

# Improved function and geriatric depression scale profile in outpatients with parkinson's disease through the participation in Lee Silverman Voice Therapy BIG<sup>®</sup> program

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## Abstract

**Background:** Studies have shown the Lee Silverman Voice Therapy BIG<sup>®</sup> (LSVT BIG) program has improved the motor symptoms of people with Parkinson's disease (PD). The role of LSVT BIG in enhancing non-motor symptoms of PD like depression requires further study.

**Objective:** To determine if LSVT BIG improves gait, balance, endurance, functional performance, and Geriatric Depression Scale scores in patients with PD upon completion of the LSVTBIG program.

**Methods:** 23 subjects with PD consented to participate in the 4-week intensive LSVT BIG program in an outpatient physical therapy practice. Outcome measures were: the Geriatric Depression Scale (short form, GDS), standard, cognitive and motor versions of Timed Up and Go (TUG), Functional Gait Assessment (FGA), Berg Balance Scale (BBS), and the 6 Minute Walk Test (6MWT). Wilcoxon Signed Rank Tests and paired t-tests and compared pre and post-test values at the  $p < .05$  level.

**Results:** Statistically significant improvements ( $p < .01$ ) in GDS scores, TUG times, FGA scores, BBS scores, and the 6MWT distances and occurred after the LSVT BIG program.

**Conclusions:** LSVT BIG, as a treatment option for individuals with PD, can help improve both motor function and Geriatric Depression Scale values associated with the disease. The immediate effect of LSVT BIG on Geriatric Depression Scale values may indicate an impact on quality of life.

## Introduction

The role of exercise in the treatment of Parkinson's Disease (PD) has become increasingly important in recent years [1-5]. Individuals with PD who exercise gained or maintained function and mobility [4-7], improved cognitive functioning [8], exhibited lower risk for falls [9,10], and improved quality of life [1,11,12]. They also required less assistance from caregivers and had slower rates of cognitive decline than those who exercised less frequently or did not exercise in a 1-year follow-up study [3]. In addition to medication, exercise is now viewed as a primary option in the early stages of PD to potentially slow progression [3]. Programs targeting the major impairments experienced by individuals with Parkinson's Disease have included general exercise training in the form of treadmill training, Tai Chi, and strength training, among others. These appear to have neuroprotective effects [13]. Lee Silverman Voice Therapy<sup>®</sup> (LSVT) has been developed to specifically target the bradykinesia and hypokinesia associated with PD [14]. Named for a benefactor with PD, Lee Silverman Voice Therapy – Loud<sup>®</sup> was the first to demonstrate positive effects of improved healthy vocal loudness and sensory perception of the vocal effort [15].

Lee Silverman Voice Therapy BIG<sup>®</sup> (LSVT BIG) applies principles of motor learning, including multiple repetitions with progressive complexity and intensity, to control appendicular and axial musculature

with the important emphasis on training augmented movement amplitude [14,16]. Tasks that are specifically important to participants are incorporated into the program. LSVT BIG emphasizes cueing strategies for increased active movement size which focus patients' attention to 'big' movements meant to counteract bradykinesia (slow movement) and hypokinesia (low amplitude movement) [14,17-19]. These 'big' movements must be practiced with sufficient repetition and intensity over extended time periods to recalibrate subjects' self-perception of movement amplitude and drive sustainable central nervous system changes [14,17-19]. Individuals with PD present with hypokinetic movements, therefore, it is expected that cues for large amplitude movements will produce movements with the typical amplitude needed for functional tasks. The approach is task and goal-oriented. LSVT-certified therapists apply shaping techniques as they

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progress daily routine exercises and hierarchical tasks for longer durations or larger amplitudes [14,17-19]. The goal of LSVT BIG is to restore the ability of individuals with PD to sense when they are moving in an abnormal way and to self-correct by increasing the amplitude of their movements [14,16,19] with resultant improvements in the speed of movements [19]. The reader is referred to Fox, Ebersbach, Ramig and Sapir [14] for details about the program. During and after the intensive 4-week program (4 1-hour sessions per week), patients are expected to continue their home exercise program. This program design intends to incorporate motor learning principles to improve and sustain overall movement quality in an effort to reverse or prevent motor symptoms that might typically occur as part of the disease process [14,16]. Clinical and laboratory-based research supports the use of LSVT BIG for patients with mild to moderate PD.

