

Results

Results

Demographic characteristics

Apart from there being more females in the dance group (82.4%, age 65.8±11.7 years, $n = 17$) than in the control group (37.5%, age 67.0±7.7 years, $n = 16$; $p = 0.008$), the groups had similar characteristics at baseline (Table 1). Participants were four to six years post PD diagnosis and they had had less than one fall in the past six-months (DG = 3 fallers, CG = 2 fallers). No adverse events (e.g. falls) were reported during the dance classes.

Dual-tasks: cognitive component

The performance and accuracy on the cognitive component of the dual-tasks was not statistically different for the groups during even and uneven surface trials at baseline and post-intervention (Appendix II).

Spatiotemporal gait analysis

Even surface

At baseline, there was no significant group difference for any spatiotemporal gait variable. The DG improved significantly compared to the CG with and without a dual-task. The overall LMM analysis revealed that the DG had higher gait velocity ($p = 0.016$), cadence ($p = 0.024$), step length ($p = 0.026$) and stride length ($p = 0.028$) compared to the CG. Univariate analysis (Table 2) of pre-post change scores in each of the three conditions, found significant improvements for the DG compared to controls on four spatiotemporal measures (velocity, cadence, step- and stride-length), with one exception; in the DT_{VERB}, the group difference for step length approached but did not reach statistical significance ($p = 0.053$). There were no differences between the DG and CG for DTC change scores for any of the gait parameters on the even surface.

Uneven surface

At baseline, there was no significant group difference for any spatiotemporal gait variable for the uneven surface. The overall LMM analysis exhibited no significant group main effect for any of the gait parameters. However, there was a significant condition main effect for stance phase % ($p = 0.001$) and double support % ($p = 0.001$). There was also a significant group*condition interaction for the stance phase % ($p = 0.001$) and double support % ($p = 0.001$). The univariate analyses of pre-post change scores for regular uneven surface walking found that the DG had a longer double support phase and stance phase compared to controls (Table 3). For the DT_{VERB} condition there were no significant group differences for any gait parameter. For the DT_{SUBT} condition, the DG improved significantly compared to the controls on gait velocity, cadence, and step length. On the uneven surface there was DTC improvement in the DG group relative to controls for four gait parameters from DT_{SUBT}; gait velocity, stride length and double support.

Discussion

This study investigated the effects gait spatiotemporal parameters of a dance intervention for people with PD compared to a PD control group who did not dance (treatment as usual). At baseline and post-intervention, gait was thoroughly assessed on even and uneven surfaces while walking regularly, and while engaging with one of two different cognitive tasks. The intervention was based on a widely used model that has shown promise on a range of gait and non-gait outcomes. We aimed to determine a) if the DfPD[®] gait benefits might extend to everyday conditions including walking on different surfaces, which is a novel addition to a gait evaluation for PD dance interventions and; b) to examine the feasibility of carrying out a large scale RCT of this question.

This study supported the hypothesised benefit of the DfPD[®] program on a wide range of gait measures and under novel conditions. The largest and most consistent pattern of benefits were observed for even surface walking, including while dual-tasking. There were mixed results for uneven surface walking, but importantly some benefits were found. At baseline, the gait parameters (velocity, cadence, stride length and double support %) for the DG were similar to previously reported values for PD fallers (15). Following intervention these parameters decreased to a low-risk for falls (15). This suggests that the DfPD[®] approach can benefit gait on a wider range of measures than previously demonstrated, and that the benefits are clinically significant.

- Even surface walking

The DfPD[®] intervention significantly improved gait velocity, cadence and step length during regular even surface walking. This is consistent with the benefits reported for previous studies using functional mobility tests [29, 50–61] [29, 51–55, 57, 58, 62–64]. The present study is the first evaluation of the DfPD[®] approach using spatiotemporal gait parameters. When compared to other PD dance programs with similar

measures, most of which used gait velocity only [14, 16, 20, 23, 27, 28, 31, 65], our findings are consistent with two studies [20, 31] while three studies showed no change [14, 16, 27]. Importantly, the improvement in gait velocity in our study was also clinically significant [66]. The minimally clinically important difference (MCID) [66–68] for gait speed among medicated people with PD from 0.05 m/s to 0.22 m/s (by distribution-based analysis) and from 0.02 m/s to 0.18 m/s per level (i.e. Hoehn and Yahr staging) [66] and in this study both cut offs were exceeded (0.150 m/s, 95% confidence interval = 0.075–0.226). We also found benefits on other spatiotemporal parameters [i.e. cadence (steps/min), stride length (m), and swing, single and double support (time or % per gait cycle)] that have not improved in prior group comparisons (i.e. partnered vs non-partnered Tango or Tango vs Ballroom) [54, 55]. Whilst the reasons for these discrepancies are a matter for speculation, this could be because we employed a treatment as usual control group rather than comparing dance-styles (potentially diluting effects), or it could be as a result of our program. In single-sample studies, our findings for cadence and single support time are consistent with the literature, including the findings for dance programs of adapted Argentine Tango [55, 57] and contact improvisation [29, 54]. It seems that dance-interventions in general can improve spatiotemporal gait parameters for even surface regular walking, and this study provides the first, thorough demonstration of these benefits using the DfPD® approach.

Following the dance intervention, there was significant improvement in gait velocity, cadence and step length when each cognitive task was added to walking on the even surface. The improvement in gait velocity was found for both dual tasks (verbal fluency: 0.14 ms^{-1} , serial subtraction: 0.15 ms^{-1}) and exceeded the threshold for a MCID. Compared to the mixed results from the previous dance intervention dual-task gait studies [14, 16, 18–20, 22], our findings are consistent with studies that used verbal fluency [20] but not serial subtraction [56, 69]. Dual-task cost for the even surface walking was consistent with previous research [45] and was similar for both these dance and control groups. Taken together the results reinforce the notion that a DfPD®-style intervention could have wider benefits than previously identified, including when dual-tasking.

