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The Effects of Adapted Tango on Spatial Cognition and Disease Severity in Parkinson's Disease

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Abstract

This study determined effects of community-based adapted tango upon spatial cognition and disease severity in Parkinson's disease (PD) while controlling for the effects of social interaction. Thirty-three individuals with mild-moderate PD (stage I–III) were assigned to twenty, 90-minute Tango (n=24) or Education (n=9) lessons over 12 weeks. Disease severity, spatial cognition, balance, and fall incidence were evaluated pre-, post-, and 10–12 weeks post-intervention. T-tests and ANOVAs evaluated differences. Twenty-three Tango and 8 Education participants finished. Tango participants improved on disease severity ($p=0.008$), and spatial cognition ($p=0.021$) compared to Education participants. Tango participants also improved in balance ($p=0.038$), and executive function ($p=0.012$). Gains were maintained 10–12 weeks post-intervention. Multimodal exercise with structured syllabi may improve disease severity and spatial cognition.

Keywords

dance; spatial cognition; balance; Parkinson's disease; exercise

Introduction

The costs of Parkinson's disease (PD) are formidable (more than \$34 billion/year) and increasing (Noyes, Liu, Li, Holloway, & Dick, 2006). Difficulty turning and dual-tasking, postural instability, and gait impairment rob individuals with PD of their quality of life (QOL) (Muslimovic, Post, Speelman, Schmand, & de Haan, 2008). Individuals with PD also commonly experience cognitive impairment in domains of spatial cognition (Possin, Filoteo, Song, & Salmon, 2008), and executive function (Hausdorff et al., 2006), which further affects mobility, increasing fall risk (Camicioli & Majumdar, 2010). PD impairment-targeted exercise programs may improve motor function (Kadivar, Corcos, Foto, & Hondzinski, 2011), reduce fall rates (Protas et al., 2005) and improve cognition (Cruise et al., 2011).

A program of Argentine tango dance (adapted tango), adapted for PD motor impairments, has improved balance, gait, and QOL, in comparison to other ballroom dances, non-

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partnered dancing and PD-tailored exercise programs (Hackney & Earhart, 2009b, 2010a; Hackney, Kantorovich, & Earhart, 2007; Hackney, Kantorovich, Levin, & Earhart, 2007). However, adapted tango's effects upon spatial cognition, which is the knowledge involving interrelationships of people, objects and space (Devlin, 2001), have not previously been examined.

Because spatial cognition is supported by brain structures particularly vulnerable to normal cerebral aging, (Klencklen, Despres, & Dufour, 2012) it is especially vulnerable to the neurodegenerative processes occurring in PD (Possin, 2010). Spatial cognition is critical for forming cognitive maps of spatial relationships used in the successful navigation of dynamic environments, and therefore underlies mobility and orientation (Klencklen et al., 2012). Thus, unique therapies tailored to enhance spatial function in individuals with PD are necessary. Tango dancing involves consistent attention to spatial relationships of posture, step patterns, the partner, and the path traveled within the room. Tango might offer a cogent opportunity for learning coordinate relationships between people, places and objects, which is crucial for encoding spatial information in memory. Potentially, tango could aid spatial cognition in those with PD because the dance requires participants to learn, store in memory, recall, use, and be cognizant of spatial postures, relationships, patterns, and paths.

Little research has investigated effects of non-pharmacologic therapies for enhancing cognition in those with PD (Hindle, Petrelli, Clare, & Kalbe, 2013). Tanaka and colleagues demonstrated an improvement on executive function in PD as a result of 180 minutes per week of multimodal (primarily aerobic) training (Tanaka et al., 2009), —a dose which also meets recommendations that older adults exceed 150 minutes of weekly exercise (Chodzko-Zajko et al., 2009). Here we implemented this 180-minute dose in the form of twenty, 90-minute biweekly sessions of adapted tango for individuals with PD. This dose, not examined in prior studies of adapted tango, was designed to increase learning time for individuals with PD to overcome well-documented motor learning challenges (Stephan, Meier, Zaugg, & Kaelin-Lang, 2011), which many participants have claimed to face in previous studies (Hackney & Earhart, 2010b). Additionally, given the retained yet slowed ability to learn experienced by those with PD (Nieuwboer, Rochester, Muncks, & Swinnen, 2009), the increased learning time may be particularly important to the encoding, storage, and recall processes related to learning spatial relationships. To be able to rule out the effects of social engagement and group learning as responsible for changes in cognition, mobility and disease severity, we assigned participants to either an interactive health education lecture series (Education) control group or adapted tango (Tango).

