ABSTRACT

EFFECTS OF WHOLE BODY VIBRATION VERSUS AGILITY TRAINING ON GAIT PARAMETERS FOR INDIVIDUALS WITH PARKINSON'S DISEASE

Purpose/Hypothesis: Parkinson's disease (PD) occurs in 1 in 100 persons over the age of 65. Due to the nature of PD, persons with PD have many gait impairments, which increases the risk of falls. There are many approaches to address gait deviations in PD. It is unclear which intervention is superior when attempting to improve gait parameters. The purpose of this study is to determine if whole body vibration (WBV) produces larger improvements in gait parameters when compared to agility training for individuals with PD. The null hypothesis is there will be no difference between WBV and agility groups in gait parameters after intervention for individuals with PD. The alternative hypothesis was there will be a difference between groups in gait parameters.

Subjects: Participants were recruited from the Greater Fresno Parkinson's Support Group and fit the selection criteria. 8 individuals (5 men, 3 women, age 67±5.7 years, Hoehn and Yahr scale 1-4) were selected.

Method and materials: Study design was a 2 group experimental pilot study.

The Zeno Walkway measured gait velocity, cadence, and step length. Outcome measures included the 6-minute walk test, timed up and go (TUG) and cognitive TUG. Interventions occurred 3 times per week for 5 weeks, 50 minutes a day. Both groups received yoga, postural activities on computerized posturography, and dual task activities. The WBV group received vibration at 18 Hz for 1 minute, 3 repetitions up to 3 minutes. The agility group performed drills with obstacles, cones, and varying surfaces. Cognitive loads were added to increase difficulty.

Results: Within group results showed no statistical difference after interventions for gait parameters, TUG, and cog TUG scores. For gait velocity, improvements were not significant between groups. In terms of greater improvement, the agility group showed greater improvements in gait velocity and step length. The WBV had greater improvements in cadence, cog TUG and TUG.

Conclusions: Based on results there was no statistical significant difference between groups in all outcome measures. Based on clinical relevance, both groups had improvements in different gait parameters, TUG and cog TUG test scores. All the subjects improved gait parameters compared to aged matched norms in terms of cadence and step length.

Taryn Yamagami
May 2018

EFFECTS OF WHOLE BODY VIBRATION VERSUS AGILITY
TRAINING ON GAIT PARAMETERS FOR INDIVIDUALS
WITH PARKINSON'S DISEASE

by

Taryn Yamagami

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APPROVED

For the Department of Physical Therapy:

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BACKGROUND

Introduction

Parkinson's disease (PD) is a late onset neurodegenerative disease with 1 in every 100 people over the age of 65 years old diagnosed with this disease.[1] PD is more prevalent in males than females with frequency expected to triple in the next 50 years.[2] Multiple systems are affected by the progressive loss of dopamine neurons in the midbrain which directly leads to motor disturbances.[3] Additional regions involve non-motor centers including cognitive and emotional centers. Motor deficits identified in this population include decreased upright balance, mobility, and the disease hallmark, bradykinesia. Specifically, decreased postural stability and freezing of gait are 2 complications that arise as the disease progresses. Other non-motor complications of PD include decreased memory capabilities, fatigue, sleep disturbances and loss of executive function all leading to a decrease in quality of life (QOL).[3] A combination of these deficits leads to an increase in falls and decreased participation in society for individuals that develop PD.

Throughout the literature there are many rehabilitation approaches to ameliorate the effects of PD. Each intervention addresses a different area of motor deficit caused by the disease. However, there is a common conclusion that there is no one specific intervention that is the standard treatment for PD.[4] Knowing that there is no superior intervention poses a question of which treatment will yield larger improvements in gait parameters for individuals with PD. Therefore, the purpose of the current pilot study seeks to find if whole body vibration (WBV) will yield larger improvements in gait parameters when compared to agility training for individuals with PD. In conjunction with this comparison, the research will investigate the effects of dual tasking activities by measuring the motor dual tasking (cognitive load) in individuals with PD as measured by the cognitive timed up and go (Cog TUG). The effects of treatment on gait parameters will be quantified using the following gait variables: velocity, stride length and cadence.

Neuroanatomy and Effects of PD

In the process of progressive PD there are changes in neuro-structures that comprise the basal ganglia. The basal ganglia is made of several gray matter structures located in the midbrain section. Specific PD pathology involves the loss of dopaminergic neurons in the substantia nigra.[3] The substantia nigra adjusts output to the periphery which provides appropriate levels of inhibition or excitation to fine tune movement. The motor output from the basal ganglia is regulated through 2 pathways. The direct pathway helps initiate movement when it is not enough to meet the demands of the environment while the indirect pathway facilitates slowing of movement.

In terms of motoric function, the output of the basal ganglia motor circuit regulates muscle contractions via the thalamus. In individuals with PD, the indirect pathway of communication is disrupted by cell death of dopaminergic cells in the substantia nigra. In the indirect pathway there are a series of excitatory and inhibitory signals from the motor cortex to the thalamus. In a normal, healthy individual, dopamine inhibits the signal from the striatum to reduce the amount of movement, in order to move the appropriate amount.[5] A decrease in dopamine allows the indirect pathway to inhibit excessively, leading to too much slowing of movement. This disturbance in the basal ganglia leads to the presentation of the cardinal signs and symptoms of PD.[5]

Common signs of PD include hypokinesia, rigidity, postural instability, resting tremors, flat affect, freezing of gait (FOG) and visuoperceptive impairments.[6] The effect of hypokinesia on motor activity is striking, serving to decrease active range of motion and inhibit movements such as arm swing while walking. Freezing of gait is not fully understood, however one hypothesis surmises that excessive inhibition to the midbrain locomotor region of the brain alongside visuoperceptive impairments interrupt the initiation of swing phase.[3] Persons with PD often experiences this interruption when approaching marks on the ground or door-way thresholds and are unable to negotiate obstacles.