Prior studies on LSVT BIG showed improved function [18-20], increased velocity of upper and lower limb movements upon completion of the program [19], and improved motor performance at a 16-week follow-up [18]. The Berlin LSVT BIG study [18] randomized participants into exercise groups: LSVT BIG (n=20), a Nordic Walking program (n=19) and a home exercise program (n=19). Groups were tested for changes in disease severity, walking speed, and the ability to perform activities of daily living (ADL). Only the LSVT BIG intervention group showed a decrease in disease severity, as measured by the motor function section of Unified Parkinson's Disease Rating Scale (UPDRS, section III). The LSVT BIG participants also demonstrated statistically significant improvement in Time-Up-and-Go, when compared to Nordic walking and home exercise, and walking speed [18], when compared to the home exercise program. Other studies indicated that patients with mild PD improved more than patients with moderate disease severity [19], therefore, starting exercise training soon after diagnosis seems warranted. Ueno, *et al.* [21] demonstrated the efficacy of LSVT BIG in a small sample of patients with Hoehn and Yahr Stages II and III.

People with PD may also have impaired kinesthetic feedback that makes it difficult for them to sense themselves moving slowly [22]. Impaired perceptual feedback [23], as well as changes in the basal ganglia, can occur early in disease progression and lead to nonuse of movement. Bradykinesia and hypokinesia may lead to activity and participation limitations for patients with PD. Such limitations would have an impact on patients' quality of life. This non-motor sequela of PD may also be reversed with exercise such as LSVT BIG.

Chaudhuri, Healy and Schapira [24] studied the high prevalence of non-motor symptoms, such as depression, in people with PD. The results showed that non-motor symptoms can have a more dramatic impact on quality of life than motor symptoms [24,25]. Chaudhuri, *et al.* defined quality of life through the patients' responses to the Parkinson's Disease Questionnaire 39 (PDQ39) which includes emotional well-being as a component in quality of life [24]. Other studies which included quality of life, as measured by the PDQ39, failed to show a statistically significant difference in observed improvements when comparing LSVT BIG to other exercise protocols [18] and when comparing a traditional 4-week LSVT BIG program to a 2-week LSVT BIG program [17]. The PDQ39 includes many domains comprising quality of life. Any effect of exercise training on single domains might be obscured by analysis of the composite score. Other studies have examined more specific non-motor issues. Dashtipour, *et al.* found that LSVT BIG had positive effects on a depression measure (Beck Depression Index) and an anxiety measure (Beck Anxiety Index) [26]. However, these positive effects were similar to those of a general

exercise program [26]. Park, *et al.* used a delayed start research design to determine if an intensive group exercise program (1 hour, 3 times/week) for 48 weeks versus one for 24 weeks would impact scores in the Beck Depression Inventory, PDQ39, and functional measures [5]. The 48-week program gave statistically significant improvements in subjects' Beck Depression Inventory scores but not for the PDQ39 or functional measures when compared to the 24-week program [5]. We targeted depression for this study because Dashtipour, *et al.* [26] noted that improvements in Beck Depression Inventory scores were maintained for 6 months after completing both the LSVT BIG training (n=6) and the general exercise training (n=5). The Geriatric Depression Scale Short Form (GDS) [27,28] is a self-report tool with simple Yes/No answers which is easily administered in a clinical setting. We elected to use this scale because it is in the public domain and it contains items relating to activity and participation limitations in the International Classification of Function, Disability and Health model. vanUem, *et al.* reported that depression was one of the body structure and function items associated with PD that correlated strongly with health-related quality of life [25].