This study aimed to examine the effects of Adapted Tango on spatial cognition as well as disease severity in individuals with PD while controlling for social interaction. Primary end points were spatial cognition, executive function, disease severity, and everyday fall incidence, mobility and QOL. We also examined gain retention 10–12 weeks post for the first time. We hypothesized that if improvement in spatial cognition is related to the learning, storage and recall of paths, body postures, steps and spatial relationships, then those in adapted tango would improve more than those in Education in spatial cognition. We also expected that the Tango group would improve more than Education on disease severity and fall incidence, mobility and QOL, with retention of gains at 10–12 weeks post.

Methods

The Institutional Review Board at Emory University School of Medicine approved this work. Participants provided written informed consent before participating. Figure 1 describes participation throughout the trial.

Participants

Participants were recruited through flyers, referral, PD newsletters, support groups, and websites. Thirty-four participants with a diagnosis of idiopathic “definite PD” (Racette, Rundle, Parsian, & Perlmuter, 1999), and who had demonstrated benefit from anti-parkinsonian medication were recruited. Participants (Hoehn and Yahr (H&Y) stages I–III) had no history of other neurological insult, were 50 years or older, and could walk 3+ meters with or without assistance. Four Education and six Tango participants reported habitual use of an assistive device such as a cane or walker. At the first visit, to characterize participants, they underwent measures of disease severity, depression, the ability to perform ADLs, cognitive impairment, and fall risk with standardized measures: the Unified Parkinson’s Disease Rating Scale motor subscale III (UPDRS-III) (Fahn & Elton, 1987), Beck Depression Inventory-II (BDI-II) (Beck, Steer, Ball, & Ranieri, 1996; Silberman et al., 2006), Composite Physical Function Index (CPF) (Rikli & Jones, 2001), Montreal Cognitive Assessment (MoCA) (Chou et al., 2010), and Berg Balance Scale (BBS) (Berg, Wood-Dauphinee, & Williams, 1995) (Table 1).

Outcome Measures

Participants underwent 3 evaluations: within 1 week before (pre-test), 1 week after (post-test) and 10–12 weeks after (follow-up) Education or Tango classes. Participants were tested “ON” medications at a participant-preferred time of day to reduce medication-related performance fluctuations. Trained raters administered measures according to standard procedures. All assessments were videotaped for blinded ratings by third year doctorate of physical therapy students and a medical student. During the study (6 months total), participants were instructed not to change habitual exercise routines and were provided with an event calendar to record adverse events, including any event that could be considered a “fall”, i.e., a slip or trip, in which they unexpectedly lost their balance and landed on the ground or a lower level. Every two weeks, staff reminded participants to use their calendars. At post and follow-up evaluations, investigators reviewed calendars and questioned participants about medical/exercise changes and any reported adverse events.

Primary Endpoints

Cognitive measures included: 1) the MoCA (Chou et al., 2010)—an assessment of global cognition/executive function, 2) the Reverse Corsi Blocks (Kessels, van den Berg, Ruis, & Brands, 2008)—a visuospatial memory assessment, and 3) the Brooks Spatial Task (Brooks) (Brooks, 1967)—a spatial cognition task using mental imagery. The Brooks task required participants to remember the placement of numbers on a verbally-described 4×4 matrix, i.e., participants were asked to visualize the numbers in their mind and then repeat the location of the numbers to the rater. Participants began with a span of three instructions (the placement of 3 numbers) and progressed up to 8 instructions (8 numbers). All levels were completed regardless of performance on preceding levels. The percentages correct (out of 50 items) were considered for analyses. Because the Brooks has been rarely used previously in individuals with PD, correlations were conducted, which demonstrated validity between Brooks and the MoCA ($r=0.72$) and Corsi Blocks ($r=0.61$). The Brooks is stable over a one month period in those with PD ($n=7$, $ICC=0.721$, $p=0.015$, unpublished data).