Additionally, the basal ganglia has 4 channels that interact with the limbic, visual, motor and cognitive systems.[6] Because of the multifaceted pathology, individuals with PD present with flat affect, visuoperceptive impairments, motor, and cognitive decline.[7] Furthermore, PD demonstrates heterogeneity in presentation, and due to the varying symptoms, various interventions have been developed.[4] A further function involves the caudate portion of the basal ganglia, as one of the main purposes is to regulate executive function.[3] This connection of caudate and motor control facilitates decision making, thus allowing individuals to evaluate their physical surroundings, contextually, ultimately selecting the appropriate action.[3]

The signs and symptoms of PD can lead to further functional limitations such as decreased walking ability, strength, and balance. Furthermore, these limitations present with characteristics such as FOG, shuffling, difficulty initiating movement and tremors which create both personal and global reductions in participation and the environmental engagement. Because of the motor presentation, persons with PD will be less inclined to be involved in social situations that involve ambulation in public. Limiting participation in public can also be due to inability to overcome environmental obstacles that amplify symptoms. Therefore, physical interventions for individuals with PD should focus on several levels; 1) regain independence in mobility in household and community; 2) reduce fall risk; 3) enhance participation in personal and social engagement and 4) reduce the motor disruptions (tremors, FOG, shuffling, posture). The ability of a physical therapy intervention to be individualized is more beneficial to persons with PD because of its variable presentation and the global impact on personal and social engagement.

Treatments for PD

Several methods of treating the impairments that are characteristic of PD have been developed, including pharmaceutical, surgical, and movement-based interventions. Pharmaceutical treatments for PD and the movement disorders include dopamine replacement via Levodopa. As the disease progresses the effectiveness of Levodopa decreases and eventually leads to decreased "on time" when the medication is actively decreasing signs of PD.[1] On time is described as a period when the medication is managing and suppressing the symptoms of PD. During the off-state individuals with PD experience the common symptoms of tremors, fatigue, and bradykinesias. This cycling of on and off states are unpredictable and can make the progression of PD limit an individual's normal life routine.

When pharmaceuticals become ineffective, surgical implantation of deep brain stimulation (DBS) becomes an option. Placement of electrical stimulation on different regions of the basal ganglia can produce improvement of gait and postural reflexes, reducing dyskinesias, and rigidity. However, to be an appropriate candidate for this treatment patients must be relatively young, healthy, and cognitively intact. With PD being a disease that typically develops after the age of 60, there is also a higher probability of comorbidities. This along with age can disqualify individuals from becoming a candidate for a deep brain stimulator. Outcomes for this procedure show effective management of PD symptoms and this greatly affects individual's quality of life.[8] Additionally, with the emphasis on exercise, physical therapy interventions using gait with PD (treadmill training, over ground training, tandem bike) have shown promise to aid in decreasing symptoms of PD.[9]

A newer approach to treatment utilizes whole body vibration (WBV). The device includes a standing platform which oscillates in the frontal plane from low (6hz) to high frequencies (40Hz). This induces vibratory effects on the musculature that produces a quick stretch on the muscle spindle that activates muscle contractions.[10] Different frequency settings on the Galileo WBV unit (Novotec Medical GmbH and Stratec Medizintechnik GmbH, Pforzheim Germany) focus on inducing different muscular responses. Higher frequencies (20-40 Hz) target muscle power and force through constant muscle activation. Intermediate frequencies (12-20 Hz) focuses on muscle function, allowing the agonist and antagonist muscles to relax between contractions focusing on conscious muscular control. Lower frequency (6Hz) settings are to further conscious muscular control against the perturbations from the oscillating plate to train balance and proprioception.[11] Developed initially for athletes, evidence has shown efficacy for improving gait in individuals with neurological sequalae.[12] Furthermore, plate oscillation occurs in the frontal plane as to mimic natural pelvic movement during ambulation which has promise for those with gait deficits.[10] Several studies suggest that exercise performed on a vibratory platform will benefit the elderly with functional strength, balance, and an improvement in gait parameters.[13-15] In a study by Calder et. al, healthy elderly participants were given WBV intervention for 6 weeks which resulted in increased lower extremity strength and increased gait velocity.[15]

Currently the literature is not clear on WBV and the levels of frequencies for specific diagnoses in PD. The studies that compare WBV to a control group utilized a range of frequency settings of 6 or 26 Hz. In a meta-analysis reviewing 16 WBV articles, of those 11 articles focused on high level frequency and 3 focused on low frequency WBV. None of the studies in this meta-analysis reported intervention of intermediate levels of 15-18 Hz.[16]

Traditionally a multimodal intervention is utilized in the physical therapy setting to address different areas of deficits such as cognitive, gait, balance, agility, and flexibility. Throughout the research there has been a wide variety of articles demonstrating the use of agility or dual task training to improve gait parameters for individuals with PD. Defining agility in movement science depicts the ability to move quickly and easily.[17] Examples of agility training methods used in the literature includes stepping in all directions, hand-eye coordination, dynamic balance, and obstacle courses.[17] Dual tasking is the ability to perform a primary, main focus, task while simultaneously performing a secondary task.[18] In a study by Shumway-Cook, individuals with PD were given cognitive or motor tasks while ambulating and observed an 18-19% decrease in gait speed when compared to control group.[19]

The current gap in the literature is that there is no comparison of WBV compared to conventional agility programs. Furthermore, there is an additional gap implementing a frequency of 18 Hz to individuals with PD to ascertain its effectiveness to improve gait parameters. This study has relevance for the field of physical therapy by addressing gait deficits due to PD. It does so by determining if WBV compared to agility training produces superior change in gait parameters.

Current Research

Whole Body Vibration

In reviewing studies with WBV, there are few studies which focus on achieving change in gait parameters in persons PD. A study by Arias et al. compared 2 groups of PD participants, one receiving WBV and a placebo group.[20] In a similar study performed by Gabner et al., subjects were allocated into experimental WBV and placebo groups that also stood on the WBV platform without vibrations.[21] Both studies had interventions delivered 2-3 times per week over a 5-week period. The results were almost identical between studies concluding both WBV and placebo groups had significant changes in gait velocity, step length. Cadence was only tested in the Gabner et al. study and demonstrated significant changes for both groups pre and post intervention ($p= 0.000$) .[21] The reasoning for both placebo control group's improvements was a placebo effect. The researchers believe this could have led to their increased gait performance. Ebersbach et al. placed subjects into WBV group and conventional therapy/control groups.[22] Both groups received muscle stretching, relaxation, speech therapy and occupational therapy (OT). Conventional therapy group received addition balance training on a tilt board for 15 minutes a session. Intervention frequency was set at twice a day, 5 days a week for 3 weeks. At 4 weeks, outcome measures were taken again, and there were no significant changes in gait velocity from the WBV compared to the control group, however both groups improved gait velocity from pre-posttest measurements. It is clear there are benefits to using WBV to improve gait parameters in individuals with PD. However, it is unclear if these improvements are superior to conventional therapies or even placebo effects.