Further study of the impact of LSVT BIG on depression appears indicated because depression may impede physical activity of persons with PD. More supporting literature is needed to substantiate the feasibility and efficacy of LSVT BIG training on various aspects of function and gait within a clinical setting. The purpose of our study is to determine if a 4-week LSVT BIG training program for adults with PD in an outpatient setting will change their gait, balance, endurance, functional task performance, and Geriatric Depression Scale scores. Our null hypothesis is that LSVT BIG treatment will have no effect on measures of gait, balance, endurance, functional performance, and GDS scores in patients with PD. To the best of our knowledge, this is the first study to look at the effect of LSVT BIG training on GDS scores in a clinical outpatient setting.

## Materials and methods

Subjects were recruited from a convenience sample of patients referred for physical therapy at Burke Rehabilitation Hospital (BRH) Outpatient Rehabilitation Services (Mamaroneck and White Plains, New York, USA), and were later screened for eligibility by staff physical therapists. Participants were included if they were ambulatory, community-dwelling adults who were newly referred for outpatient physical therapy by a physician and who presented with mild to moderate signs and symptoms related to PD. All participants read and spoke English. The research physical therapists used the following criteria to exclude participants from the study were: cardiac impairments which prohibited 1-hour exercise bouts, musculoskeletal problems that prohibited large amplitude motion of the limbs, other neurological problems that produced significant weakness of limb or trunk musculature, advanced Parkinson's Disease with marked bradykinesia and hypokinesia, and cognitive impairments that would interfere with compliance.

Eligible patients were asked if they would opt for LSVT BIG training and then asked about consent to use their data for the study. In accordance with LSVT BIG recommendations all participants were informed prior to enrollment that they must attend all sessions and commit to completing the home exercise component of the program simultaneously during these four weeks. An institutional policy was to inform participants that treatment would be discontinued if they missed more than two sessions or if they were non-compliant with their home exercise program. Each subject provided written informed consent to

participate in this research project and agreed to the above-mentioned stipulations. Enrollment began on June 1, 2015 and continued through December 31, 2016. The respective Institutional Review Boards at BRH and the Hunter College, City University of New York approved the project in accord with the ethical standards of these committees and institutions.

### Procedures

LSVT BIG treatment sessions were administered in accordance with established LSVT BIG protocols consisting of maximal daily exercises, functional tasks, hierarchical tasks, and ambulation, as led by a physical therapist certified in LSVT BIG during billable physical therapy sessions. Seven maximal daily exercises were completed in each treatment session (Table 1). Functional tasks included single-step daily activities that are uniquely selected for each patient (Table 1). The exercises became progressively more complex over the four weeks of treatment based on each patient's progress. Hierarchical tasks are multi-step activities, such as getting in and out of a car. One or two activities were self-selected by the patient, and the patient performed these tasks during each session. Practice of hierarchical tasks was performed via part-task practice that began in blocked random order and gradually progressed over the four weeks to whole-task practice. Gait training was also performed in each session and was tailored to each person's level of mobility, with the main focus of using BIG movements throughout the gait cycle. Examples of gait training progressions included, but were not limited to: BIG walking that included walking in all directions, walking with head turns, walking with eyes closed, carrying objects while walking, and walking with turning. Patients also had a daily home exercise program to complete throughout the treatment month. This home exercise program was based on the LSVT BIG protocol and was individualized by the physical therapist for each patient. Patients completed it once per day on clinic days and twice per day on non-clinic days. They logged home exercise on a check-off sheet which was periodically checked by the physical therapist to ensure compliance.