Standard measures of disease severity, mobility, and balance included: UPDRS-III (Fahn & Elton, 1987), Fullerton Advanced Balance Scale (FAB) (Hernandez & Rose, 2008; Klein, Fiedler, & Rose, 2011; Rose, Lucchese, & Wiersma, 2006), Four-Square Step Test (Dite & Temple, 2002), Single/Dual timed up and go (Shumway-Cook, Brauer, & Woollacott, 2000) with single task (TUG), dual-cognitive (Cognitive-TUG: counting backward by 3s from a randomly generated number between 20 and 100) and dual-manual (Manual-TUG: carrying full cup of water) conditions and everyday fall incidence outside of class. Because the BBS

is prone to ceiling effects in higher functioning community dwelling older adults (Pardasany et al., 2012) and screening this sample with the BBS revealed these participants were relatively high functioning in balance, the more challenging FAB was used to increase sensitivity to detect changes in higher functioning individuals. Because the FAB has rarely been used in individuals with PD, correlations were conducted between the BBS and the FAB, which demonstrated validity ($r=0.78$).

Psychosocial questionnaires included: PD Questionnaire-39 (Peto, Jenkinson, Fitzpatrick, & Greenhall, 1995), Freezing of Gait Questionnaire (FOGQ) (Giladi et al., 2000), and Short Form health survey-12 (SF-12) including the Physical (PCS) and Mental Composite (MCS) scales (Ware, Kosinski, & Keller, 1996). Using the FOGQ, participants were classified as freezers if they scored > 1 on item 3 (Giladi et al., 2000), indicating freezing of more than once per week (Nieuwboer et al., 2007).

Secondary Endpoints

Secondary endpoints included adverse events during class and participant attrition, which were tracked by a trained medical student. To assess participant satisfaction, an exit questionnaire, cited previously (Hackney & Earhart, 2009a, 2010a; Hackney, Hall, Echt, & Wolf, 2013) was administered at post-testing only.

Intervention

Participants were assigned to twenty, 90-minute lessons in Tango or Education that took place at two senior independent living communities. Participants were not allowed to attend more than 20 classes and were instructed not to participate in Tango or Education seminars between the conclusion of their 20 lessons and their 10–12 week follow-up visit. Additionally, for safety purposes and to control Tango dose, Tango participants were instructed throughout the study not to practice Tango outside of class at their home or other location. Due to scheduling and physical constraints of the senior community living centers hosting the programs, Education started one week earlier than Tango and was limited in its enrollment as the available space could comfortably accommodate at most 10 individuals with PD. Therefore, recruitment occurred as such: participants were recruited and assigned sequentially first to Education and then to Tango. Class instructors and moderators for both Tango and Education were not involved in participant recruitment, screening, assessment, or class-assignment.

Tango

Nine dance instructors without clinical qualifications participated in a 12-hour workshop on adapted tango methods, PD-specific motor impairments, and fall prevention, followed by an additional 3 hours of individual training from the senior author. Teachers were given an adapted tango manual, prepared for this study from former work about a 20h program (Hackney & Earhart, 2010b) as well as a 30h program (Hackney, Hall, Echt, & Wolf, 2011; Hackney et al., 2013). The manual delineates: PD motor impairments, fall risk and prevention, partnering enhancement and rhythmic entrainment, and a 20-class syllabus and format (Hackney et al., 2011, 2013). Teacher-trainees had 2–25 years of experience teaching dance and >1 year working with older adults in a fitness/dance setting. Based upon their demonstrated proficiency with safety concepts and adapted tango methods, four teacher-trainees were selected to teach Tango.

Tango classes strictly followed the manual's syllabus (Hackney & Earhart, 2010b; Hackney et al., 2011, 2013), which presents step-progression on a specific timeline. Classes began with practice of previously learned steps and a 20-minute standing warm-up followed by partnering and rhythmic enhancement exercises. Next, novel step elements were introduced

and amalgamated to previously learned steps. Everyone lead and followed all step patterns with multiple partners. Participants with PD always danced with individuals *without* PD: caregivers, friends, and relatives as well as several graduate and undergraduate student volunteers.

Volunteers received training in human research, falls detection/prevention, and adapted tango methods. Volunteers were initially partnered with individuals at low fall risk (as per their BBS score (greater than 46 points) and Hoehn and Yahr staging (2 or better)), and observed for proficiency before partnering individuals at higher fall risk. In efforts to maximize safety through appropriate pairings, investigators identified participants at high fall risk to the teachers prior to the first class. The senior author and a trained medical student monitored adherence to the syllabus on a near-daily basis. Adverse events during class, and participant attrition were tracked through records corroborated by adapted tango teachers and the medical student.

