

A comparison of computerized dynamic posturography therapy to standard balance physical therapy in individuals with Parkinson's disease: A pilot study¹

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Abstract. Postural instability is a common impairment in idiopathic Parkinson's disease (PD). People with PD are prone to balance and walking difficulties. This study analyzed the feasibility of a prospective investigation of Computerized Dynamic Posturography (CDP) and standard Physical Therapy (PT) treatments in individuals with mild-moderate PD. Treatment took place at two sites: 1) CDP therapy at the Southeast Parkinson's Disease Research Education and Clinical Center (PADRECC) within a Veterans Affairs Medical Center and 2) standard physical therapy at a community outpatient rehabilitation center. Final analysis compared 15 patients randomly assigned for therapy to either the CDP or PT treatments. Therapy time was eight weeks (four weeks of CPD or PT followed by home therapy for four weeks). The CDP therapy included gradually intensified closed chain and mobility training. Standard PT consisted of upright, mat, and theraball exercises and gait training. The home exercise phase was identical for both groups. The pilot data demonstrated treatment was tolerated by 68 percent of the sample despite the occurrence of a progressive neurological condition and medical comorbidities. While results failed to reveal any differences between treatment groups, both groups demonstrated improvement on selected outcome measures. An expanded prospective study with methodological improvements appears warranted.

Keywords: Balance, computerized dynamic posturography, Parkinson disease, postural instability, long forceplate, Berg Balance Scale, physical therapy

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*PD balance poor
Treatment via two methods
Outcome feasible®*

– Unknown

1. Introduction

A hallmark of Parkinson's disease (PD) is postural instability, which usually occurs in the late stages of the disease, but can impact even those individuals with

early or mild symptoms. The increased extremity and truncal tone, motor incoordination, and dysautonomia often leads to falls. This inability to maintain balance with subsequent loss of balance and falls leads to marked disability [1,2]. Nearly two-thirds of individuals with PD had fallen in the recent past and 13% fell more than once a week [3,4], due to balance impairment [5–8]. In light of these studies, the effective treatment of balance problems is a significant issue for the PD patient population.

The most commonly available treatment for balance deficits has been interventions utilizing standard physical therapy techniques such as upright, mat, and theraball exercises, as well as gait training. More recently, computerized dynamic posturography (CDP) systems have been developed as an alternative treatment method. CDP provides an objective assessment of the sensory and voluntary motor control of balance on a movable surface with a changing visual surround. As Parkinson's occurs in older adults, their ability to tolerate formal and sustained exercise in light of the progressive nature of PD is problematic. Additionally, the co morbid medical conditions in older adults further complicates involvement in structured and consistent community exercise programs. The aim of the current study was to assess the feasibility of using these techniques with sample of patients diagnosed with PD and to determine if differential effects of the two treatments existed.

2. Method

Twenty-two eligible patients were recruited by PADRECC staff between September 2005 and December 2005. The PADRECC is a six-site program, begun in 2000, designed to provide multidisciplinary care to all Veteran's with Parkinson's disease and related movement disorders. Patients underwent a comprehensive interdisciplinary evaluation that included examinations by a neurologist, neuropsychologist, physiatrist, and nurse. A diagnosis of PD was confirmed by a neurologist using appropriate clinical findings and confirmed responsiveness to dopamine or dopamine-agonists. Eligible patients had to be ambulatory with or without an assistive device and free of moderate to severe postural instability. Additionally, they were judged to be cognitively capable of understanding instructions for testing and treatment as assessed by a Mini Mental Status Score of 25 or higher. The Unified Parkinson's Disease Rating Scale (UPDRS) [9] part III

Motor Component was employed to quantify disease stage. Data from patients' medical records, clinical interviews, and physical examination were collected. A signed consent form, consistent with Internal Review Board processes, was obtained prior to data collection.

Pre-testing was conducted with all patients in the "on" stage of medication at the Hunter Holmes McGuire Veterans Affairs Medical Center in Richmond, Virginia using the Smart Balance Master[®] computerized dynamic posturography system (NeuroCom[®] International Inc, 9570 SE Lawnfield Rd, Clackamas, OR 97015, USA) and the Berg Balance Scale (BBS) [8]. Patients were then randomly assigned to either the CDP group or the PT group for balance therapy. Therapy consisted of the following protocols: the CDP group was trained twice weekly for four weeks (30 minute sessions) using the Longforce plate of the Smart Balance Master to improve gait and balance (Appendix I). The PT group received twice weekly 30-minute sessions for four weeks (Appendix II). Therapy was conducted by physical therapists trained in balance and gait. The intensity, timing to complete tasks, and repetitions were gradually increased as tolerated in both groups. After completing treatment, all patients were instructed on home therapy and given a daily log book. The logbook catalogued thirteen specific therapeutic exercises, such as head turns, trunk rotation, hamstring stretch, straight leg raises, and on back leg abduction. Patients were asked to record their compliance with these daily exercises over the course of the four weeks. After completing four weeks of home exercise, patients from both treatment groups were re-evaluated using the Berg Balance Scale and CDP.

