

**EFFECTS OF EXERCISE ON BALANCE AND FUNCTION IN PARKINSON'S
PATIENTS**

A Thesis by
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The following faculty members have examined the final copy of this thesis for form and content, and recommend that it be accepted in partial fulfillment of the requirement for the degree of Master of Education with a major in Exercise Science.

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DEDICATION

I dedicate this thesis to my family who helped me achieve my dreams. To my husband who gave up his time with me so I can lock myself in the office and write this paper. To Aspyn, my daughter, who babysat the dog and cats for me while I wrote and who made sure I ate while I was typing. I would like to thank those who were willing to see this study through and did not mind being the “guinea pigs” as they called themselves, Jim, Albert, Jim M., Nancy, Joyce and Wes. You motivate me to get up every day and move even when I think I can’t. Thank you all.

“Talent is God given. Be humble.

Fame is man given. Be grateful.

Conceit is self-given. Be careful.”

- John Wooden

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ABSTRACT

INTRODUCTION: Parkinson's disease (PD) is a disturbance of the neurotransmitter dopamine in the brain. Dopamine aids the muscle in normalization of sequential muscle movements, muscle tone, and automatic learned movements; balance is a combination of visual, vestibular and mechanoreceptors that factor into body position while standing. This study evaluated the effects of exercise on postural balance and strength in people diagnosed with Parkinson's disease. **METHOD:** Seven PD patients (5 male; 2 female) aged 55-76 participated in an exercise program consisting of progressive strength and balance training 3 days per week for 12 weeks. Balance was measured using the Biodex Balance System. Functional strength, endurance and flexibility were measured utilizing a battery of tests, including arm curls, chair stand, up and go, 6-minute walk, back scratch, and sit-and-reach. **RESULTS:** Pre to post comparisons found no significant difference in arm curl ($P = .071$), chair rise ($P = .586$), up and go ($P = .906$), 6-minute walk ($P = .619$), back scratch ($P = .257$), or sit and reach ($P = .604$). The Biodex Balance test showed no significant difference in anterior/posterior sway ($P = .456$), medial/lateral sway ($P = .248$), or stability index ($P = 0.82$). **CONCLUSION:** There was no difference after 12 weeks of postural balance and progressive strength training classes. Future testing should involve a longer training period, a greater number of participants, and a control group.

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Parkinson's disease (PD) is a debilitating disease that disrupts several physiological systems including neuromuscular, musculoskeletal, cognitive and sensory that are involved in proprioception. PD patients suffer different symptoms individually but all will eventually suffer with tremors and loss of postural balance. The lack of dopamine in PD patients affects their muscle in normalization of sequential muscle movements, muscle tone, and automatic learned movements. The lack of dopamine has an effect on postural balance. PD patients will eventually hunch their shoulders forward and shuffle the feet in plantar flexion. The combination of forward leaning of the shoulders and shuffling increases a risk for falls.

Exercise has been shown to be beneficial to those who have PD. Boxing, the Tango, Tai Chi, recumbent cycling, resistance training and water exercise are some of the many forms of exercise PD patients have performed in different studies. However, the optimal type and intensity of the exercise for PD patients is still unknown. Studies have shown that high intensity with short bouts of aerobic exercise give rise to more fluid movement directly after and for some time following the exercise in patients with PD. Other studies have shown lower intensity with longer bouts of aerobic exercise can increase fluid movement with less freezing and tremors.

Resistance training and balance training have been studied in the past with PD. Most of the studies show a positive effect of resistance and balance training on PD patients. The type of balance testing and strength testing differ among the studies along with the equipment used for balance and resistance training. Various studies have shown no significant

improvement in fall prevention between those with PD who participate in a balance training program and those who do not. Fall prevention is considered to be part of quality of life for PD patients.