Education

Highly diverse health-related topics were delivered in a seminar designed to encourage extensive interaction and socialization. In 90-minute sessions, medical students and professors from local universities delivered one hour of lecture/discussion followed by one half hour of partnered and group learning through structured activities, question and answers, and further discussion. These seminars, on physical, mental and social wellbeing as well as contemporary scientific advances, included some PD-related information, and were moderated by a graduate student and several undergraduate students. Adverse events and participant attrition were tracked through careful records maintained by the moderators.

Statistical Analysis

Descriptive statistics were calculated. Independent samples t-tests compared groups. Fisher's exact test compared groups for categorical variables. The last data point was carried forward for all participants who did not complete all evaluations, including those who had only baseline measures. Outcome measures were compared with 2×3 repeated measures (RM) analyses of variance (ANOVAs) with two groups (Education and Tango) as the between factor and three time-points (pre, post, and follow-up) as the within factor. RM multivariate ANOVAs were used for psychosocial measures. Pairwise comparisons examined changes within groups over time, when main effects were detected. Because the study was underpowered to determine all main effects, some planned comparisons within groups were conducted on main effects of time. To determine validity of novel measures, Pearson correlations were calculated between: FAB and BBS and between the Brooks task and both MoCA and Corsi. The significance level was $\alpha=0.05$; however, in order to control the rate of incorrectly rejected null hypotheses, the False Discovery Rate (FDR) method was used in a procedure that corrected for multiple comparisons. Given 14 outcome measures, the new significance level for the ANOVAs was set at $p<0.027$. For post-hoc tests examining within-group changes from pre to post and from post to follow-up, the FDR correction was $p<0.038$, given the two tests performed. Analyses were performed using SPSS (version 19).

Results

Thirty-three participants enrolled (Tango, $n=24$; Education, $n=9$). Twenty-three Tango and 8 Education participants completed 20 lessons. Figure 1 describes participation throughout the trial. There were no significant differences between groups related to measures of PD (duration of PD, UPDRS, H&Y Staging, freezing status), but Education was slightly older than Tango (Table 1), therefore age was used as a covariate in analyses. These participants

experienced mild-moderate PD, had completed post-secondary education, experienced minimal to mild depression, were mildly afraid of falling, had generally high quality of life and were relatively high functioning in completing ADLs. Table 2 lists performance on motor, cognitive and psychosocial measures for both groups.

Cognition—There was a group x time interaction on the Brooks ($F(2,60)=4.131, p=0.021, \eta_p^2=0.121$) (Figure 2A). Tango improved ($F(2,22)=5.457, p=0.012$), between pre and post ($p=0.017$), and maintained at follow-up ($p=0.484$); whereas Education did not ($F(2,7)=0.620, p=0.565$). There was a main effect of time in the MoCA ($F(2,62)=4.753, p=0.012, \eta_p^2=0.133$), but no group x time interaction (Figure 2B). There was a trend toward an effect of time on Corsi Blocks ($F(2,62)=2.874, p=0.064, \eta_p^2=0.085$), but no group x time interaction (Figure 2C).

Disease Severity and Motor—There was a group x time interaction on the UPDRS-III ($F(2,60)=5.297, p=0.008, \eta_p^2=0.148$) (Figure 2D). Tango improved ($F(2,22)=4.919, p=0.017$) between pre and post ($p=0.017$) and maintained at follow-up ($p=0.364$); whereas Education showed a trend towards increased disease severity over time ($F(2,7)=4.249, p=0.062$). There was a main effect of time on the FAB ($F(2,56)=3.463, p=0.038, \eta_p^2=0.120$). Planned comparisons revealed Tango improved on the FAB from pre to post ($p=0.004$) and maintained gains at follow-up ($p=0.195$); whereas Education did not ($p=0.265$) (Table 2). There was a main effect of time on the Four Square Step Test ($F(2,56)=4.438, p=0.031, \eta_p^2=0.137$). Planned comparisons revealed no significant changes in either group as a result of time (Tango: $p=0.196$, Education: ($p=0.134$). There were no main effects of time on the TUG, ($F(2,58)=0.750, p=0.477, \eta_p^2=0.025$), Cognitive-TUG ($F(2,58)=1.145, p=0.325, \eta_p^2=0.038$) or Manual-TUG ($F(2,58)=1.937, p=0.164, \eta_p^2=0.063$). There were no main effects of time or group on Correct Response Rate of the counting backwards by 3s task during the Cognitive-TUG ($p>0.05$). (Table 2)

Psychosocial—On the PDQ39-SI, FOG, PCS and MCS, there were no main effects ($F(8,112)=0.662; p=0.724, \eta_p^2=0.045$) (Table 2).