- Uneven surface walking

This study did not find the hypothesised improvements on spatiotemporal gait parameters for regular uneven surface walking. Compared to controls we found that the DG had significantly increased stance and double support phases and a corresponding decrease in swing phase; characteristics that are synonymous with more cautious gait. Uneven surface trials have not previously been studied in PD dance interventions. However, it could be that as a result of the program, the DG participants took greater care walking in the higher risk environment, which could be interpreted as an improvement. This test should be replicated in future research given that everyday walking environments are comprised of different irregular surfaces [70] and such characteristics cause increased fatigue, fear of falling and more frequent freezing episodes in people with PD [71].

The dance intervention resulted in improvements in gait velocity, cadence and step length while walking on an uneven surface and performing serial subtractions. There was also significant improvement in dual-task cost for the dance group for the subtraction condition. However, no gait improvements were observed for DT_{VERB} . This illustrates the importance of evaluating gait performance on more challenging surfaces which mimic everyday environments. It also lends support to the DfPD® approach as an effective method for improving dual-task performance, which has previously proven resistant to modification [45]. It is unclear why this benefit was observed for the subtraction task only. However, it has been reported that in healthy individuals a verbal fluency task did not show any effect on stride velocity whereas an arithmetic task instigated a decline in gait speed and the ability to enumerate numbers compared to single-task conditions [72]. It is plausible that the subtraction task could have demanded more attention and executive function along with the additional physical challenge provided by the uneven surface. Adapting locomotor movements to varied terrains is important in daily lives, and the current study provides support for future research that improves gait under different task and environmental constraints.

Why did gait improve?

Gait improvement following our intervention may be because the program attributes promoted of different attentional cues for movement (visual, auditory, somatosensory). Cueing strategies have demonstrated improved gait in people with PD [21, 73–76]. External cues have been hypothesised to bypass defective basal ganglia using alternative pathways [77]. The music that is used in dance is thought to provide an important auditory cue to move [21] via variations in rhythm and tempo. Tactile feedback could also cue movement; for example when holding hands with a dance partner [49]. Rhythmic auditory cues and attentional strategies have been effective in improving walking speed and step amplitude when dual-tasking [73]. Gait may have improved in this study because the intervention: promoted generalized use of external cues, developed movement skills or confidence, or was spurred by other program attributes.

The gait benefits seen in dual-tasking warrants close consideration. Since dual tasking relies on executive function and the ability to divide attention, the improvement may have been due to the cognitive skills practised in dancing, such as learning and remembering dance sequences [9]. During dancing, participants must rapidly and skilfully switch between dance routines, processes which involve executive control and working memory [78]. The “dancer” must attend to the dance teacher’s instruction and performance, plan and execute the required movement,

and maintain control and balance throughout the artistic performance. These task specific aspects of multitasking may thus be related to improved dual-task gait resulting from participation in the DfPD[®] classes.

The study was limited by the sample size. This was in part due to feasibility constraints on the pilot study class size. Additional parallel groups should be offered in future research, such as a group with Argentine Tango. We speculate that the benefits observed in this research could be due to the complex, multi-dance style design of the intervention we used; however this idea should be tested. Group allocation was pseudo random as it was affected by participants' availability. This resulted in unequal male to female ratio in the two groups and although this was controlled for during statistical analyses, this is limitation of this study.

Conclusion

This feasibility study indicates the very high potential that a large scale RCT will also find positive and clinical meaningful benefits for dance on spatiotemporal even surface gait parameters with and without a dual-task and uneven surface walking with a serial subtraction task. It also demonstrates the practicality for safely undertaking a large scale randomised controlled trial of this type of program. Future studies should examine the durability of these benefits, including transferability to home environments and community ambulation, and if they extend to reducing falls risk.

Declarations

Abbreviations

6MWT: Six-minute walk test, ACE: Addenbrooke's Cognitive Examination, ANZCTR: Australian New Zealand Clinical Trials Registry, DT_{VERB}: Dual task Verbal fluency, DT_{SUBT}: Dual Task serial Subtraction, DTC: Dual Task Cost, DfPD[®]: Dance for Parkinson's disease, LMM: Linear Mixed Model, PD: Parkinson's disease, RCT: Randomised Control Trial, QUT: Queensland University of Technology, TUG: Timed Up and Go Test

Acknowledgements

We are thankful to the participants with PD, the caregivers, volunteers and dance teachers from Queensland Ballet.

Authors' Contributions

NK was the principal investigator of the study. Authors NK, GK, KS, GM, SB and ERJ were involved in conceptualization and organization of the research project. NK and GK involved in designing and execution of the statistical analysis. GK and KS assisted the first author in writing the manuscript. All authors have involved in reviewing and critiquing the manuscript and have approved the final version.

Funding

The study was funded by Queensland University of Technology, Brisbane, Australia and Post Graduate Research Grant from University Grants commission Sri Lanka.

Availability of data and material

Any person wishing to access data of this study must submit a formal request to the corresponding author for approval.

Ethics approval and consent to participate

Ethics approval was obtained from the Human Research Ethics Committee at Queensland University of Technology (#1700000005). Written informed consent was obtained from the participants in accordance with the Declaration of Helsinki.

Consent for Publication

Not Applicable

Competing interests

The authors declared the potential conflicts of interest with respect to the research. Erica Rose Jeffrey is the Director of Dance for Parkinson's Australia and a lead teacher in Dance for Parkinson's attached to Queensland Ballet. The other authors have no conflicts of interest to declare.