1.2 Statement of the Problem

Studies have shown that exercise; progressive resistance training and motor training may improve balance-related activities in PD patients (Allen, Sherrington, Paul & Canning, 2011). Exercise has been found beneficial to those with mild to moderate PD (Hoehn & Yahr stages of 1-3). However, these topics are unclear:

1. Do those with stages 3&4 PD benefit from progressive resistance and postural balance training?
2. Does postural balance improve in PD patients that perform progressive resistance and postural balance training over a 12 week period?
3. Do the exercises require modification for patients with PD?

1.3 Significance of the Study

Exercise is an important treatment of the symptoms of PD and has been prescribed for over fifty years by physicians who believed exercise slowed down the progression of PD. Neurotrophic factors are released during exercise and neuroprotective effects (Zigmond, Cameron, Hoffer & Smeyne, 2011). However, physical exercise has not been shown to slow the progression of PD (Jankovic & Poewe, 2012). Balance is essential for standing and locomotion and is defined as the bodies center of gravity over a supportive base while standing or through movement; coordination of biomechanical, sensory, motor and central nervous system are combined (Kara, Genc, Colakoglu & Cakmur, 2012) and are encompassed under the title proprioception or awareness of the body in space.

Evidence based practice of exercise for PD patients are in demand. Physical therapists, occupational therapists, and exercise physiologists often work with PD patients. Studies that examine how exercise can benefit PD patients are needed. The type of exercise along with intensity, the type of equipment required for the best results, and modification to exercises are necessary knowledge for a successful program.

1.4 Hypotheses

1. Stage 4 PD patients will benefit from progressive resistance and postural balance training.
2. PD patients will have better balance following progressive strength and postural balance training.

1.5 Assumptions

It is assumed that all participants were at stage two or higher on theHoehn and Yahr scale for PD. It was assumed that participants would not be performing resistance training or balance training outside of class, as they were advised not to exercise outside of class.

1.6 Limitations

Participants have PD and fatigue easily and require several breaks. Medication for PD can cause nausea, dizziness, sleepiness, and irritability. PD patients are often nauseous depending on their medication and depending on the stage of PD will miss training class because of illness brought on by medication. The sample of PD patients involved with this study is small but, PD patients are likely to fall or lose their balance and a small group is easier to assist with stage 4 PD patients in attendance. This study did not include a non-exercising PD group (control group) for comparison.

1.7 Delimitations

The study was delimited to PD patients to perform progressive resistance and postural balance training. The PD patients took their medicine within a 30 minute time frame of participating in progressive resistance and postural balance training if needed.

1.8 Definitions

Activities of Daily Livings (ADLs): Activities performed on a daily basis for self-care such as standing up out of a chair, brushing teeth, dressing and using the toilet.

Akinesia: The inability to initiate movement due to bradykinesia and hypokinesia and results in a fixed posture that can last seconds or hours.

Bradykinesia: Slowness of movement and difficulty in initiating movement.

Bradyphrenia: Slowness of thinking.

Center of Gravity (COG): Balance over a base and is considered part of center of mass and can change depending where the body is in space.

Center of Mass: The point located in the center of the total body mass found by weighted average of each body segment.

Choreatic: A rapid movement that is unpredictable in direction or magnitude.

Cognitive Movement Strategies: A breakdown of a movement into sub-movements that should be performed in a series the same way every time.

Dopamine: A neurotransmitter that is produced in the substantia nigra compacta and is stored in axon terminals that terminates in the striatum. Dopamine is responsible for normalization of sequential movement, automaticity of learned movements, and normalization of tone.

External Cues: Cues that are external or outside the body that direct an individual to perform the required task.

Freezing: Inability to take steps or move from the position the individual is in and attempted movement cannot always be obtained.

Hoehn & Yahr Scale: Stage 1- unilateral disease; stage 2- bilateral disease, balance intact; stage 3- mild to moderate bilateral disease, some postural instability, physically independent; stage 4- severe disability, still able to walk or stand unassisted, stage 5- wheelchair bound or bedridden unless aided.