Everyday Falls—In this sample, 47 falls were reported in the year before the study, 14 falls occurred outside of class time during the 3 months interventional period, and 28 falls during the 10–12 weeks before the follow-up evaluation. The number of fallers versus non-fallers was not significantly different between groups. Tango was 1.42 times (CI 0.02–111.5, $\phi=0.066, p=0.724$) more likely than Education to experience decreased or no change in fall incidence during the follow-up period compared to the year before the program. Among participants who improved balance, 66% of Tango and 50% of Education experienced decreased or no change in fall incidence.

Secondary Endpoints

Safety: Fall Incidence within Class—Two non-injurious falls—involving two self-reported frequent fallers—occurred out of 48 offered tango classes. After each incident the involved participant was eager to resume dancing in the same class session, after 10–15 minutes mandated rest. Root cause analysis determined reasons for falls that occurred and systematic changes were implemented to prevent future events. No falls occurred during Education classes.

Attrition/Participant Satisfaction—Attrition rates were 11% for Education and 0% for Tango. The Exit Questionnaire showed both groups strongly agreed they enjoyed the program. Tango strongly agreed they would continue and noted balance, walking, mood, coordination, strength, and endurance improvements. Both groups agreed they were more

physically and mentally active. There were no statistically significant differences between groups.

Discussion

Twenty-three individuals with mild-moderate PD participated in 30 hours of adapted tango and improved in spatial cognition and disease severity in comparison to an Education control group. Improvements in disease severity and mobility were comparable to prior studies (Duncan & Earhart, 2012; Hackney & Earhart, 2009a, 2009b, 2010a). Here, with an Education control, we have demonstrated that partnered, social interaction and group learning are improbably responsible for gains. Importantly, evaluations at 10–12 weeks post, a previously uninvestigated interval, demonstrated gain-retention. Despite 50% higher dosage compared to former work, participant satisfaction for Education and Tango was high (Figure 2) and attrition was low.

Tango's improvement and retention of gains on the Brooks spatial test, may suggest that Tango enhances cognition. While social interaction and group learning can play an important role in gains from rehabilitation (Glass, de Leon, Marottoli, & Berkman, 1999), the significant improvement in Tango compared to Education, another highly interactive and social group activity, suggests motor training inherent to adapted tango could underlie observed changes. This study's design does not permit the demonstration that elements unique to Tango were responsible for gains observed in spatial or other cognitive domains. The possibility exists that cognitive gains noted in Tango occurred because aerobic exercise has beneficial effects upon cognition (Kraft, 2012; Ratey & Loehr, 2011). Tango could be considered light-moderate exercise because participants are stepping at 60–120 beats/minute (typical tempi of tango music) and expending at least 3 Metabolic Equivalent of Task (METs) per minute during typical tango dancing (Heyward, 2010). Further, the novel dose—30 hours over 10–12 weeks—may have affected cognitive and motor function merely because participants exceeded weekly exercise dosage recommendations for deconditioned older adults with chronic illness (Chodzko-Zajko et al., 2009). However, prior work has demonstrated Tango's improvement upon PD mobility and QOL versus other partnered dances' steps and structure (Hackney & Earhart, 2009a), non-partnered dance (Hackney & Earhart, 2010a) and generalized exercise (Hackney, Kantorovich, Levin, et al., 2007), while here partnered/social learning and interaction have been shown to be improbably responsible for gains. Thus, adapted tango elements, including structured motor components that engage memory of steps and directions whilst encouraging keen awareness of spatial relationships, could have contributed through some currently undetermined mechanism, to gains in cognition. Further study into application of therapies like adapted tango for improving cognition is warranted and definitely needed (Hindle et al., 2013) given the prevalence of mild cognitive impairment in PD, which affects the spectrum of mental function.

Through the Exit questionnaire, the program satisfaction instrument, both Education and Tango reported high satisfaction with classes, and indicated spheres related to QOL were enhanced. However, no significant changes were observed in psychosocial function in either group, potentially because, similar to motor domains, the sample demonstrated high baseline psychosocial functioning. Both groups began and remained in the average range for healthy individuals *without* PD on measures of physical (SF-12 PCS) and mental (SF-12 MCS) well-being (Ware et al., 1996). This sample's global QOL (PDQ39-SI) was also substantially better than that typically noted in individuals with mild-to-moderate PD (Damiano et al., 2000).