Author details

¹Movement Neuroscience, Institute of Health and Biomedical Innovation, QUT, Brisbane, Queensland, Australia, ²School of Exercise and Nutrition Sciences, Faculty of Health, QUT, ³Department of Allied Health Sciences, Faculty of Medicine, University of Colombo, Sri Lanka, ⁴School of Psychology and Counselling, Faculty of Health, QUT, ⁵Institute of Health and Biomedical Innovation, QUT, ⁶School of Creative Practice, Faculty of Creative Industries, QUT, ⁷School of Health and Rehabilitation Sciences, Faculty of Health and Behavioural Sciences, University of Queensland, Brisbane, Queensland, Australia, ⁸Queensland Ballet, South Brisbane, Queensland, Australia, ⁹Dance for Parkinson's Australia, Brisbane, Queensland, Australia

References

1. Morris ME, Iansek R, Matyas TA, Summers JJ: *Ability to modulate walking cadence remains intact in Parkinson's disease. Journal of Neurology, Neurosurgery & Psychiatry* 1994, **57**(12):1532–1534.
2. Morris ME, Iansek R, Matyas TA, Summers JJ: *The pathogenesis of gait hypokinesia in Parkinson's disease. Brain* 1994, **117**(5):1169–1181.
3. Morris ME, Iansek R, Matyas TA, Summers JJ: *Stride length regulation in Parkinson's disease. Brain* 1996, **119**(2):551–568.
4. Morris ME, Matyas TA, Iansek R, Summers JJ: *Temporal stability of gait in Parkinson's disease. Physical Therapy* 1996, **76**(7):763–777.
5. Cole MH, Silburn PA, Wood JM, Worringham CJ, Kerr GK: *Falls in Parkinson's disease: kinematic evidence for impaired head and trunk control. Movement Disorders* 2010, **25**(14):2369–2378.
6. Mak MK, Wong EC, Hui-Chan CW: *Quantitative measurement of trunk rigidity in parkinsonian patients. Journal of Neurology* 2007, **254**(2):202–209.
7. Cole MH, Silburn PA, Wood JM, Kerr GK: *Falls in Parkinson's disease: evidence for altered stepping strategies on compliant surfaces. Parkinsonism & Related Disorders* 2011, **17**(8):610–616.
8. Yogev-Seligmann G, Hausdorff JM, Giladi N: *The role of executive function and attention in gait. Movement disorders: official journal of the Movement Disorder Society* 2008, **23**(3):329–342.
9. Della Sala S, Baddeley A, Papagno C, Spinnler H: *Dual-task paradigm: a means to examine the central executive. Annals of the New York Academy of Sciences* 1995, **769**(1):161–172.
10. O'Shea S, Morris ME, Iansek R: *Dual task interference during gait in people with Parkinson disease: effects of motor versus cognitive secondary tasks. Physical therapy* 2002, **82**(9):888–897.
11. Shumway-Cook A, Patla AE, Stewart A, Ferrucci L, Ciol MA, Guralnik JM: *Environmental demands associated with community mobility in older adults with and without mobility disabilities. Physical Therapy* 2002, **82**(7):670–681.
12. Kalyani H, Sullivan KA, Moyle G, Brauer SG, Jeffrey E, Roeder L, Berndt S, Kerr G: *Effects of dance on gait, cognition and dual-tasking in Parkinson's disease: A Systematic Review and Meta-Analysis. Journal of Parkinson's disease* 2019.
13. de Natale ER, Paulus KS, Aiello E, Sanna B, Manca A, Sotgiu G, Leali PT, Deriu F: *Dance therapy improves motor and cognitive functions in patients with Parkinson's disease. NeuroRehabilitation* 2016.
14. Duncan RP, Earhart GM: *Are the effects of community-based dance on Parkinson disease severity, balance, and functional mobility reduced with time? A 2-year prospective pilot study. Journal of Alternative and Complementary Medicine* 2014, **20**(10):757–763.
15. Hackney ME, Earhart GM: *Effects of dance on movement control in Parkinson's disease: a comparison of Argentine tango and American ballroom. Journal of Rehabilitation Medicine* 2009, **41**(6):475.