Outcome measures for the current study consisted of the subscales obtained from the CDP system and the Berg Balance Scale (BBS). The CDP system measures balance deficits by utilizing two dynamic 9" X 18" dual force plates with rotational capabilities to measure the vertical forces exerted by the examinee's feet, and a movable visual surround to provide real and distorted visual reference points. Standardized test protocols exposed the patient to support surface and visual surround motions, during which time the patient's postural stability and motor reactions are recorded on 12 scales and subscales (see Table 1). Procedures for the computation of scale scores are outlined in detail elsewhere [10].

The Berg Balance Scale (BBS) is designed to measure changes in functional standing balance over time and has been validated in a PD population [11]. The BBS is a 14-item scale, with each function being rat-

Table 1
Summary of CDP scales, subscales, and functional relevance for balance

Scale	Subscale	Functional Relevance For Balance
SOT ¹	Comprehensive	Overall index of sensory organization
	Visual	Ability to use input from visual system
	Vestibular	Ability to use input from vestibular system
	Somatosensory	Ability to use input from somatosensory system
ADT ²	Preference	Preference for visual input, even if erroneous
	Toes Up	Ability to maintain balance when encountering changes in surface inclination and surface irregularities when patient is tilted backward.
	Toes Down	Ability to maintain balance when exposed to surface irregularities and changes in inclination when patient is tilted forward.
LOS ³	Reaction Time	Ability to move center of gravity quickly after instruction
	Movement Velocity	Center of gravity movement measured in speed and distance
	Directional Control	Ability to control movement toward a target while minimizing counterproductive movement
	Endpoint Excursion	Maximum distance of first movement toward a target without loss of balance.
	Maximal Excursion	Maximal center of gravity movement without loss of balance

¹Sensory Organization Test.

²Adaptation Test.

³Limits of Stability.

Table 2
Demographic and Clinical Variables of Study Subjects (N = 15)

	CDP Group	Standard Therapy Group
Number Of Subjects	9	6
Age	71.89 (8.46)	73.67 (5.13)
Updrs Part Iii Score At Study Entry	15.33 (5.90)	13.67 (4.59)
Berg Balance Scale Pre-Score	43.89 (6.09)	48.83 (3.76)
Berg Balance Scale Post-Score	48.56 (3.64)	48.17 (3.76)

ed from 0 (worst) to 4 (best) along a dependence-independence continuum. This summative scale measures balance abilities observed during tasks involving sitting, standing, and positional changes. Total scores are indicative of overall balance abilities, with scores interpreted in the following manner; 0–20 wheelchair bound, 21–40 walking with assistance, 41–56 independent [7,12].

Data were analyzed with SPSS version 14.0 for Windows. The present design included both between- (treatment condition) and within- (measurement time) subject effects. The condition-by-time interactions (which assessed change over time between the groups) and the time main effects (which assessed change over time in both groups) for the BBS and 12 CDP scales were analyzed with a series of 2 (treatment condition) x 2 (time) mixed analysis of variances (ANOVAs). Given the number of individual ANOVAs conducted, a Bonferroni correction was applied to the analysis in order to diminish the effects of family-wise error. An alpha level of 0.004 was used as the standard for statistical significance.

3. Results

All patients were male. Age and pre and post treatment BBS and UPDRS scores for each treatment group are reported in Table 2. Sixty-eight percent of the patient sample completed all elements of the study. Three members of the CDP treatment group and four members of the PT treatment group terminated participation secondary to medical reasons. Consequently, data from nine CDP patients (75% of total enrolled) and six PT patients (60% of total enrolled) were available for analysis. A mixed ANOVA revealed no significant interaction between treatment group and measurement time, $F(1, 13) = 4.331, p = 0.058$ on the BBS. The main effect for time was also found to be non-significant, $F(1, 13) = 2.426, p = 0.143$. No significant condition-by-time interaction effects were found among any of the twelve CDP subscales. Four main effects for time were found in the Limits of Stability subscales: Reaction Time, Movement Velocity, Endpoint Excursion, and Maximum Excursion. See Table 3 for pre/post CDP outcomes and main effect ANOVA results. All patient log books were analyzed for compliance rates. One patient in each treatment group was unable to enter the required information

Table 3
CDP subscale pre and post treatment scores and time main effect mixed ANOVA statistics