Within Tango, we observed little change in fall incidence outside class. However, other exercise studies for those with PD (Allen, Sherrington, Paul, & Canning, 2011; Goodwin et

al., 2011; Tomlinson et al., 2012) and older adults (Faber, Bosscher, Chin, & van Wieringen, 2006; Nowalk, Prendergast, Bayles, D'Amico, & Colvin, 2001; Rosendahl, Gustafson, Nordin, Lundin-Olsson, & Nyberg, 2008; Wolf et al., 2003) have also reported little or no change in fall incidence. Nevertheless, similar to findings from institution-based studies (Duncan & Earhart, 2012; Hackney & Earhart, 2009b; Hackney, Kantorovich, Levin, et al., 2007), a minimal clinically important difference (CID) (between 2.3 and 2.7 points) (Shulman et al., 2010) in disease severity was noted on the motor subscale of the UPDRS for Tango (maintained at follow-up). While this change was small, it may impact the ability of an individual with PD to perform functional activities. Furthermore, the CID for the UPDRS has been used to evaluate drug therapy and weigh the risks and benefits of an intervention. The low side-effect profile of adapted tango compared with many of the drugs noted to have achieved a CID could be a compelling reason for clinicians to "prescribe" adapted tango therapy for individuals with PD. Finally, Tango demonstrated balance improvement on the FAB—also noted in individuals with PD who participated in modern dance (Batson, 2010). Although clinical significance of FAB changes cannot currently be determined, the FAB scale allowed greater sensitivity to detect balance changes in higher functioning participants, who would have reached a ceiling with the BBS—on which improvements were previously noted (Hackney & Earhart, 2009a, 2010a; Hackney, Kantorovich, Levin, et al., 2007). The participant makeup of this study highlights the fact that therapies targeting higher functioning individuals in earlier stages of PD are imperative (Hirsch, 2009). While gains in balance and correspondingly, fall risk, are encouraging, further research to improve exercise programming to decrease fall incidence is needed.

It must be emphasized that fall occurrence *within* exercise classes for individuals with PD is a real possibility (Li et al., 2012) and therefore, must be anticipated. In this study, though 2 falls occurred during Tango, no injuries resulted and participants continued therapy. The results and risks observed in this study are generalizable only for the specific PD population characterized (in Table 1) and studied here. While other populations may benefit from Tango as well, the PD population identified here is appropriate for and may benefit from the adapted tango intervention.

Limitations

The study was limited by small sample size, particularly in Education. A slight age difference between those in Education and Tango may have impacted outcomes; however, age was co-varied, and the groups were well matched on disease severity, duration with and stage of PD, factors which likely affect motor and cognitive function more. Also, participants' knowledge of their class assignment and any potential bias towards one treatment or another may have impacted performance on outcome measures. A major limitation is that some raters were not blinded to class assignment at post-testing. The two treatments took place at two comparable, but nevertheless different community living centers because of scheduling and space constraints. Education began one week earlier than Tango and spaces in the Education program were filled before those in Tango. These personnel, location and scheduling differences may have affected treatment effectiveness and enthusiasm, in currently unknown ways. Further, this study's findings can only be generalized to outcome performance while participants are ON medications. Future studies must evaluate the effects of adapted tango while participants are OFF medications. Some evidence implies that those with Right-side versus Left-side dominant disease are differentially affected by impairments of specific cognitive domains, (Verreyt, Nys, Santens, & Vingerhoets, 2011) which suggests that further research with respect to side of disease onset and treatment outcomes is necessary. This study's outcomes should be considered in light of hypothesis testing and effect size generation, for adequately powering future, larger

studies that will more definitively determine the effects adapted tango may have on cognition, as well as mobility.

Conclusions

Currently, few therapies have been indicated to specifically target and benefit aspects of cognition in those with PD (Hindle et al., 2013). Here, findings of enhanced cognition with retention of gains at 10–12 weeks post in those who participated in tango are therefore, encouraging. Further, because exercise may serve as a disease modifying intervention (Ahlskog, 2011), potentially preventive therapies like adapted tango should be promoted in higher-functioning individuals, perhaps even slowing disease progression, as noted here. Although traditional exercise programs suffer more than 30% attrition (Jancey et al., 2007), successful models for PD exercise programs now exist (Corcos et al., 2013). When examined in future, larger randomized controlled trials, the adapted tango program, with already encouraging compliance rates, could benefit from methodology employed in these successful PD exercise programs. Adapted tango with high retention and demonstrated efficacy should be pursued as a potential means for improving PD motor and cognitive impairments and possibly slowing disease progression.