- 16.Hackney ME, Kantorovich S, Earhart GM: *A study on the effects of Argentine tango as a form of partnered dance for those with Parkinson disease and the healthy elderly. American Journal of Dance Therapy* 2007, 29(2):109–127.
- 17.Hashimoto H, Takabatake S, Miyaguchi H, Nakanishi H, Naitou Y: *Effects of dance on motor functions, cognitive functions, and mental symptoms of Parkinson's disease: a quasi-randomized pilot trial. Complementary therapies in medicine* 2015, 23(2):210–219.
- 18.McKee KE, Hackney ME: *The effects of adapted tango on spatial cognition and disease severity in Parkinson's disease. Journal of motor behavior* 2013, 45(6):519–529.
- 19.Rios Romenets S, Anang J, Fereshtehnejad SM, Pelletier A, Postuma R: *Tango for treatment of motor and non-motor manifestations in Parkinson's disease: a randomized control study. Complementary Therapies in Medicine* 2015, 23(2):175–184.
- 20.Duncan RP, Earhart GM: *Randomized controlled trial of community-based dancing to modify disease progression in Parkinson disease. Neurorehabilitation and Neural Repair* 2012, 26(2):132–143.
- 21.Batson G, Hugenschmidt CE, Soriano CT: *Verbal Auditory Cueing of Improvisational Dance: A Proposed Method for Training Agency in Parkinson's Disease. Frontiers in Neurology* 2016, 7:15.
- 22.McKay JL, Ting LH, Hackney ME: *Balance, Body Motion, and Muscle Activity After High-Volume Short-Term Dance-Based Rehabilitation in Persons With Parkinson Disease: A Pilot Study. Journal of Neurologic Physical Therapy* 2016, 40(4):257–268.
- 23.McNeely ME, Mai MM, Duncan RP, Earhart GM: *Differential Effects of Tango Versus Dance for PD in Parkinson Disease. Frontiers in Aging Neuroscience* 2015, 7:239.
- 24.Hackney ME, Earhart GM: *Short duration, intensive tango dancing for Parkinson disease: an uncontrolled pilot study. Complementary Therapies in Medicine* 2009, 17(4):203–207.
- 25.Hackney ME, Earhart GM: *Effects of dance on movement control in Parkinson's disease: a comparison of Argentine tango and American ballroom. Journal of Rehabilitation Medicine* 2009, 41(6):475–481.
- 26.Hackney ME, Earhart GM: *Effects of dance on gait and balance in Parkinson's disease: a comparison of partnered and nonpartnered dance movement. Neurorehabil Neural Repair* 2010, 24(4):384–392.
- 27.Hackney ME, Kantorovich S, Levin R, Earhart GM: *Effects of tango on functional mobility in Parkinson's disease: a preliminary study. Journal of Neurologic Physical Therapy* 2007, 31(4):173–179.
- 28.Seidler KJ, Duncan RP, McNeely ME, Hackney ME, Earhart GM: *Feasibility and preliminary efficacy of a telerehabilitation approach to group adapted tango instruction for people with Parkinson disease. Journal of telemedicine and telecare* 2016.
- 29.Marchant D, Sylvester JL, Earhart GM: *Effects of a short duration, high dose contact improvisation dance workshop on Parkinson disease: A pilot study. Complementary Therapies in Medicine* 2010, 18(5):184–190.
- 30.Jeffrey E, Moyle, G, Kerr, G K., Brauer, S., Lamont, R, & Kemp, K: *Dance for Parkinson's Pilot Research Report - Queensland Ballet. In.;* 2014.
- 31.Ventura MI, Barnes DE, Ross JM, Lanni KE, Sigvardt KA, Disbrow EA: *A pilot study to evaluate multi-dimensional effects of dance for people with Parkinson's disease. Contemporary Clinical Trials* 2016.
- 32.Westheimer O, McRae C, Henchcliffe C, Fesharaki A, Glazman S, Ene H, Bodis-Wollner I: *Dance for PD: a preliminary investigation of effects on motor function and quality of life among persons with Parkinson's disease (PD). Journal of Neural Transmission* 2015, 122(9):1263–1270.
- 33.Association WM: *World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. Jama* 2013, 310(20):2191.
- 34.Brauer S, Jeffry E, Lamont R, Kerr G, Moyle G: *The impact of a 6 months Dance for Parkinson's programme on physical function and wellbeing. In: 4th World Parkinson Congress. 2016.*
- 35.Racette BA, Rundle M, Parsian A, Perlmutter JS: *Evaluation of a screening questionnaire for genetic studies of Parkinson's disease. American Journal of Medical Genetics* 1999, 88(5):539–543.
- 36.Goetz CG, Poewe W, Rascol O, Sampaio C, Stebbins GT, Counsell C, Giladi N, Holloway RG, Moore CG, Wenning GK: *Movement Disorder Society Task Force report on the Hoehn and Yahr staging scale: status and recommendations the Movement Disorder Society Task Force on*

rating scales for Parkinson's disease. *Movement Disorders* 2004, 19(9):1020–1028.

37.Kaszás B, Kovács N, Balás I, Kállai J, Aschermann Z, Kerekes Z, Komoly S, Nagy F, Janszky J, Lucza T: *Sensitivity and specificity of addenbrooke's cognitive examination, mattis dementia rating scale, frontal assessment battery and mini mental state examination for diagnosing dementia in Parkinson's disease. Parkinsonism & related disorders* 2012, 18(5):553–556.

38.Kadaba MP, Ramakrishnan H, Wootten M: *Measurement of lower extremity kinematics during level walking. Journal of Orthopaedic Research* 1990, 8(3):383–392.

39.Tebbutt P, Wood J, King M: *The vicon manual*. In.: Vicon Motion Systems, Lake Forest, CA; 2002.

40.Hausdorff JM, Cudkowicz ME, Firtion R, Wei JY, Goldberger AL: *Gait variability and basal ganglia disorders: stride-to-stride variations of gait cycle timing in Parkinson's disease and Huntington's disease. Movement Disorders* 1998, 13(3):428–437.

41.Menz HB, Lord SR, Fitzpatrick RC: *Acceleration patterns of the head and pelvis when walking on level and irregular surfaces. Gait & posture* 2003, 18(1):35–46.

42.Ikudome S, Mori S, Unenaka S, Kawanishi M, Kitamura T, Nakamoto H: *Effect of long-term body-mass-based resistance exercise on cognitive function in elderly people. Journal of Applied Gerontology* 2017, 36(12):1519–1533.

43.Vaportzis E, Georgiou-Karistianis N, Stout JC: *Age and task difficulty differences in dual tasking using circle tracing and serial subtraction tasks. Aging Clinical and Experimental Research* 2014, 26(2):201–211.

44.McKendrick R, Ayaz H, Olmstead R, Parasuraman R: *Enhancing dual-task performance with verbal and spatial working memory training: continuous monitoring of cerebral hemodynamics with NIRS. Neuroimage* 2014, 85:1014–1026.

45.Kelly VE, Eusterbrock AJ, Shumway-Cook A: *A Review of Dual-Task Walking Deficits in People with Parkinson's Disease: Motor and Cognitive Contributions, Mechanisms, and Clinical Implications. Parkinson's Disease* 2012, 2012.