Measurements were taken at the initial evaluation and again during the discharge session by physical therapists. The clinical researchers reviewed the study protocols with these therapists. The dependent measures for our study included: the standard, motor and cognitive versions of the Geriatric Depression Scale, Timed Up and Go (TUG) test, Functional Gait Assessment (FGA), Berg Balance Scale (BBS), and the Six-Minute Walk Test (6MWT). These measures were chosen for their ability to measure functional tasks including balance, gait quality, gait distance and gait speed [17]. Aside from the GDS, the measures were in routine use by the LSVT-certified outpatient physical therapists

who decided order of testing. Prior LSVT BIG efficacy studies have used the standard TUG [17,18,20,21], the FGA [20,29], the 6MWT [17], the timed 10-meter walk test [18,21], gait speed [19,29] and the BBS [29] as outcome measures.

The Geriatric Depression Scale is designed as a screening tool; this measure was not being used to diagnose depression in the current study. The GDS is a self-rating questionnaire used to screen for signs of depression [30]. The short form consists of 15 Yes/No questions written to delineate if signs of depression exist. A score greater than 5 on the GDS is suggestive of depression and warrants a follow-up comprehensive assessment. A score on the GDS of greater than or equal to a 10 is almost always indicative of depression [27]. Ertan, *et al.* looked at 109 patients with PD: 48.6% of the patients were not depressed while 51.4% were diagnosed as clinically depressed [30]. The 30-item GDS was validated because the group with depression had a significantly higher average GDS total score (indicating depression) than the group without depression [30]. Williams, *et al.* determined that the 30-item GDS, from which the short form was derived, was the most efficient depression screening tool when compared to 8 other similar scales [31]. Comparisons of the 30-item and the 15-item GDS showed favorable psychometric properties with elderly samples [32,33].

The TUG assesses mobility by recording the time (s) to ambulate from a seated start position, stand, walk 3 m forward at a normal pace, turn, return to the chair at a normal pace, then sit back down [34]. The cognitive TUG (TUG assessment while counting backwards by 4), as well as the motor TUG (TUG assessment while carrying a cup of water) were also utilized. The standard TUG has proven test-retest and interrater reliability, and has been validated in the PD population [35]. Minimal detectable change of the standard TUG was 3.5 seconds for patients with mild to moderately severe PD [36].

The FGA measures a participant's ability to maintain his or her posture and balance while performing certain tasks when walking. Yang, *et al.* assessed individuals with PD using the FGA, BBS, Functional Ambulation Category (FAC), TUG, Activities-specific Balance Confidence Scale, Movement Disorder Society sponsored revision of the Unified Parkinson's Disease Rating Scale-Motor Examination, fast walking speed, modified Hoehn and Yahr scale and falls history [37]. The FGA was shown to have construct, concurrent and predictive validity for individuals with PD [37]. A minimal detectable change of 4 was reported for patients in Hoehn and Yahr stages I-III [38].

The 6MWT measures the distance (m) that a participant can walk within six minutes. Steffen and Seney determined test-retest reliability of the 6MWT with elderly subjects with PD over a range of 7 days [39]. A minimal detectable change of 82 m was established for the 6MWT for individuals with Hoehn and Yahr scores ranging from I to IV [39].

Lastly, the BBS measures static and dynamic standing balance in patients by assessing their performance in various functional tasks. Fourteen stationary and movement-based standing tasks are graded on 0-4 scale, resulting in a score between 0-56 with a higher score indicating better balance. Steffen and Seney found high test-retest reliability of BBS and minimal detectable change of 5 for patients with Hoehn and Yahr scores ranging from I to IV [39]. According to Brusse, *et al.* the BBS has shown a strong correlation between ambulation, balance, and walking speed in individuals with PD [34]. They justified the physical therapists' preference for the BBS, indicating that it is an accurate measure of early or middle stages of PD. The BBS is a reliable measure for identifying individuals with PD who are at risk for falling [34].