Hypokinesia: A decrease in amplitude of movement and progressive lessening of amplitude with each repetitive movement.

Internal Cues: A stimulus driven response to initiate a movement, thought to be from the basal ganglia in the brain.

Intrinsic Fall Factors: Fall risk factors related to the patient such as weakness, limited vision, reduced sensory input, impaired cognitive status, and so forth.

Motor Fluctuation: A change in the ability to move in response to taking dopamine replacement medications, they can be subtle or dramatic and are related to dopamine levels in the brain.

Movement Strategies: External cues such visual or verbal cues and internal cues given by the basal ganglia.

Neuroplasticity: Ability of the brain to reorganize itself after an injury or disruption of neural connections.

Neuroprotective: Slows down the neurodegeneration.

Postural Tremor: A type of essential tremor that occurs while attempting to maintain a position in which the body part is not fully supported against gravity.

Proprioception: Biomechanical, physiological, neurological and cognitive awareness of where the body is in space.

Resting Tremor: A tremor that presents itself when a body part is at rest and supported. This type of tremor is associated with PD.

Rigidity: Increased resistance felt throughout the movement by the evaluator when passively moving a body part.

Sarcopenia: Loss of muscle mass

Stride Length: The distance covered from one heel strike to the next heel strike of the same foot.

Tandem Standing: A static standing position the one foot is directly in front of the other with the toes touching the heel of the foot in front.

Tremor: A rhythmical involuntary movement of a body part.

Verbal Cues: Cues that are clearly spoken and give direction on how and where to move the body in accordance with the task.

Visual Cues: A marking, light, or another object that can be seen and cues the individual to perform the required task.

CHAPTER 2: REVIEW OF LITERATURE

2.1 Parkinson's Disease

Parkinson's disease (PD) is understood to be a progressive neurodegenerative disease that might be genetic in a small number of PD patients. More belief that PD is a multi-factor disease that involves the environment and multiple genetic predispositions (Fernandez, 2012), although to date no clear cut finding has been proven. PD presents with disruption of motor control, movement patterns, rigid limbs, bradykinesia, balance, and gait deficiencies. Non-motor features such as pain, depression, and fatigue are also present (Fernandez, 2012). PD patients suffer a loss of motor control from a neuronal loss of dopamine and symptoms from PD are generated when neuronal loss reaches up to half in the posterior putamen of the brain (Pagan, 2012). With greater loss of dopamine cells, synthetic dopamine is required for the PD patient. Levodopa is synthetic dopamine and after months to years of use the synthetic dopamine starts to create tremors in PD patients as well (Pagan, 2012).

2.1.2 Treatment of Parkinson's disease

PD is a debilitating disease that slowly takes control of the body and then the patient may eventually develop dementia. PD patients are mostly treated for motor symptoms and the signs of PD without being treated for the depression that comes with PD. Medication and surgery are the two most widely used treatments for PD with exercise becoming a growing focus in the treatment of PD (Utti, 2011). Exercise intervention studies with those who have PD have shown positive results but often a return to baseline values once the supervised period of exercise is completed. This return to baseline values is likely caused by the decline in physical activity once the supervised exercise is finished (Erne, McRae & Schenkman, 2011).

Several forms of exercise have been studied with the PD population including Tai Chi which found PD patients had a lower incidence of falls in comparison to a stretching group and a resistance training group (Fuzhong et al., 2012). Endurance exercise has been found to be beneficial in motor control and movement patterns in PD patients (Muller & Muhlack, 2010). Aquatic therapy is a more recent form of therapy for PD patients and has been shown to benefit postural stability (Vivas, Arias, & Cudiero, 2011).

The cost of continually having to pay a physical therapist can be expensive and insurance does not always cover the cost of Parkinson's specific classes that are one-on-one or in a small group with a physical therapist. The cost-benefit ratio of exercise was examined in a study that evaluated healthcare in social care, hospital based care, and primary health care. The outcome found that there is a high probability that exercise is a cost-effective form of treatment for PD (Fletcher, Goodwin, Richards, Campbell & Taylor, 2012).