46.Benton AL: *Differential behavioral effects in frontal lobe disease. Neuropsychologia* 1968, 6(1):53–60.

47.Lees A, Smith E: *Cognitive deficits in the early stages of Parkinson's disease. Brain* 1983, 106(2):257–270.

48.Pennington L: *The Serial Sevens Test as a psychometric instrument. American Journal of Orthopsychiatry* 1947, 17(3):488.

49.Westheimer O: *Why dance for Parkinson's disease. Topics in Geriatric Rehabilitation* 2008, 24(2):127–140.

50.Allen JL, McKay JL, Sawers A, Hackney ME, Ting LH: *Increased neuromuscular consistency in gait and balance after partnered, dance-based rehabilitation in Parkinson's disease. Journal of Neurophysiology* 2017, 118(1):363–373.

51.Duncan R, Earhart G: *Randomized controlled trial of community-based dancing to modify disease progression in Parkinson disease. In: Neurorehabilitation and neural repair*. vol. 26; 2012: 132–143.

52.Duncan R, Earhart G: *Are the effects of community-based dance on Parkinson disease severity, balance, and functional mobility reduced with time? A 2-year prospective pilot study. In: Journal of alternative and complementary medicine (New York, NY)*. vol. 20; 2014: 757–763.

53.Hackney M, Earhart G: *Effects of dance on movement control in Parkinson's disease: a comparison of Argentine tango and American ballroom. In: Journal of rehabilitation medicine*. vol. 41; 2009: 475–481.

54.Hackney M, Earhart G: *Short duration, intensive tango dancing for Parkinson disease: an uncontrolled pilot study. In: Complementary therapies in medicine*. vol. 17; 2009: 203–207.

55.Hackney M, Earhart G: *Effects of dance on gait and balance in Parkinson's disease: a comparison of partnered and nonpartnered dance movement. In: Neurorehabilitation and neural repair*. vol. 24; 2010: 384–392.

56.Hackney M, Kantorovich S, Levin R, Earhart G: *Effects of tango on functional mobility in Parkinson's disease: a preliminary study. In: Journal of neurologic physical therapy: JNPT*. vol. 31; 2007: 173–179.

57.McKay JL, Ting LH, Hackney ME: *Balance, Body Motion, and Muscle Activity After High-Volume Short-Term Dance-Based Rehabilitation in Persons With Parkinson Disease: A Pilot Study. Journal of Neurologic Physical Therapy* 2016, 40(4):257–268.

58. McNeely ME, Mai MM, Duncan RP, Earhart GM: *Differential effects of tango versus dance for PD in Parkinson disease. Frontiers in Aging Neuroscience* 2015, 7(DEC).
59. Rios Romenets S, Anang J, Fereshtehnejad SM, Pelletier A, Postuma R: *Tango for treatment of motor and non-motor manifestations in Parkinson's disease: A randomized control study. Complementary Therapies in Medicine* 2015, 23(2):175–184.
60. Ventura MI, Barnes DE, Ross JM, Lanni KE, Sigvardt KA, Disbrow EA: *A pilot study to evaluate multi-dimensional effects of dance for people with Parkinson's disease. Contemporary Clinical Trials* 2016, 51:50–55.
61. Volpe D, Signorini M, Marchetto A, Lynch T, Morris ME: *A comparison of Irish set dancing and exercises for people with Parkinson's disease: a phase II feasibility study. BMC Geriatr* 2013, 13:54.
62. de Natale ER, Paulus KS, Aiello E, Sanna B, Manca A, Sotgiu G, Leali PT, Deriu F: *Dance therapy improves motor and cognitive functions in patients with Parkinson's disease. NeuroRehabilitation* 2017, 40(1):141–144.
63. Shanahan J, Morris ME, Bhriain ON, Volpe D, Lynch T, Clifford AM: *Dancing for Parkinson's: a randomized trial of Irish set dancing compared to usual care. Arch Phys Med Rehabil* 2017.
64. Shanahan J, Morris ME, Bhriain ON, Volpe D, Richardson M, Clifford AM: *Is Irish set dancing feasible for people with Parkinson's disease in Ireland? Complementary therapies in clinical practice* 2015, 21(1):47–51.
65. Westbrook BK, McKibben H: *Dance/movement therapy with groups of outpatients with Parkinson's disease. American Journal of Dance Therapy* 1989, 11(1):27–38.
66. Hass CJ, Bishop M, Moscovich M, Stegemöller EL, Skinner J, Malaty IA, Shukla AW, McFarland N, Okun MS: *Defining the clinically meaningful difference in gait speed in persons with Parkinson disease. Journal of Neurologic Physical Therapy* 2014, 38(4):233–238.
67. Schrag A, Sampaio C, Counsell N, Poewe W: *Minimal clinically important change on the unified Parkinson's disease rating scale. Movement Disorders* 2006, 21(8):1200–1207.
68. Huang S-L, Hsieh C-L, Wu R-M, Tai C-H, Lin C-H, Lu W-S: *Minimal detectable change of the timed "up & go" test and the dynamic gait index in people with Parkinson disease. Physical Therapy* 2011, 91(1):114–121.
69. Batson G, Migliarese SJ, Soriano C, Burdette JH, Laurienti PJ: *Effects of improvisational dance on balance in Parkinson's disease: A two-phase fMRI case study. Physical & Occupational Therapy in Geriatrics* 2014, 32(3):188–197.
70. Menant JC, Perry SD, Steele JR, Menz HB, Munro BJ, Lord SR: *Effects of shoe characteristics on dynamic stability when walking on even and uneven surfaces in young and older people. Archives of physical medicine and rehabilitation* 2008, 89(10):1970–1976.
71. Lamont RM, Morris ME, Woollacott MH, Brauer SG: *Community walking in people with Parkinson's disease. Parkinson's Disease* 2012, 2012.
72. Beauchet O, Dubost V, Herrmann FR, Kressig RW: *Stride-to-stride variability while backward counting among healthy young adults. Journal of Neuroengineering and Rehabilitation* 2005, 2(1):26.
73. Baker K, Rochester L, Nieuwboer A: *The immediate effect of attentional, auditory, and a combined cue strategy on gait during single and dual tasks in Parkinson's disease. Archives of Physical Medicine and Rehabilitation* 2007, 88(12):1593–1600.
74. Chuma T, Reza MF, Ikoma K, Mano Y: *Motor learning of hands with auditory cue in patients with Parkinson's disease. Journal of Neural Transmission* 2006, 113(2):175–185.
75. Galletly R, Brauer SG: *Does the type of concurrent task affect preferred and cued gait in people with Parkinson's disease? Australian Journal of Physiotherapy* 2005, 51(3):175–180.
76. Lewis GN, Byblow WD, Walt SE: *Stride length regulation in Parkinson's disease: the use of extrinsic, visual cues. Brain* 2000, 123(10):2077–2090.
77. Rubinstein TC, Giladi N, Hausdorff JM: *The power of cueing to circumvent dopamine deficits: a review of physical therapy treatment of gait disturbances in Parkinson's disease. Movement disorders: official journal of the Movement Disorder Society* 2002, 17(6):1148–1160.
78. Kimura K, Hozumi N: *Investigating the acute effect of an aerobic dance exercise program on neuro-cognitive function in the elderly. Psychology of Sport and Exercise* 2012, 13(5):623–629.