**Table 1.** Sample Exercises for LSVT BIG® Sessions.

Examples of Maximal Daily Exercises for All Subjects	Examples of Exercises Unique to Each Subject	
	Functional Tasks	Hierarchical Tasks
Reaching from floor to ceiling while seated	Standing up from a seat (always included)	Floor to stand transfers
Reaching from side to side	Buttoning a shirt	Getting in and out of a car
Stepping forward while standing	Taking milk out of the refrigerator	Going out to dinner
Sideways stepping while standing	Lifting leg to put sock on foot	
Backwards stepping while standing	Opening a door	
Rocking forward and reaching while standing	Rolling over in bed	
Rocking sideways and reaching while standing		

## Data analysis

This study used a within-subjects design, comparing measurements taken before and after the 4-week LSVT BIG training program. The dependent measures were the following: GDS scores, three TUG times, FGA scores, BBS scores, and the 6MWT distances.

A Wilcoxon signed rank test was used for GDS in order to compare pre and post-test values. Paired t-tests compared pre and post scores for the three versions of the TUG (standard, cognitive, motor), BBS, FGA, and 6MWT. Measures were considered statistically significant if the p-value was less than or equal to .05 for all analyses.

## Results

Twenty-five patients were initially recruited, with two patients discontinuing participation in the study. The volunteers for this study included 17 male and 8 female patients over the age of 47 years. One male participant fell (no apparent injury) during the 15<sup>th</sup> session, cancelled the discharge session due to residual soreness, and was not able to return for the discharge session due to scheduling conflicts. Another participant completed 5 sessions before discontinuing due to the perception that prior lower back pain was exacerbated with training. He continued with twice weekly, 30-minute sessions of traditional physical therapy. These participants were not included in the data analysis. Feasibility was confirmed because there were no issues with reimbursement or delivery of care. None of the subjects had severe 'off' times during the training or testing sessions; time since taking medication was not documented.

Participants' ages ranged from 48 to 86 years with an average of 70 years (n=23; SD=9.8). Most of the patients were diagnosed within the past 4 years (n=17). Patients with increased age had increased disease duration but Chi-Square analysis showed no statistical difference in disease duration across age groups (5-year increments;  $\chi^2 = 11.1$ , df=12, p=.517; Table 2). Most subjects were male (n=15) but Chi-Square analysis showed no difference in male to female distributions across age groups ( $\chi^2 = 3.8$ , df=2, p=.829; Table 2). Participants' comorbid conditions are listed in Table 3. Attendance rates ranged from 15-20 sessions (M= 15.8, SD= 1.0).

All outcome measures showed statistically significant improvement with intervention using LSVT BIG. Table 4 shows Wilcoxon signed rank test results for GDS. Table 4 also shows pre and post-intervention descriptive statistics for outcome measures as well as results of paired t-test comparisons of TUG times, BBS scores, FGA scores and 6-minute walk test distances.

**Table 2.** Age and Gender Distributions Relative to Time since Diagnosis of Parkinson's Disease.

Disease Duration	4 years or less		5-9 years		10+ years		Total
	Male	Female	Male	Female	Male	Female	
Age (y) Group							
Under 60	2	1	0	0	0	0	3
60-64	1	0	0	0	0	1	1
65-69	4	0	0	0	0	0	5
70-74	2	2	2	1	0	0	7
75-79	2	1	0	0	0	0	3
80-84	0	1	1	0	1	0	3
85-89	0	1	0	0	0	0	1
Total	11	6	3	1	1	1	23

**Table 3.** Past Medical History of Participants.

Conditions	Frequency
None	17
Cardiovascular Conditions	2
Systemic Conditions	3
Musculoskeletal Conditions	3