CDP subtest	CDP Pre	CDP Post	PT Pre	PT Post	F (df)	p
SOT: Composite	65.56 (10.84)	64.22 (10.34)	70.83 (12.17)	72.50 (11.24)	0.01 (1.13)	ns
SOT: Visual	83.83 (8.21)	87.62 (5.72)	87.81 (12.61)	91.91 (4.60)	2.46 (1.13)	ns
SOT: Somatosensory	94.81 (4.25)	94.51 (3.85)	95.80 (5.48)	96.49 (1.73)	0.04 (1.13)	ns
SOT: Vestibular	43.45 (25.18)	37.80 (22.94)	60.59 (16.13)	54.59 (27.54)	1.36 (1.13)	ns
SOT: Preference	98.39 (18.50)	100.87 (22.16)	90.44 (14.57)	100.26 (7.44)	1.02 (1.13)	ns
ADT: Toes Up	46.67 (24.10)	50.89 (29.73)	54.67 (15.12)	55.33 (8.16)	13.00 (1.13)	ns
ADT: Toes Down	47.22 (14.20)	59.78 (24.82)	46.67 (7.31)	54.33 (12.66)	6.16 (1.13)	ns
LOS: Directional Control	71.22 (7.41)	73.22 (9.88)	71.33 (31.33)	73.33 (8.50)	1.78 (1.13)	ns
LOS: Reaction Time %	1.70 (0.68)	1.02 (0.25)	1.66 (0.85)	1.14 (0.29)	13.75 (1.13)	< 0.004
LOS: Movement Velocity %	1.96 (1.19)	2.76 (0.97)	1.52 (0.59)	2.35 (0.54)	40.36 (1.13)	< 0.001
LOS: Endpoint Excursion %	48.67 (12.68)	60.56 (14.88)	45.67 (11.99)	57.50 (11.17)	24.35 (1.13)	< 0.001
LOS: Maximum Excursion %	60.44 (16.06)	74.44 (14.50)	55.83 (10.11)	68.83 (9.15)	38.51 (1.13)	< 0.001

to complete log books. Of the thirteen who returned data, PT and CDP patients completed home exercises at rates of 80% and 87%, respectively. An independent samples t-test revealed no significant differences between treatment groups in the compliance rates, $t(11) = 0.03$, $p = 0.98$.

4. Discussion

A particular challenge when undertaking treatment studies in a geriatric population diagnosed with multiple medical problems is the subject attrition rate. The primary aim of this pilot study was to gauge the feasibility of conducting a randomized trial of balance treatments in a geriatric sample of individuals diagnosed with PD. Nearly seventy percent of the original sample was retained and demonstrated the ability to complete the pre-testing, the respective eight-week treatment regimes consisting of four weeks of outpatient therapy followed by four weeks of self-directed home therapy, and the post-testing. This indicates that undertaking a larger scale study in order to provide an expanded dataset is warranted and that the gathering of such data can be expected to succeed at a reasonable rate.

The current study employed several inclusion criteria that deserve discussion. Each patient had a mild to moderate degree of PD as measured by the UPDRS (see Table 2 for mean pretest UPDRS scores). Scores in this range suggest mild to moderate impairments. Future research designed to continue this line of investigation would improve internal validity by maintaining similar criteria. Should future data suggest that one or either therapy improves patient functioning in the mild to moderate patient, more severe PD symptomology could then be examined. In a similar vein, all patients had a Mini Mental Status score of 25 or higher in order

to improve the likelihood that they maintained the cognitive capacity to understand test and treatment instructions. In order to reduce potential confounds, future data collection also needs to consider this variable in patient inclusion.

The current study brought to light several methodological issues that will require adjustment in future research. The first set of issues appeared to be a result of the small sample sizes employed in pilot data. As described in the results section, the current study had a high degree of variability among several dependent variables to include the BBS and LOS Toes Up subscale. Additionally, despite the random assignment of patients to treatment groups the BBS pre-test means demonstrated a notable, if not statistically significant difference, which may have represented a selection confound in the pilot data. It is estimated that with a larger sample size of randomly assigned patients these issues will be minimized. Second, the issue of practice effects on the CDP post-test for individuals in the CDP group should be addressed in any follow-up study. While several of the subtests are functionally separate from the elements of treatment conducted on the SMART balance system, mere familiarity and time spent with the apparatus may represent a confound when comparing the PT group who has only testing exposure to the system to the CDP group who conducts treatment exclusively on the apparatus. Having the PT group engage in activities on the CDP system that do not mimic elements of the CDP subtests may equalize this difference between treatment groups. Finally, adding a wait list control group who under-go only pre and post testing will improve the internal validity of the design. This appears especially relevant given that the PT group showed virtually no change in BBS scores from pre to post testing. It may be that, within this population of patients diagnosed with a progressive neurological disorder, simply maintaining functioning as a

result of treatment becomes evident. Eventually, future data collection may also wish to analyze a combination therapy group that utilizes elements of standard PT and CDP.