Tables

Table 1: Descriptive statistics and group comparisons of baseline and PD characteristics.

Characteristics	Dance group (n=17)	Control group (n=16)	p-value
<i>Gender, n (%)</i>			
Male	3 (17.6%)	10(62.5%)	0.008
Female	14 (82.4%)	6(37.5%)	
<i>Age (years), M(SD)</i>	65.24 ± 11.88	66.50 ± 7.70	0.721
<i>Education, n (%)</i>			
Primary school	0 (0%)	0 (0%)	0.141
Secondary school	5 (29.4%)	8 (50%)	
Technical college	1 (5.9%)	3 (18.8%)	
University	11 (64.7%)	5 (31.3%)	
<i>Number of falls during previous six months, M(SD)</i>	0.18 ± 0.39	0.13 ± 0.34	0.692
<i>Years since PD diagnosis, M(SD)</i>	3.76 ± 2.88	5.94 ± 3.61	0.064
<i>Levodopa equivalent dose (mg/day)M(SD)</i>	555.57 ± 332.41	715.56 ± 418.38	0.261
<i>MDS-UPDRS, M(SD)</i>	73.82 ± 25.67	58.06 ± 22.72	0.072
<i>MDS-UPDRS motor subscale III, M(SD)</i>	38.71 ± 17.67	30.25 ± 15.64	0.157
<i>Hoehn and Yahr scale, M(SD)</i>	1.65 ± 0.79	1.56 ± 0.81	0.763
<i>Addenbrooke's examination, M(SD)</i>	93.71 ± 3.18	92.69 ± 4.33	0.445

Notes. N = 23, M = mean, SD = standard deviation: Comparisons are performed with either independent samples *t* test or Pearson Chi-Square test whenever appropriate. MDS-UPDRS: Movement Disorder Society: Unified Parkinson's Disease Rating Scale. Bold values are significant (i.e., *p*-value < 0.05)

Table 2: Pre post change score of the spatiotemporal parameters of gait during even surface walking without a secondary task, and with cognitive secondary tasks

Notes. n = 23, ¹ Dance and control group were not significantly different for any measure at baseline, ² Linear Mix Model applied for change scores. Covariates: gender and disease severity. ³ Bold values are significant (*p*-value < 0.05), ⁴Effect sizes (d) calculated using Campbell Collaboration online calculator

Table 3: Pre post change score of the spatiotemporal parameters of gait during uneven surface walking without a secondary task, and with cognitive secondary tasks

Notes. n = 23, ¹ Dance and control group were not significantly different for any measure at baseline, ² Linear Mix Model applied for change scores. Covariates: gender and disease severity. ³ Bold values are significant (*p*-value < 0.05), ⁴Effect sizes (d) calculated using Campbell Collaboration online calculator

Table 4: Calculation of dual task cost for gait variables during verbal fluency task and serial subtraction tasks on even surface and uneven surface

Notes. n = 23, ¹DTC (Dual Task Cost) = [dual-task - single-task]/single-task * 100) ²Change scores are adjusted for gender and disease severity (UPDRS) ³General linear model applied for change scores. Bold values are significant (*p*-value < 0.05). ⁴Effect sizes (d) calculated using Campbell Collaboration online calculator