Systematic reviews have been conducted to analyze the effect of WBV on gait with individuals with PD. In a review by Sharififar et al., 6 articles were analyzed involving effects of WBV on mobility and balance in PD.[23] The researchers concluded there was lack of consistency in the studies analyzed. In the review, variability in outcome measures were evident with some studies concluding an effect on both mobility and balance, while other studies cited only mobility or balance was advanced. In a similar systematic review involving effects of WBV on sensorimotor performance in PD, Lau et al. reviewed 6 articles.[24] After analysis, the same conclusion was drawn that there were inconsistent effects on motor performance. In terms of individual studies, there were no significant differences between control or placebo groups and WBV groups post-treatment. Although no statistical significance was concluded in these studies, a positive change may be clinically relevant and applicable to optimize outcomes in persons with PD.

Agility

To address the difficulty with turns, changing gait speed and direction limitations that accompany PD, agility training can be utilized.[25] Agility training was utilized in 2 studies by Protas et al and Smith et al.[25,26] The population of interest was individuals with PD. Treadmill training in 4 directions was the intervention of choice and occurred over the span of 8 weeks for each study. Treadmill speed was adapted to the comfortable walking speed of each individual in the studies. Individuals walked forwards, backwards, and sideways, left and right. When gait parameters were measured after intervention, both studies concluded improvements were made in gait velocity, cadence, and step length. Protas et al. saw significant improvements in gait speed and cadence.[25] Smith et al. observed improvements in majority of participants by exceeding the MDC for gait speed (0.18 m/s) and 6 minute walk test distance MDC (82 m). The study concluded that an 8-week treadmill training program with different directions was effective and safe for individuals with PD.[26]

Dual Task Training

Dual tasking has shown to have negative effects on gait parameters in individuals with PD. This can be especially detrimental to persons with PD because these individuals already have gait disturbances secondary to the disease process. Studies have shown that by combining cognitive or motor loads to other forms of interventions can improve the ability of an individual to perform under loads.[18,27] Brauer et al. implemented a single 20 minute training session for individuals with PD. The training session consisted of gait training to improve step length while performing word association and counting cognitive loads. Under the 6 different cognitive loads, the study observed significant improvements pre to post test for step length in 5 out of 6 conditions and gait speed in 3 out of 6 conditions.[18] Conradsson et al. delivered a 10-week Hi-balance training program to subjects with PD. During the sensory integration, anticipatory postural adjustments, motor agility and stability of limits training, individuals were given cognitive loads to increase task difficulty. These interventions resulted in significant differences between pre and post-test for dual task walking ($p=0.006$).[27] The improvements observed included those in gait velocity, cadence and step length.

Hypothesis

Based on literature researched, the research project was developed to compare the effects of WBV versus agility training, both in combination of conventional therapy, on gait velocity, cadence and step length, timed up and go (TUG) and cog TUG in individuals with PD. The null hypothesis is there will be no difference between participants receiving WBV compared to agility training in gait velocity, step length and cadence post treatment for individuals with PD, H&Y 1-4, age 40-80. The alternative hypothesis is there will be a difference between groups in gait velocity, step length, cadence, TUG, and cog TUG post treatment for individuals with PD, H&Y 1-4, age 40-80. Additional findings are to ascertain whether these interventions showed changes in dual task activities.

METHODS

Participant Recruitment

Participants were recruited from the Greater Fresno Parkinson's Support Group and fit the selection criteria discussed. Individuals who expressed interest came to study's assessment day. On the initial day of assessment, participants signed consent forms and were given copies of the forms. All demographic information obtained was kept in a locked file drawer and kept separate from the participant data.

Selection Criteria

The study recruited individuals with Parkinson's disease. Inclusion criteria included age 40-80, Hoehn and Yahr scale 1-4, ambulatory with or without assistive device, with a stable medical regiment for over one month and be able to follow an exercise program. Exclusion criteria included hospitalized within the last 3 months, a second neurological diagnosis with resulting motor diagnosis, drug induced psychosis, or poorly and uncontrolled hypertension or cardiopulmonary pathology that would exclude them from participating in exercise. Other exclusions were pregnancy, acute inflammation of locomotor system, active arthrosis or arthropathy, acute hernia, acute discopathy, gallstones, rheumatoid arthritis, and epilepsy due to secondary risk of injury. Participants were randomly assigned to either the WBV group or agility training.

Assessment

After the study was reviewed, consent forms were signed, demographic information forms were completed, and participants were assigned an ID number. Testing on initial assessment day was conducted at California State University, Fresno in McLane Hall rooms 103, 104 and 111. Graduate students in the Doctor of Physical Therapy program were trained, completed competency in all outcome measures, and assisted with the assessments. These assessors were blinded to participant's group allocation and were not involved in the interventions. The co-primary investigators were blinded to assessment outcomes.

Total assessment time was one hour and 30 minutes. Functional mobility tests included were provided in this order for each participant: functional gait assessment (FGA), 6-minute walk test (6MWT), timed up and go (TUG), and cognitive TUG (dual task: gait and cognitive). The TUG has excellent, reliability and validity in community dwelling elderly[28]. The Cog TUG completed in longer than 15 seconds classifies the person as a faller with an 87% prediction rate. In the PD population, there is positive predictive value of falls and no other reliability or validity is reported for TUG or Cog TUG.[28] Gait parameters were measured using the Zeno Walkway: Computerized mat for gait kinematics. The Zeno Walkway has high to excellent reliability and validity in measuring gait parameters (Intra-class correlation coefficient (ICC) gait velocity = 0.88-0.91, cadence ICC = 0.82-0.83, step length ICC =0.88-0.92).[29] The gait parameters measured included gait velocity, limb velocity, integrated limb pressure and step and stride length. These outcome measures were chosen based upon the American Physical Therapy Association (APTA) Neurology Section PD EDGE taskforce. For the purpose of this study, gait parameters, TUG and the Cog TUG will be the outcome measures of interest.