**Table 4.** Comparisons of Pre and Post-Test Outcome Measures.

	M	n	SD	P	Minimum	Maximum
Pretest GDS	3.4	23	3.1	.006†	0	9
Posttest GDS	2.1	23	2.2		0	6
Pretest TUG Standard (s)	11.6	23	4.3	.000*	7	24
Posttest TUG Standard (s)	8.8	23	2.4		5	16
Pretest TUG Cognitive (s)	15.4	22	6.2	.001*	7	34
Posttest TUG Cognitive (s)	10.6	22	4.2		6	22
Pretest TUG Motor (s)	12.1	22	4.7	.001*	7	28
Posttest TUG Motor (s)	9.3	22	3.0		6	19
Pretest BBS	47.0	23	6.0	.000*	34	56
Posttest BBS	53.7	23	3.1		44	56
Pretest FGA	19.8	23	5.0	.000*	9	29
Posttest FGA	26.0	23	3.5		16	30
Pretest 6MWT (m)	346.8	22	111.6	.000*	133.8	589.8
Posttest 6MWT (m)	460.4	22	103.1		249.9	623.6

†Wilcoxon Signed-Rank Test results. \*Paired t-tests results.

M - mean, n - subjects, SD - standard deviation, m.- meters, s - seconds, TUG - Timed Up and Go, BBS - Berg Balance Scale, GDS - G

## Discussion

Participation in LSVT BIG helped patients with PD significantly improve gait, balance, endurance, functional task performance, and GDS scores. The program is feasible within an outpatient physical therapy setting but prior conditions or falls may affect ability to complete the intensive, 4-week protocol. We offer two new dimensions to the research about LSVT BIG: use of the Geriatric Depression Scale Short Form and inclusion of the dual task TUG times.

Decreased GDS scores suggest an overall improvement. One notes in Table 4 that the range of GDS scores decreased after subjects completed the program. Using the established cut-off to indicate further work up for depression [27], 7 of the 23 participants met or exceeded a score of 5 and none exceeded the score of 10 at the pre-test. At post-test, 4 exceeded the score of 5. Four of the 23 participants had GDS scores that were up to 2 points worse after training; 3 people had no change; and, 16 had improvements between 1 and 6 points from pre-test to post-test. The Geriatric Depression Scale [27] reflects some dimensions of quality of life because it addresses participation issues like going out and doing new things, starting new projects, attending social gatherings as well as functions such as decision-making, concentration, worry and memory. We are only able to compare our results with prior studies of the exercise effect on the Beck Depression Inventory or a quality of life measure. Park, *et al.* [5] showed improvement in Beck Depression Inventory with a long-term group exercise program. Dashtipour, *et al.* [26] showed immediate and long-term improvements in the Beck Depression Inventory for patients partaking in general exercise and LSVT BIG training. Our results support these findings. The Parkinson's Disease Questionnaire - 39 (PDQ-39) [40] was used in several LSVT BIG studies as a quality of life instrument [17,18]. Although PDQ39 scores improved more in the LSVT BIG groups, these studies failed to show a statistically significant difference among training programs in PDQ-39 scores; post hoc analyses showed that these studies did not have sufficient sample sizes to provide adequate power [17,18]. The

current study was limited by a lack of a control group or alternative exercise program, therefore, we cannot state that LSVT BIG had a greater effect on GDS scores than a general exercise program. However, this is the first study using the GDS which may indicate a positive immediate effect of LSVT BIG on participation and attitude-associated impairments of individuals with PD. Future studies should explore the effect of LSVT BIG training on depression by using a control group.

Our study confirmed previous studies that LSVT BIG was able to significantly decrease standard TUG time in patients with PD [17,18]. Studies with small samples did not show statistically significant improvements in standard TUG scores in patients with later stages of PD (n=8) [21] or for a younger cohort in a case series (n=3) where scores did not exceed minimum detectable change values [20] of 3.5 s [36]. In the current study, 7 of the 23 subjects met or exceeded this minimum detectable change value but other authors have suggested minimal detectable change values ranging from as little as 2 s to as much as 15 s [39]. We add new information to LSVT BIG research: dual task TUG durations (motor TUG and cognitive TUG) also decreased after training with LSVT BIG. These TUG variations were chosen to mimic gait performance during functional tasks that a person with PD may experience in everyday life, such as holding a glass of water or cognitive distractions.