<i>Gait parameters</i>	<i>Regular walking</i>			<i>Verbal fluency</i>			<i>Serial subtraction</i>		
	<i>Mean change score² [95% CI]</i>			<i>Mean change score² [95% CI]</i>			<i>Mean change score² [95% CI]</i>		
	<i>Dance¹</i> <i>(n=17)</i>	<i>Control¹</i> <i>(n=16)</i>	<i>p-value³</i> <i>Effect size⁴</i>	<i>Dance¹</i> <i>(n=17)</i>	<i>Control¹</i> <i>(n=16)</i>	<i>p-value³</i> <i>Effect size⁴</i>	<i>Dance¹</i> <i>(n=17)</i>	<i>Control¹</i> <i>(n=16)</i>	<i>p-value³</i> <i>Effect size⁴</i>
Gait velocity (ms ⁻¹)	0.150 [0.075, 0.226]	0.013 [-0.056, 0.082]	p = 0.017 <i>d = 0.976</i>	0.140 [0.061, 0.22]	0.015 [-0.056, 0.086]	p = 0.035 <i>d = 0.866</i>	0.146 [0.069, 0.224]	-0.003 [-0.075, 0.068]	p = 0.012 <i>d = 1.033</i>
Cadence (steps/sec.)	0.120 [0.053, 0.188]	0.015 [-0.046, 0.077]	p = 0.039 <i>d = 0.842</i>	0.136 [0.067, 0.207]	0.024 [-0.041, 0.089]	p = 0.034 <i>d = 0.672</i>	0.123 [0.053, 0.193]	0.0001 [-0.064, 0.065]	p = 0.021 <i>d = 0.905</i>
Step length (metres)	0.044 [0.018, 0.070]	0.004 [-0.020, 0.027]	p = 0.040 <i>d = 0.809</i>	0.041 [0.015, 0.068]	0.0001 [-0.024, 0.025]	p = 0.039 <i>d = 0.828</i>	0.048 [0.022, 0.075]	0.001 [-0.024, 0.025]	p = 0.018 <i>d = 0.951</i>
Stride length (metres)	0.088 [0.036, 0.140]	0.008 [-0.039, 0.055]	p = 0.041 <i>d = 0.843</i>	0.083 [0.03, 0.137]	0.006 [-0.043, 0.055]	p = 0.053 <i>d = 0.779</i>	0.097 [0.044, 0.151]	-0.001 [-0.050, 0.048]	p = 0.015 <i>d = 0.992</i>
Stance phase (%)	-0.745 [-1.574, 0.084]	-0.144 [-0.905, 0.618]	p = 0.324 <i>d = 0.387</i>	0.093 [-0.813, 0.999]	0.141 [0.707, 0.989]	p = 0.942 <i>d = 0.029</i>	0.498 [-1.399, 0.403]	0.176 [-0.669, 1.021]	p = 0.311 <i>d = 0.187</i>
Swing phase (%)	0.745 [-0.084, 1.574]	0.144 [-0.618, 0.905]	p = 0.324 <i>d = 0.387</i>	-0.093 [-0.999, 0.813]	-0.141 [-0.989, 0.707]	p = 0.942 <i>d = 0.029</i>	-0.498 [-1.403, 1.399]	-0.176 [-1.021, 0.669]	p = 0.311 <i>d = 0.187</i>
Double support (%)	-1.490 [-3.147, 0.168]	-0.288 [-1.811, 1.235]	p = 0.324 <i>d = 0.387</i>	0.186 [-1.626, 1.997]	0.282 [-1.415, 1.979]	p = 0.942 <i>d = 0.029</i>	0.996 [-2.798, 0.807]	0.352 [-1.338, 2.041]	p = 0.311 <i>d = 0.187</i>
Single support (%)	1.490 [-0.168, 3.147]	0.288 [-1.235, 1.811]	p = 0.324 <i>d = 0.387</i>	-0.186 [-1.997, 1.626]	-0.282 [-1.979, 1.415]	p = 0.942 <i>d = 0.029</i>	-0.996 [-0.807, 2.798]	-0.352 [-2.041, 1.338]	p = 0.311 <i>d = 0.187</i>
Stride time variability	-13.24 [-24.08, -2.40]	-0.34 [-7.11, 6.43]	p = 0.249 <i>d = 0.743</i>	-21.19 [-46.58, 4.21]	-8.13 [-24.22, 7.96]	p = 0.272 <i>d = 0.029</i>	-18.50 [-42.89, 5.89]	-1.04 [-12.75, 10.67]	p = 0.318 <i>d = 0.470</i>