Interventions

Participants attended 3 group sessions a week for 5 weeks of interventions. Each of the daily sessions were further divided into 2 groups. 1 session had 4 of the participants and the second session of the day had the other 4 participants. The sessions that occurred on Tuesday and Thursday were 45 minutes in length and included flexibility, gait, balance, cognitive and dual-task training with each group's allocated WBV or agility training. Rest breaks were included within the sessions. The third session of the week occurred on Friday and consisted of flexibility training and the allocated group specific intervention. Perceived exertion, blood pressure and heart rate were taken prior to the start of each session. See Table 1 for breakdown of each intervention session.

Participants were randomly allocated to the WBV group or the agility group. DPT students involved in outcome measure assessments were blinded to subject allocation. DPT students in the intervention program were not involved in the assessment process, thus they were blinded to the assessment results. There were 2 primary individuals that led each intervention group. One group was given vibration, dual task drills, Bertec balance drills and flexibility training. The second group was given agility drills, dual task drills, Bertec balance drills and flexibility training. WBV was delivered at intermediate frequency of 18 Hz, for 1 minute, 3 times. The duration receiving the vibration was increased to 3 minutes, 3 times if the subject tolerated it. Flexibility training consisted of seated and standing stretches of the whole body and breathing with movements was performed. For agility training an obstacles course was utilized with additional cognitive loading to make the task more difficult. Balance training utilized the Bertec (Bertec Incorporated, Columbus, Ohio, USA) to perform rhythmic weight shifts and directional control. Cognitive loads were also added to balance training to increase difficulty. Specific dual task drills incorporated subjects to stand with variable stance while reacting to audible cues given to identify specific markers on the wall. Details of interventions are provided in Table 2.

Analysis

Analysis of the data will be performed using Microsoft Excel software 2016. The study analyzed the mean and standard deviation from the following tests and devices 1) Zeno Mat, 2) TUG, 3) Cog TUG. Between group comparisons (WBV versus Agility) determined changes in scores from the pre and post test data for each of the above-mentioned measurements. Changes in score mean for each group were compiled and analyzed using a paired t-test. Within group comparisons of pre and post measures were analyzed using the paired t-test. Significance was set at $p \leq 0.05$. Demographic information was analyzed to establish between group differences in age, Hoehn and Yahr classification, Parkinson's disease diagnosis duration, and on/off status for PD medications.

RESULTS

A sample of PD subjects was obtained through community programs that offer support for individuals with PD. Eight individuals (5 men, 3 women, age 67±5.7 years, Hoehn and Yahr scale 1-4) were recruited for the study. All 8 participants completed the study and participated in post-test measurements. The 8 subjects were allocated randomly to 2 groups receiving either WBV or agility training. More males than females were allocated to the WBV group. In the agility group there were equal amounts of males and female subjects. The 2 groups were similar in age and H&Y (Table 1 for demographics), there was no statistical difference in age between groups. See Table 3 for subject characteristics. Figure 1 summarizes change as one group before and after interventions.

Summary of Subjects

Subject 1 was a 58-year old female diagnosed with PD in 2015. She was in the on state of her Parkinson’s medications. For ambulation the subject utilized a single point cane. She was on a total of 6 medications and had 8 health conditions such as comorbidities or surgeries.

Subject 2 was a 69-year old male diagnosed with PD in 2013. He was in the on state of his Parkinson’s medications. The subject was independent with ambulation. He was taking a total of 5 medications and had 8 other health conditions including comorbidities and surgeries.

Subject 3 was a 59-year old male diagnosed with PD in 2016. He was not taking Parkinson’s medications and was independent with al ambulation. He had a total of 5 medications for 2 associated health conditions.

Subject 4 was a 69-year old male diagnosed with PD in 2000. He was in the on state of his Parkinson’s medications. He utilized a single point cane or wheeled walker for short distance ambulation but required an electric scooter for community mobility. The subject was taking 7 medications and had 3 health conditions including comorbidities or surgeries.

Subject 5 was a 76-year old male diagnosed with PD in 2009. He was in the on state of his Parkinson's medication. He was able to ambulate independently. The subject was taking 4 medications with only 1 other health condition.

Subject 6 was a 75-year old female diagnosed with PD in 2015. She was in the off state of her Parkinson's medication. She was able to ambulate independently. The subject was taking 8 medications for her associated 7 conditions including comorbidities and surgeries.

Subject 7 was a 69-year old male diagnosed with PD in 2011. He was in the on state of his Parkinson's medication. He utilized a single point cane as needed for ambulation. The subject was taking 8 medications for associated 4 health conditions.

Subject 8 was a 65-year old female diagnosed with PD in 2012 She was in the on state of her Parkinson's medication. The subject was independent with ambulation. She was taking 1 medication and had 1 health condition including comorbidities or surgeries.

Gait Velocity

There were no significant differences in gait velocity between WBV and agility groups using a 2 sample t-test. ($p=0.124$). In group pre and post testing, a paired t-test did not show statistical significance of gait velocity changes revealing pre- test scores ($M=89.8$ cm/sec, $sd=17.8$) and post test scores ($M= 94.7$ cm/sec, $SD=11.5$); $t(7) = -1.25$, $p = 0.25$. Of the 8 participants, 6 improved post-test with an average difference of +9.25 cm/sec. The average difference of post-test results for the 2 participants that did not improve was -8.478 cm/sec. Furthermore, the results did not show a MDC of 18 cm/s for individuals with PD when comparing pre and post-test. See Figure 2 for gait velocity results as whole group or between groups before and after interventions. Tables 4 and 5 represent the average differences of the whole group and each group pre and post-intervention and the statistical difference value.

Cadence

The results of the study examining the effects of WBV versus agility exercises showed no statistically significant changes from pre and post-test in cadence ($p=0.214$). As one group, a paired t-test of did not show statistically significant changes revealing slight improvement in post-test scores (Pre test scores: $M=101.2$, $SD=9.3$; post- test scores: $M= 103.7$ steps/min, $SD=3.8$; $t(7) = -0.84$, $p = 0.43$). Of the 8 participants, 5 improved post-test with an average difference of +6.04 steps/min. The average difference of post-test results for the 3 participants that did not improve was -3.23 steps/min. See Figure 3 for cadence results as whole group or between groups before and after interventions.