With regards to the current data analysis, while the pilot data failed to reveal any significant differences between the CDP and PT treatment groups, both groups evidenced significant improvement on several of the CDP Limits of Stability subscales. This would suggest that both treatments improved functioning in select domains. The lack of a statistical difference between the two groups highlights the improvements possible with relatively “low-tech” modalities such as traditional physical therapies when compared to more sophisticated “high-tech” methods, such as CDP, to improve balance.

Overall, this feasibility study indicates that an expanded effort in this realm with improved methodology is warranted. Addressing the methodological and sample size issues listed above will improve the internal and external validity of the design and allowing for improved functional application to balance treatments in patients with PD.

Appendix 1: Sequence Training at Long Force Plate of SBM

Closed Chain Training	Ankle Right Level 1 50%
Closed Chain Training	Ankle Left Level 1 50%
Seated Training	Level 3
Mobility Training	Level 2
Mobility Training	Level 3
Mobility Training	Level 4
Mobility Training	Level 6
Mobility Training	Level 6

Notes: Shoes off

Appendix 2: Outpatient Rehabilitation Center Training

UPRIGHT EXERCISES	Rockerboard medial lateral, anterior posterior, standing on foam (eyes closed), mini squats and marching on foam, marching on trampoline, heel and toe raises, ball toss on rockerboard, trampoline, and foam
GAIT TRAINING	Tandem walking, heel/toe walking, lateral steps, backward walking
THERABALL EXERCISES	Medial lateral, anterior posterior, circles and ball toss, PNF (D2) with breathing exercises, PNF(D2) with yellow T-band
MAT EXERCISES	Lower trunk rotations, bridges

References

- [1] B.R. Bloem, Y.A. Grimbergen, M. Cramer, M.D. Willemsen and A.H. Zwiderman, Prospective assessment of falls in Parkinson’s disease, *J Neurol* **248** (2001), 950–958.
- [2] B.H. Wood, J.A. Bilclough, A. Bowron and R.W. Walker, Incidence and prediction of falls in Parkinson’s disease: a prospective, multicenter study, *J Neurol Neurosurg Psychiatry* **72** (2002), 721–725.
- [3] M.D. Willemsen, Y.A. Grimberger, M. Slabbekorn and B.R. Bloem, Falling in Parkinson’s disease: more often due to postural instability than to environmental factors, *Ned Tijdschr Geneeskde* **144** (2000), 2309–2314.
- [4] J.Y. Wee, H. Wong and A. Palepu, Validation of the Berg Balance Scale as a predictor of length of stay and discharge destination in stroke rehabilitation, *Arch Phys Med Rehabil* **84** (2003), 731–735.
- [5] M. Visser, J. Marinus, B.R. Bloem, H. Kijesjes, B.M. van den Berg and J.J. van Hilten, Clinical tests for the evaluation of postural instability in patients with Parkinson’s disease, *Arch Phys Med Rehabil* **84** (2003), 1669–1674.
- [6] B.R. Bloem, G.J. Lammers, S. Overeem, Y.A. Grimbergen and J. Tetrud, Outcome assessment of retropulsion tests in Parkinson’s disease. [abstract] *Mov Disord* **15**(suppl 3)(2000), 179.
- [7] J.G. Nutt, J.P. Hammerstad and S.T. Gancher, *Parkinson’s Disease: 100 Maxims*, London, Edward Arnold, 1992.
- [8] K.O. Berg, S.L. Wood-Dauphinee, J.I. Williams and B. Maki, Measuring balance in the elderly: validation of an instrument, *Can J Public Health* **83**(Suppl 2)(1992), S7–11.
- [9] S. Fahn, R.L. Elton and members of the UPRRS Development Committee, Unified Parkinson’s Disease Rating Scale, in: *Recent Developments in Parkinson’s Disease*, A. Fahn, C.D. Marsden, M. Goldstein and D.B. Calne, eds, Macmillan, New York, 1987.
- [10] H.M. Bronte-Stewart, A.Y. Minn, K. Rodrigues, E.L. Buckley and L.M. Nashner, Postural instability in idiopathic Parkinson’s disease: the role of medication and unilateral pallidotomy, *Brain* **125** (2002), 2100–2114.
- [11] A.A. Qutubuddin, P. Pegg, D. Cifu, R. Brown, S. McNamee and W. Carne, Validating the Berg Balance Scale for Individuals with Parkinson’s Disease: A Key to Rehabilitation Evaluation, *Archives of Physical Medicine Rehabilitation* **86** (2005), 789–792.
- [12] M. Thomas, J. Jankovic, M. Suteerawattananon, S. Wankadia, K.S. Caroline, K.D. Vuong and E. Protas, Clinical gait and balance scale (GABS): validation and utilization, *Journal of the Neurological Sciences* **217** (2004), 89–99.