Figures

Gait parameters	Regular walking			Verbal fluency			Serial subtraction		
	Mean change score² [95% CI]			Mean change score² [95% CI]			Mean change score² [95% CI]		
<i>Dance¹</i> (n=17)	<i>Control¹</i> (n=16)	<i>p-value³</i> <i>Effect size⁴</i>	<i>Dance¹</i> (n=17)	<i>Control¹</i> (n=16)	<i>p-value³</i> <i>Effect size⁴</i>	<i>Dance¹</i> (n=17)	<i>Control¹</i> (n=16)	<i>p-value³</i> <i>Effect size⁴</i>	
Gait velocity (ms ⁻¹)	0.130 [0.046,0.214]	0.040 [-0.039,0.12]	p = 0.162 d = 0.570	0.138 [0.054, 0.222]	0.046 [-0.034, 0.126]	p = 0.152 d = 0.583	0.165 [0.081, 0.249]	0.036 [-0.044, 0.116]	p = 0.048 d = 0.817
Cadence (steps/sec.)	0.096 [0.011,0.181]	0.010 [-0.071,0.092]	p = 0.186 d = 0.531	0.152 [0.067, 0.237]	0.042 [-0.040, 0.124]	p = 0.092 d = 0.672	0.170 [0.085, 0.255]	0.022 [-0.060, 0.104]	p = 0.026 d = 0.905
Step length (metres)	0.045 [0.012,0.078]	0.020 [-0.012,0.051]	p = 0.307 d = 0.396	0.046 [0.013, 0.079]	0.011 [-0.021, 0.043]	p = 0.174 d = 0.555	0.069 [0.036, 0.102]	0.019 [-0.013,0.051]	p = 0.051 d = 0.793
Stride length (metres)	0.091 [0.028,0.155]	0.050 [-0.01,0.111]	p = 0.392 d = 0.347	0.092 [0.029, 0.155]	0.027 [-0.034, 0.088]	p = 0.182 d = 0.540	0.132 [0.069, 0.195]	0.038 [-0.023, 0.099]	p = 0.057 d = 0.781
Stance phase (%)	0.843 [-0.372,2.059]	-1.002 [-2.189,0.185]	p = 0.049 d = 0.067	-1.076 [-2.292, 0.139]	-1.194 [-2.397, 0.009]	p = 0.899 d = 0.050	-2.072 [-3.295, -0.848]	-0.925 [-2.128, 0.279]	p = 0.221 d = 0.480
Swing phase (%)	-0.843 [-2.059,0.372]	1.076 [-0.139,2.292]	p = 0.049 d = 0.067	1.076 [-0.139, 2.292]	1.194 [-0.009, 2.397]	p = 0.899 d = 0.050	2.072 [0.848, 3.295]	0.925 [-0.279, 2.128]	p = 0.221 d = 0.480
Double support (%)	1.687 [-0.744,4.118]	-2.003 [-4.377,0.37]	p = 0.049 d = 0.417	-2.152 [-4.584, 0.279]	-2.388 [-4.795, 0.019]	p = 0.899 d = 0.049	-4.143 [-6.590, -1.696]	-1.849 [-4.256, 0.558]	p = 0.221 d = 0.537
Single support (%)	-1.687 [-4.118,0.744]	2.003 [-0.37,4.377]	p = 0.049 d = 0.417	2.152 [-0.279, -0.019]	2.388 [-0.019, 4.795]	p = 0.899 d = 0.049	4.413 [1.696, 6.590]	1.849 [-0.558, 4.256]	p = 0.221 d = 0.537
Stride time variability	-13.47 [-57.95, 31.00]	-7.82 [-25.37, 9373]	p = 0.434 d = 0.085	-53.64 [-105.05, -2.23]	10.99 [-40.96, 62.95]	p = 0.286 d = 0.666	63.19 [-102.82, -23.56]	-12.59 [-47.13, 21.94]	p = 0.399 d = 0.719

<i>Gait parameters</i>	<i>Walking surfaces</i>	<i>Conditions</i>	<i>DTC Pre-test¹</i> <i>Mean (SD) - %</i>		<i>DTC Post-test</i> <i>Mean (SD) - %</i>		<i>Change scores</i> <i>Mean² - %²</i> <i>[95% CI]</i>		<i>p-value³</i>	<i>Effect size⁴</i>
<i>Dance (n=17)</i>	<i>Control (n=16)</i>	<i>Dance (n=17)</i>	<i>Control (n=16)</i>	<i>Dance (n=17)</i>	<i>Control (n=16)</i>					
Gait velocity	Even surface	Serial subtraction	-22.74 (13.96)	-13.43 (10.73)	-20.14 (16.79)	-15.33 (12.04)	2.60 [-16.41, 27.27]	-1.90 [-22.91, 22.40]	0.56	0.37
		Verbal fluency	-20.19 (13.57)	-15.12 (12.26)	-17.73 (17.29)	-15.55 (12.96)	2.45 [-30.55, 18.41]	-0.42 [-23.18, 30.22]	0.33	0.22
	Uneven surface	Serial subtraction	-26.34 (14.97)	-12.36 (7.34)	-17.99 (15.81)	-13.28 (8.07)	8.35 [-13.40, 54.77]	-0.91 [-12.75, 14.32]	0.05	0.68
		Verbal fluency	-20.36 (13.58)	-16.82 (10.56)	-15.14 (15.61)	-16.59 (11.24)	5.22 [-11.65, 34.62]	0.23 [-12.80, 15.87]	0.15	0.51
Stride length	Even surface	Serial subtraction	-13.96 (12.31)	-7.22 (6.00)	-11.94 (10.78)	-8.29 (9.18)	2.01 (-9.26, 23.22)	-1.06 (-17.24, 13.25)	0.92	0.39
		Verbal fluency	-11.68 (10.82)	-8.19 (7.59)	-10.38 (12.20)	-8.89 (8.46)	1.30 (-14.75, 17.57)	-0.70 (-19.01, 18.76)	0.42	0.24
	Uneven surface	Serial subtraction	-13.83 (13.56)	-5.50 (6.64)	13.83 (13.56)	-5.50 (6.64)	4.03 (-19.14, 27.60)	-1.64 (-10.02, 15.13)	0.05	0.44
		Verbal fluency	-9.83 (11.33)	-8.94 (7.06)	-8.69 (11.19)	-10.87 (7.95)	1.14 (-7.96, 10.69)	-1.93 (11.78, 12.32)	0.16	0.57
Double support %	Even surface	Serial subtraction	14.37 (14.14)	10.16 (12.05)	18.27 (13.89)	12.68 (7.80)	3.91 [-41.19, 29.24]	2.52 [-8.63, 26.35]	0.94	0.09
		Verbal fluency	11.61 (11.78)	11.35 (12.45)	19.95 (18.49)	13.48 (12.17)	8.33 [-23.95, 40.55]	2.49 [-17.96, 24.12]	0.31	0.41
	Uneven surface	Serial subtraction	24.10 (23.36)	6.71 (10.75)	4.01 (20.27)	8.42 (19.18)	-20.09 [-57.78, 24.83]	1.70 [-38.20, 43.35]	0.01	0.98
		Verbal fluency	18.85 (19.76)	13.83 (15.24)	5.43 (16.86)	12.40 (18.10)	-13.41 [-70.76, 18.29]	-1.43 [-65.73, 23.26]	0.25	0.55

Figure 1: Consort diagram of participant recruitment, group allocation and tracking over the course of the study

Figure 1

Consort diagram of participant recruitment, group allocation and tracking over the course of the study

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Supplementarymaterial.docx](#)