Step Length

The results of the study examining the effects of WBV versus agility exercises showed no statistically significant changes from pre and post-test in step length ($p=0.112$). A paired t-test did not show significant changes revealing pre-test scores ($M=52.8$ cm, $SD=10.3$) and post test scores ($M= 55.2$ cm, $SD=7.2$); $t(7)= -1.33$, $p=0.22$. WBV and conventional therapy groups were not separated. Of the 8 participants, 5 improved post-test with an average difference of +5.86 cm. the average difference of post-test results for the 2 participants that did not improve was -3.46 cm. See Figure 4 for step length results as whole group or between groups before and after interventions.

TUG

Within group analysis of the TUG score before and after intervention shows a decrease in time to perform (pre M=17.19 seconds, SD= 19.62; post M=14.04, SD=10.45). Between WBV and agility training groups, the mean difference in pre-post test scores was higher for WBV ($M\Delta_{agility}$=0.24 seconds p=0.43, $M\Delta_{WBV}$=6.54 seconds, p=0.195). Overall, the WBV group had greater difference in pre to post-test means of the TUG. The agility group however, had lower fall risk scores under the cut-off of 15 seconds while the WBV group was unable to meet this cut-off.

Cognitive TUG

Analyzing the group comparison of Cog TUG pre and post intervention reveals there was an improvement in whole group performance (pre-M= 25.98 seconds, SD= 30.6; post M=20.9, SD= 24.24, p=0.06). Between WBV and agility training groups, the mean difference in pre-post test scores was higher for WBV ($M\Delta_{agility}$=0.78 seconds p=0.39, $M\Delta_{WBV}$=9.36 seconds, p=0.07). Overall, WBV group had greater improvements between pre and post-test means. Between WBV and agility group post-test results, there was no statistically significant difference (p=0.23).

DISCUSSION

Summary

The purpose of this study was to investigate the effects of WBV versus conventional physical therapy on gait parameters with individuals that have Parkinson's disease. In the measures of gait velocity, cadence and step length, there were no statistically significant differences between WBV and agility training groups. In analyses of the Cog TUG within group, there was near statistical significance for time ($p=0.06$). Improvements in gait parameters were anticipated but based on statistical significance we accepted the null hypothesis that there are no statistically significant differences between intervention groups in gait parameter measurements. Analysis of the post-test means we can see that overall the agility group had better results than the WBV group in the areas of gait velocity, cadence, step length, TUG and cog TUG. In terms of clinical significance, we can accept the alternative hypothesis that there was a difference between groups post-test.

Comparisons of the subjects as one group and between groups (WBV vs agility), showed no significant differences. In studies comparing WBV to a placebo they determined there were no statistically significant difference between groups in gait velocity, cadence[13] and step length.[30] These groups had similar protocol for WBV with frequency set at 6 Hz, amplitude 3 mm, for 1 minute on and 1-minute rests for a total of 5 minutes receiving the vibration stimulus. This setting differs from the current study and other that investigated the effects of WBV on performance measures.[11]

Other Studies

Other studies have shown improvements in mobility outcome measures such as counter movement jump height, muscle activity, and other gait analysis with the use of WBV. WBV delivery protocol ranged from 20-30 Hz depending on the intensity of maximal voluntary contraction that was targeted.[12,15] The range of frequency depends on the tolerance of each subject and the goal of treatment[31] along with recommendations to target muscle strengthening and power.[22] The present study aimed to use WBV as a strengthening regimen with frequency set at 18 Hz. Based on previous findings we expected gains in gait parameters secondary to strength gains in lower extremity muscles. We can expect the current study's results would be different than similar studies focusing on WBV as an intervention for individuals with PD because the frequency settings had different targets.[11]

When comparing the current study with studies successful in improving gait parameters, there are differences in intervention protocol. Subjects in the current study were able to make comparable improvements in their gait parameters and follow the trend found in current literature. Other studies that tested the efficacy of WBV to improve gait parameters saw improvements in gait velocity, cadence, and step length.[20-22] All 3 WBV studies did not show superior treatment when compared to the placebo or conventional therapy as both groups improved. Conventional therapy consisted of tilt board balancing, flexibility training, occupational and speech therapy.[22] Possible explanation for improvements in placebo groups can be explained by the interventions provided. In the Arias and Gabner studies, subjects in the placebo group were set up on the WBV platform in similar semi-squat position. There were given verbal instruction to stand as still as possible. Throughout the placebo WBV, subjects were given visual cues of a light when there were moving along with verbal instruction to stand still, and the light would turn off.[20,21] This set up could have provided an extra balance training session similar to the WBV group.

Most studies in the body of literature concerning WBV have dealt with frequencies in the low or high end of the established parameters. Each setting has a specific aim for treatment. In 2 systematic reviews, roughly 10 studies focused on the lower range frequencies at 6-12 Hz. This range focuses on balance and proprioception improvements for reacting to the vibration plate perturbations. In this scenario, improvements have been shown to carry over into improvements in gait parameters.[32] In theory, working in the higher end (20-40 Hz) could result in improved gait velocity, cadence, and step length. Further improvements in strength training for lower extremities by increasing ability for gait initiation thus making gait more efficient.[33]Higher frequencies focus on power and strength gains.[11] In a review of the effects of WBV on sensorimotor, mobility and balance 6 out of 7 studies used frequencies in lower frequency ranges of 6-9 Hz.[23,24] These studies concluded that WBV improved post test scores however, results were not superior to other treatments. An additional meta-analysis with older adults. WBV and associated strength gains found that amongst the 16 studies, only one implemented the intermediate frequencies.[16] When it comes to research that utilizes intermediate frequencies (12-18 Hz), there is a scarcity in the literature to support the efficacy of this WBV setting.