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Figure 1.
Consort Diagram of Participation.

Figure 2.

Between-Group Differences in Measures of Cognition and Disease Severity. Values plotted are means $\pm$ standard deviations at pre, post, and follow-up. Values for Education are shown in grey with dashed and capped error bars, and values for Tango are shown in black with black and capped error bars. *Denotes a significant group by time interaction, $p < 0.05$. (A) Brooks Spatial Task Percentage Correct*. (B) Montreal Cognitive Assessment. (C) Reverse Corsi Blocks span. (D) Unified Parkinson's Disease Rating Scale-Motor Subscale III*.

Table 1**Baseline Participant Demographics & Characteristics**

	Lecture Series n=9	Tango n=24	<i>p</i> ^a
Sex	1 F; 8 M	12 F; 12 M	0.056*
UPDRS Motor Subscale-III	27.2 (7.0)	28.1 (6.9)	0.747
Hoehn & Yahr Stage (<i>Median (1st, 3rd Quartiles)</i>)	2.0 (2.0, 2.0)	2.3 (2.0, 2.6)	0.438
Age (years)	74.4 (6.5)	68.4 (7.5)	0.041
Duration of PD (years)	7.2 (4.9)	7.0 (5.5)	0.900
Education (years)	16.4 (1.3)	16.5 (2.1)	0.941
Freezer (#yes/#no)	3/6	8/16	1.000*
Number of Comorbidities	3.1 (1.2)	3.3 (1.7)	0.775
Number of Prescription Medications	7.8 (6.6)	5.4 (4.5)	0.343 [^]
Use of Assistive Device (#yes/#no)	4/5	6/18	0.3999*
Hx of 1 falls in Past Year (#yes/#no)	5/4	15/9	1.000*
Fear of Falling [§]	3.1 (1.4)	3.0 (1.5)	0.907
Quality of Life [§]	5.1 (1.1)	5.2 (0.9)	0.752
Beck Depression Inventory-II (/63)	12.1 (9.6)	12.1 (5.5)	0.992
Composite Physical Function (/24)	20.2 (4.7)	20.3 (4.9)	0.971
Montreal Cognitive Assessment (/30)	26.0 (2.8)	24.9 (3.3)	0.384
Berg Balance Scale (/56)	48.1 (13.2)	51.1 (4.6)	0.325

Unless otherwise noted, values are given in means and standard deviations (*M (SD)*). Abbreviations: PD, Parkinson's Disease; UPDRS, Unified Parkinson's Disease Rating Scale; Hx, History; SD, Standard Deviation.

^aIndependent t-tests compared groups.

* Fishers Exact Test.

[^]Equal variance not assumed.

[§]Rating worry about falling / quality of life from 1 (low) to 7 (high).