By using the BBS, our study was able to show improvements in balance after an LSVT BIG intervention. Millage, *et al.* [29] demonstrated that 4 of 9 patients in Hoehn and Yahr Stage I met or exceeded the minimum detectable change value of a 4-point improvement on the BBS immediately after LSVT BIG training. This minimum detectable change value was based on a study of older adults undergoing rehabilitation whereby the baseline BBS value was related to the amount of change that was clinically significant [29,41]. The current study showed that 17 of 23 participants who completed training met or exceeded the 5-point minimum detectable change for the BBS in patients with PD suggested by Steffen and Seney [39].

Our study confirmed previous research showing that LSVT BIG significantly improved overall walking distance during the 6MWT [17]. All subjects exceeded the 82-m minimal detectable change reported by Steffen and Seney [39]. Studies including other gait velocity measures [19,29] showed improvement after LSVT training similar to that of other training protocols [17,18]. In contrast, Ueno, *et al.* [21] did not observe improved 10-m walk speeds with a 4-week LSVT BIG program (n=9). One would expect this task-specific training to yield a positive result because gait training occurs in every LSVT BIG session.

We included the FGA because it captures the quality of gait and balance when presenting the patient with motor challenges like pivoting or moving the head while walking. Results indicated that patients could make statistically significant improvements in FGA with LSVT BIG training. Our study had a more heterogeneous and larger sample than other studies which used the FGA [20,29]. Millage, *et al.* [29] noted improved FGA scores despite a ceiling effect because their subjects were in the early stages of PD (n=9). In their case series of 3 subjects in Hoehn and Yahr stages I-III, Janssens, *et al.* [20] noted improved FGA scores which did not reach minimal detectable change values of 4.2 which was established for patients with stroke [38,42]. The current study showed that 17 of the 23 participants met or exceeded this minimal detectable change value of 4 established for patients with PD [38].

We were not able to generalize findings because the design did not include a control group undergoing another regular exercise program. Due to this limitation, we were unable to conclude whether

LSVT BIG is exclusively effective in increasing functional measures or GDS scores compared to other exercise or rehabilitation approaches. This study occurred in an outpatient setting, as opposed to a clinical laboratory setting, where patients specifically opted for LSVT BIG training, therefore, a control group with general exercise training was not feasible. The fact that patients committed to this active, intensive program may have made change more likely, especially for the GDS scores. Our study had a high participant retention rate for the duration of the LSVT BIG program. Two male subjects were unable to continue with the study, one due to increased back pain and the other due to a fall. We elected to analyze data of subjects who completed the trial; subsequent analysis using an intention-to-treat model yielded the same statistically significant improvements in functional scores and GDS. Training and testing occurred in the same outpatient setting, therefore, blinding of therapists conducting pre and post-training tests was not feasible. Future randomized controlled studies with blinded examiners and larger samples using functional outcomes and depression measures appear indicated with a control group participating in an alternate intensive exercise protocol.

## Conclusion

LSVT BIG has the potential to improve deficits in gait, balance, endurance, and functional task performance as well as Geriatric Depression Scale scores. LSVT BIG treatment principles, including high repetition, high intensity, and use of patient-specific, functional activities, demonstrated overall improvements in bradykinesia and hypokinesia affecting function of patients with PD as demonstrated by improved times on the TUG and improved performance on the BBS and 6MWT. The program allows for the patient's overall functional status to be treated while encouraging participation and engagement with lifelong physical activity. GDS improvements may reflect improvement in activities and participation for patients with mild to moderate symptoms of PD undergoing LSVT BIG training. Further study is warranted with a control group.

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## Conflict of interest

The authors have no conflict of interest to report.

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