The current study aimed to add to the literature on frequency choice in the intermediate range for improving gait parameters in individuals with PD. Intermediate settings focus on allowing muscle agonist and antagonist to contract and relax. This setting can be consciously controlled through muscle contractions and controlled through the spinal reflex incorporating muscle spindles. Furthermore, the alignment of the force plate provides stimulation of muscles that are coordinated to mimic activation in gait patterns.[11] Due to the absence of WBV using intermediate settings and the benefits of it, the current study chose to utilize intervention of intermediate frequencies. Though frequency levels were different in the current study, both WBV and agility training groups improved in gait parameters.

Agility Training

The effects of agility training are examined in a few studies concerning individuals with PD. The aims of these studies were to analyze the changes made in gait parameters after 4-8 weeks of an agility training program. Individuals who participated in an organized agility boot camp intervention improved their stride velocity, gait velocity, cadence, and step length.[17,25] Significant differences were reports in the agility training studies conducted for 10 weeks and 4 weeks. The current study did not have significant differences in pre and post test scores but saw improvements in majority of subjects in gait velocity, cadence, and step length. The improvement of gait parameters in the current study follow trends seen in studies focusing on agility training in individuals with PD.

Cognitive TUG

Along with the improvements in gait parameters, near statistical significant changes in cognitive TUG scores were evident in the entire group. In further analysis of the between group results, the agility group was able to achieve reduced times to complete the Cog TUG in comparison to the results of the WBV group. See Figure 5 for pre and post-test comparisons. This is not the first time this result has been observed. In a previous pilot study by Rivera et. al., the Cog TUG was measured after an 8-week Yoga intervention. When the pre and post-test results were analyzed, there was a decrease in Cog TUG time by -4.27 seconds (MCID not reported in PD or community-dwelling older adults).

The findings in Cog TUG is intriguing as the change scores in the TUG were not comparable. Given the Cog TUG is a dual task activity, there may be greater changes in dual task gait activities compared to gait velocity. Similar findings were observed in a study by Brauer et. al. subjects with PD were given 6 different dual task conditions with cognitive or motor components while walking.[18] Gait parameters were measured during these conditions. Between pre and post- measurements, one 20-minute training session of stepping with counting dual task was given to subjects. Gait speed saw improvements in 4 of the 6 conditions and step length improvements were identified in 5 out of the 6 conditions.[18] Another study utilizing a 10-week Hi-Balance training program instituted program difficulty by adding dual task activities. After training, there was an 8% improvement in cognitive walking in the dual task training group.[27] Both studies did not utilize the cog TUG, however they did use an outcome measure of gait parameters with cognitive loads to accurately determine if their training program created change in individuals with PD.

Comparison to Norm Values

Aside from improvements in outcome measures, the results of this study were compared to age matched normalized values for gait in elderly adults in observational studies. The average age of the study subjects was 67 years old (range=59-77 years). For community dwelling older adults, the group of 65-69-year-old subjects had higher performance than the subjects in the current study in the areas of gait velocity and step length. However, in both agility and WBV, the groups fell within the normal ranges for cadence. The study subjects were also compared to normal values in adults ages greater than 70 years as the range was up to 77 years old. Using this age range, the subjects fell into normal ranges in gait velocity, cadence, and step length.[34] The ability of individuals with PD to produce performance improvements in gait parameters to meet age matched norms in community dwelling adults shows potential to normalize gait patterns. In terms of normalizing gait, interventions of agility or WBV may be an avenue to decrease gait variability which could lead to a decrease in risk of falls.[35] See Table 6 for comparison of current study's result to aged matched normal values.

Gait Variability

Another consideration when assessing the outcomes in PD motor investigations is to adequately measure gait variability. Hausdorff favors this method by stating that gait variability is a relevant measure, which provides a sensitive method to evaluate a person's response to treatment interventions.[36] A study by Frenkel-Toledo analyzed gait parameters during over level-ground walking, over level-ground walking with a 4-wheel walker, and treadmill training in persons with PD.[9] Although treadmill training was strongly favored as an effective cue to decrease gait variability, no difference in step length was observed when all conditions of ambulation were compared. When looking at stride time and swing time, the averages of these measures yielded no difference between walking conditions. However, when these measures were analyzed for the percent of variability, there was significant difference between both over ground conditions and treadmill walking with the treadmill providing a cuing effect to set pace at a consistent rate. By measuring gait parameter averages, the current pilot study was unable to measure variability accurately and accordingly. Utilizing stride-stride time, swing-swing time, and variability of these measures can be analyzed to determine the effectiveness of a treatment, degree of disease effect on gait, and the risk of falls a person has when their gait is impaired.

Limitations

This study was a pilot study and produced helpful insight into future suggestions through the limitations identified. Eight individuals comprised the subject group. If any subjects had dropped out from the study, this would have decreased the strength of the study. A larger group of individuals would have allowed room for drop outs, and provided a stronger study with a sample that more represents the population of persons with PD. By having a larger sample this study would have been able to exclude outliers, so the data would not be skewed.

Due to the nature of the study, group interventions did not allow for individualized intervention focus. PD has many areas that could present with deficits. Common areas of deficits include balance, strength, ambulation, bradykinesia, postural control, cognition, and flexibility.[3] Each person with PD has different severity of symptoms and limitations from the disease. To effectively decrease the limitations of each symptoms an individualized physical therapy program needs to be implemented.[4] Having an individualized plan of care will target areas of deficits that can improve gait variability, balance and freezing of gait which can all lead to a decreased risk in falls.[4] If a plan of care was developed for each subject by case, perhaps there would have been more improvements in gait parameters measured in this study.

The current study features 2 intervention groups of WBV of agility training. In studies they include a control group that is a treatment that is independent from the treatment interventions that are being analyzed or compared.

Clinical Relevance

The results from the current pilot study reveal several key clinical implications. In the case of addressing the deficits that result from PD progression, a multi-modal plan of care should be implemented. There is no standard physical therapy treatment that can address the numerous signs and symptoms that lead to limitations in activity, participation, environment, and personal factors. When comparing 2 interventions, WBV and agility, there was no significant difference between groups in improving gait parameters for individuals with PD. The results of the current pilot study follow the trend in research that there is no single treatment for PD. A combination of treatment strategies is needed to address the many areas of deficit such as balance, strength, gait, postural instability, and flexibility. When implementing a task specific intervention, there needs to be an outcome measure that correlates with conditions of that intervention to accurately detect change in that area of deficit. For example, for a decrease in performance with cognitive loading, an intervention of dual task training would be appropriate. However, to measure change in performance under dual task conditions, an outcome measure such as the cognitive TUG or gait parameters with dual task need to be conducted. When cognitive or motor tasks are added to gait training there has been an observed change in gait variability. Results from this current study suggest perhaps by participating in interventions under dual task conditions can decrease gait variability. By decreasing this variability in gait in persons with PD, there further possibility of decreasing the fall risk in this population that will become more common in the future.