Table 2**Motor, Cognitive & Psychosocial Measures**

	Education	Tango
Motor and Disease Severity		
Unified Parkinson's Disease Rating Scale -motor subscale III ^{*a} (/108)		
Pre	27.2 (7.0) [18.5–40.5]	28.1 (6.9) [9.0–41.0]
Post	29.3 (7.5) [19.0–41.0]	24.0 (7.9) [11.0–38.0]
Follow-up	29.5 (6.7) [19.5–41.0]	25.9 (7.5) [7.0–41.0]
Fullerton Advanced Balance Scale (/40)		
Pre	28.6 (3.7) [23.0–34.0]	28.7 (5.2) [21.0–36.0]
Post	29.8 (4.6) [23.0–36.0]	31.3 (4.5) [21.0–38.0]
Follow-up	28.6 (3.2) [23.0–33.0]	30.4 (6.1) [14.0–38.0]
Timed Up and Go Baseline (s)		
Pre	9.5 (1.7) [7.6–12.7]	10.1 (3.1) [6.7–19.3]
Post	10.5 (1.7) [9.0–14.0]	10.3 (3.2) [6.4–19.3]
Follow-up	10.1 (1.4) [8.1–12.8]	10.3 (3.6) [6.2–19.9]
Timed Up and Go Cognitive (s)		
Pre	13.4 (2.4) [10.3–17.6]	14.6 (8.1) [6.9–42.6]
Post	14.7 (3.4) [9.8–19.8]	14.3 (7.4) [7.4–42.6]
Follow-up	12.5 (2.0) [9.1–14.3]	14.4 (8.3) [7.0–42.6]
TUGc Correct Response Rate (correct numbers given/total numbers given/s)		
Pre	0.065 (0.03) [0.054–0.097]	0.081 (0.03) [0.025–0.144]
Post	0.071 (0.02) [0.051–0.102]	0.074 (0.03) [0.031–0.135]
Follow-up	0.076 (0.01) [0.060–0.097]	0.080 (0.04) [0.017–0.143]
Timed Up and Go Manual (s)		
Pre	12.5 (1.5) [10.4–15.0]	12.8 (4.1) [7.5–25.5]
Post	14.2 (2.6) [11.1–19.1]	13.7 (5.1) [7.1–26.8]
Follow-up	13.5 (1.8) [11.6–16.4]	13.3 (4.7) [7.4–25.5]
Four Square [^] (s)		
Pre	12.1 (2.0) [9.1–15.3]	13.2 (5.1) [8.3–28.0]
Post	11.8 (1.7) [8.9–13.7]	13.2 (5.4) [7.9–27.9]
Follow-up	10.1 (1.7) [8.1–11.5]	11.5 (5.8) [6.2–28.9]
Cognitive		
Brooks Spatial Task [*] (% correct)		
Pre	65.3 (12.1) [48.0–86.0]	60.4 (20.4) [4.0–90.0]
Post	65.3 (14.4) [46.0–88.0]	66.8 (21.0) [4.0–96.0]
Follow-up	60.4 (19.3) [36.0–90.0]	68.4 (18.2) [16.0–96.0]
Montreal Cognitive Assessment [^] (/30)		
Pre	26.0 (2.8) [21.0–29.0]	24.9 (3.3) [20.0–30.0]
Post	26.3 (2.3) [22.0–30.0]	26.1 (3.3) [17.0–30.0]
Follow-up	27.4 (2.5) [22.0–30.0]	26.3 (3.9) [16.0–30.0]

	Education	Tango
Corsi span (/9)		
Pre	4.0 (0.7) [3.0–5.0]	4.4 (1.4) [2.0–8.0]
Post	4.4 (0.5) [4.0–5.0]	4.8 (1.4) [3.0–9.0]
Follow-up	4.7 (1.0) [3.0–6.0]	4.5 (1.4) [3.0–8.0]
Psychosocial		
Freezing of Gait ^a (/24)		
Pre	7.1 (6.6) [1.0–20.0]	5.4 (5.1) [0.0–14.0]
Post	5.7 (4.1) [1.0–14.0]	4.7 (4.2) [0.0–14.0]
Follow-up	6.2 (4.7) [1.0–16.0]	5.5 (4.6) [0.0–15.0]
SF-12 Physical Composite Score ^b (/100)		
Pre	41.5 (9.3) [28.2–55.4]	42.2 (11.0) [17.0–58.3]
Post	41.8 (8.8) [30.6–54.3]	40.4 (11.2) [17.0–54.1]
Follow-up	40.8 (11.5) [23.2–57.0]	41.3 (12.6) [9.2–59.9]
SF-12 Mental Composite Score ^b (/100)		
Pre	45.1 (15.2) [16.5–62.1]	50.0 (8.5) [33.0–65.7]
Post	50.4 (11.3) [31.1–64.1]	50.7 (7.3) [34.5–65.7]
Follow-up	50.5 (12.3) [31.1–64.7]	50.0 (9.1) [31.6–68.4]
Parkinson's Disease Questionnaire 39-Summary Index ^a (/100)		
Pre	18.3 (10.0) [8.9–42.2]	19.3 (9.6) [7.6–42.6]
Post	17.7 (10.2) [7.7–38.0]	19.5 (11.1) [2.5–44.0]
Follow-up	19.3 (8.1) [10.7–37.0]	18.7 (9.4) [4.3–40.2]

Values presented as mean (standard deviation) [range].

* Significant group by time interaction, $p < 0.05$

^ Significant main effect of time, $p < 0.05$

^a Lower score indicates less symptomatology.

^b Higher score indicates greater physical / mental well-being.