Further Direction

This pilot study was a pioneer in discovering the effects of intermediate WBV frequency on gait parameters for individuals with PD. It would be a pleasure to see this study continued with minor changes to the methods. Some suggestions include a longer length of intervention to accommodate for normal neural adaptations during a training protocol. A length of intervention longer than 8 weeks would accomplish strength gains and hopefully increase improvements in gait parameters. By having a larger group of subjects, future studies could more accurately represent the growing population of persons with PD. A control group would be a useful addition to future research. A control group of flexibility training would allow for comparison to previous study's interventions of flexibility be a comparison for normative data of improvements. Using flexibility as a control intervention would also strengthen the study by giving intention to treat to all intervention groups. Utilizing an outcome measure specific to gait variability will also add to the field of literature discussing the ability to change this deficit individuals with PD experience. This problem can be detected measuring gait parameters, and can reveal an underlying increased risk of falls for persons with PD.

Conclusions

The results of this study have messages to carry over into physical therapy practice. When working with persons with PD it is best to adopt a multimodal plan of care. This is necessary especially with the progression of PD due to its variable presentation in persons and the degree of symptoms vary on an individual basis. When targeting specific deficits by using task specific interventions, an outcome measure that correlates to the performance at question is best to determine if your treatment if causing positive change.

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TABLES

Table 1. Intervention Day Breakdown

Group 1 Tuesday Thursday		Group 2 Tuesday Thursday		Group 1 Friday		Group 2 Friday	
Flexibility exercise/task	15 min	Flexibility exercise/task	15 min	Flexibility exercise/task	15 min	Flexibility exercise/task	15 min
Vibration	9 min	Drills	8 min	Vibration	9 min	Walking, step up, and turning	9 min
Bertec	15 min	Walking, step up, and turning	9 min				
Drills	8 min	Bertec	15 min				

Table 2. Details of Interventions

Flexibility exercise/task	• **Exercises: Prone, supine, sitting and standing activities** • **Standing weight shifting, standing trunk rotation, standing tall** • **Prone stretching, prone to stand with chair (assisted with DPT students)** • **Sitting trunk flexion, trunk rotation, leg ROM**
Drills	• Walk forward and walk back counting out loud • Dual task activities: dynamic forward reaching to various objects (random activity) • Side to side stepping
Bertec Balance Advantage	• Dynamic stability • Rhythmic weight shifts to targets • Squats and lunges
Walking, step up, down, and turning	• Walking activity incorporated with stepping up, down, and over obstacles • Includes walking around and turning objects • Dual tasking activities (walking and pointing out environmental objects) • All individuals will be supervised
Whole Body Vibration: Galileo Med L	• Side to side alternating amplitude 5.2mm • Begin first session with 1 minute for 3 repetitions: increase each session for 1 minute • Work up to 3 minutes 3 times: 9 minutes total • Stop the WBV session with symptoms of nausea or dizziness. Individuals will not be returned to the next activity until symptoms have resolved. • Individuals will be supervised at all times

Table 3. Subject Characteristics

	Subject Demographics										
	Subject	Sex	H&Y	Age	AD	ON/OFF State	Years Dx	Comorbidities	Levodopa Meds	Depression Meds	Other Meds
Agility	1	F	2	58	SPC	ON	2	3	yes	no	6
	2	M	3	69	no	ON	4	4	no	no	5
	3	M	1	59	no	OFF	1	2	no	no	5
	5	F	2	75	no	ON	2	6	yes	no	6
WBV	6	M	3	76	no	ON	8	0	yes	no	3
	7	M	4	69	SPC, FWW	ON	6	2	yes, 2	yes	6
	8	F	2	65	no	ON	5	0	yes	no	0
	4	M	4	69	Scooter, Cane, FWW	ON	17	2	yes	yes	6

Table 4. Post-test Measurements of Whole Group

	VELOCITY (meter/second)			CADENCE (steps/minute)			STEP LENGTH (centimeters)		
PD #	Pre	Post		pre	post		pre	post	
1	96.08	97.95		117.95	109.69		49.39	52.66	
2	94.79	100.84		97.23	101.86		57.78	62.99	
3	110.45	112.04		96.64	105.45		67.66	65.45	
4	57.23	69.98		100.15	98.48		34.38	41.28	
5	75.42	85.76		106.95	105.23		41.74	48.87	
6	108.78	96.81		106.45	100.13		60.89	57.48	
7	102.30	97.33		100.62	108.23		60.5	55.75	
8	73.61	96.56		83.36	100.77		50.39	57.19	
MEAN	89.83	94.66	p=0.126	101.173	103.73	p=0.214	52.84	55.21	p=0.112
SD	17.80	11.48		9.336	3.770		10.31	7.21	

Table 5. Pre and Post-test Means for WBV and Agility Groups

		VELOCITY			CADENCE			STEP LENGTH		
	PD #	Pre	Post		Pre	Post		Pre	Post	
AGILITY	1	96.08	97.95		117.96	109.69		49.39	52.66	
	2	94.79	100.84		97.23	101.86		57.78	62.99	
	3	110.46	112.04		96.64	105.45		67.66	65.45	
	5	75.42	85.76		106.95	105.24		41.74	48.87	
	MEAN	94.19	99.15	p=0.048	104.69	105.56	p=0.416	54.14	57.5	p=0.09 7
WBV	4	57.24	69.98		100.16	98.49		34.38	41.28	
	7	102.31	97.33		100.62	108.23		60.5	55.75	
	8	73.62	96.56		83.37	100.77		50.39	57.19	
	6	108.79	96.81		106.46	100.14		60.89	57.48	
	MEAN	85.5	90.2	p=0.299	97.7	101.9	p=0.24	51.54	52.92	p=0.34

FIGURES

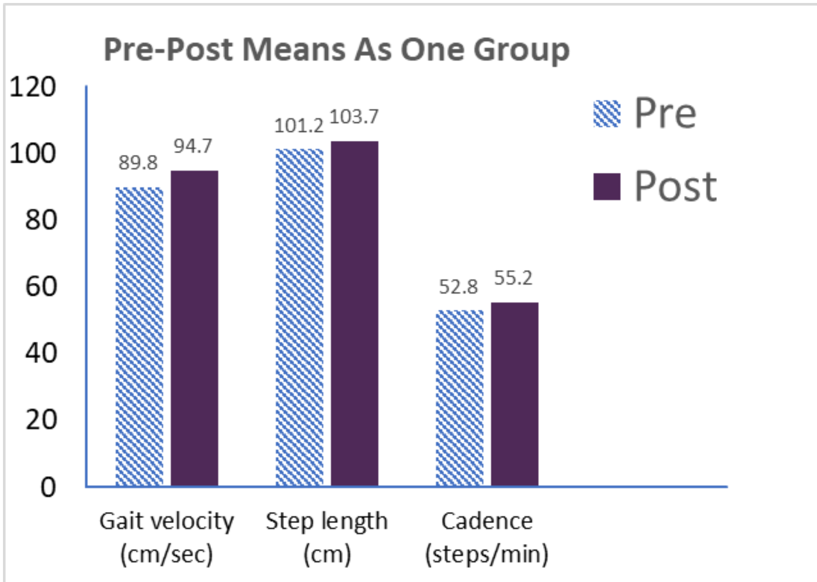

Figure 1. Pre and post-test means of gait parameters

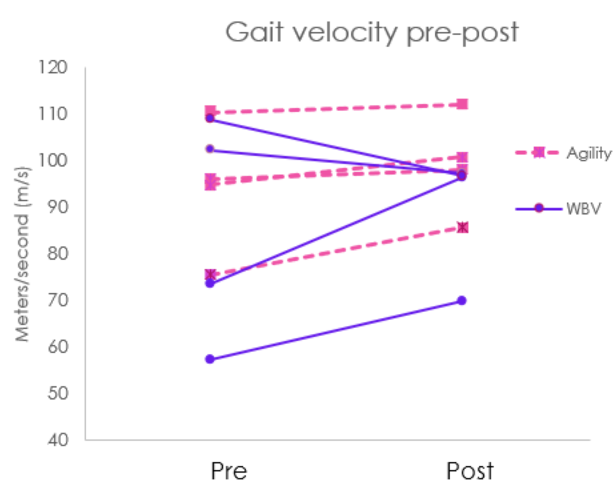

Figure 2. Gait velocity pre-post intervention

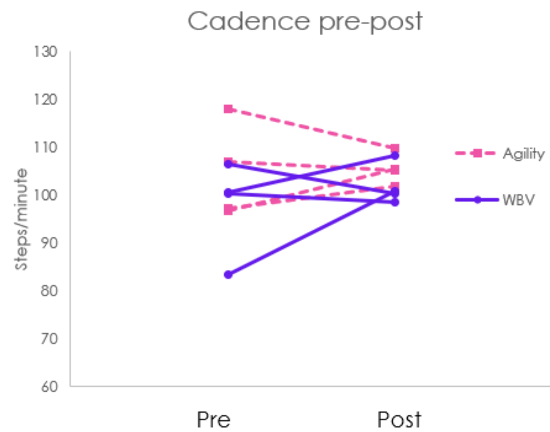

Figure 3. Cadence pre-post intervention

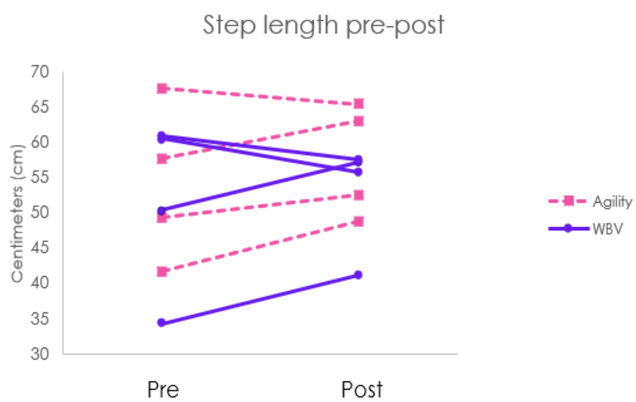

Figure 4. Step length pre-post intervention

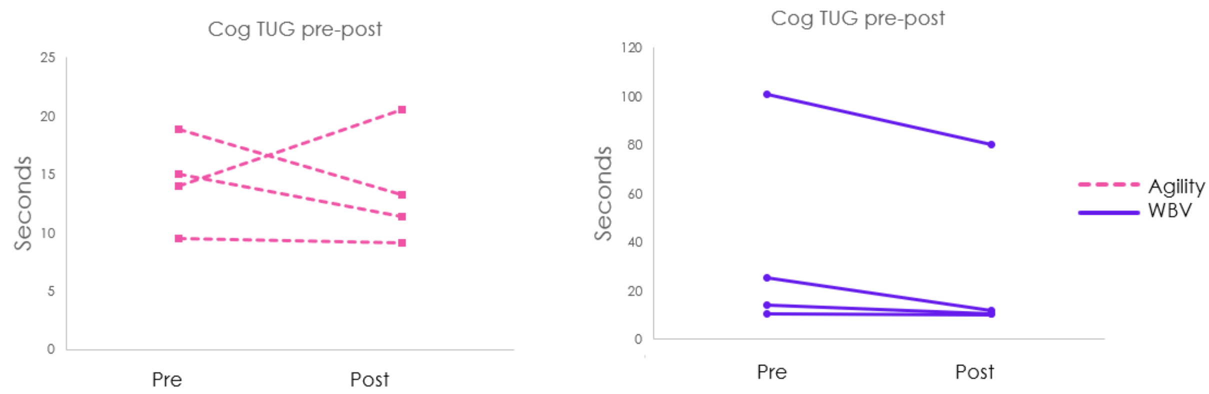

Figure 5: Cognitive TUG analysis by group before and after interventions