2.1.3 Postural Instability

Postural instability in PD is characteristically seen in the stooped forward posture and the shuffle movement of the feet. Decreased joint range of motion, a narrowed foot stance and axial rigidity (Nagumo & Hirayama, 1996) cause musculoskeletal instability that negatively effects postural balance (Conradsson, Lofgren, Stahle, Hagstromer & Franzen, 2012). Balance training is often studied in PD patients because of lack of motor control and balance that leads to falls. A study that evaluated balance training on PD patients found that balance training improved postural stability, confidence level in performing daily activities that involve postural stability and reduced the frequency of falls (Smania et al., 2013). A home-based balance training program using the Wii Fit Balance Board also found static and dynamic balance, and functional daily tasks were improved in PD patients (Esculier, Vaudrin, Beriault, Gagnon & Tremblay, 2012).

2.1.4 Freezing of Gait

Disturbances in gait are among the main symptoms of PD and contribute to a patient's immobility and loss of independence. Sensory cueing can improve gait control (Rubinstein, Giladi & Hausdorff, 2002). Movement strategies are often utilized in therapy with PD patients and include visual cues and verbal cues that along with exercise have been found to improve walking speed, balance, endurance and quality of life (Morris, Iansek & Kirkwood, 2009). Freezing of gait can be negated with sensory cues such as verbal and visual cues that are a way of tricking the brain and body to connect in a movement pattern. Overloaded attention of the PD patient and lack of understanding of what is causing the disturbance of movement can add or detract to the cueing of tasks with freezing of gait. Development of future cueing programs for alleviating freezing of gait are in need of incorporation with PD programs (Nieuwboer, 2008) (Van Vaerenbergh, Vranken & Baro, 2003). A study with early stage PD patients that had not started medication found that bradykinesia, rigidity and a lack of dopamine provided limited movement in gait, combination of drug treatment and physical exercise with external cues might improve gait in PD patients (Winogrodzka, Wagenaar, Booij & Wolters, 2005). Freezing of gait can arise through any type of movement pattern and a rapid movement out of a freezing episode can lead to falls. Cueing has been shown to reduce freezing of gait while turning (Spildooren et al., 2012) and can alleviate some of the fatigue that may be caused by freezing of gait. The reduction of external cues was found to slow movement and the verbal cue "stand up" along with the PD patient trying to stand up was found to increase freezing of gait (Georgiou et al., 1994).

The effect of high intensity exercise on PD patients showed improved gait speed, stride length, and distribution of weight during sit-to-stand measures but showed no improvement in

those who participated in low intensity exercise (Fisher et al., 2008). Progressive resistance training showed improvement in the center of pressure for body weight in base support, in stride length and gait speed, suggesting that lower extremity strengthening may have important therapeutic results (Hass, Buckley, Pitsikoulis & Barthlelemy, 2012). Gait performance is positively correlated with lower extremity strength and can improve mobility of the PD patient (Nocera, Buckley, Waddell, Okun & Hass, 2010).

2.1.5 Quality of Life

Quality of life (QOL) is needed throughout our lives and is often the most important aspect of treatment that PD patients speak about. QOL is affected by PD because activities of daily living (ADLs) are a struggle to attend by themselves. PD patients find it harder to feed themselves because of tremors that shake the hand. Likewise, brushing their teeth requires motor control as do most ADLs. Supervised exercise for PD patients found an improvement of QOL, motor control, mental and emotional functions, ADLs, general quality of health (Dereli & Yaliman, 2010) and perceived health by those with PD (Yousefi, Tadibi, Khoei, & Montazzeri, 2009).

2.1.6 Balance Loss

Balance is essential in locomotion and is described as the ability to maintain center of gravity over the base of support while either standing motionless or movement. Balance involves proprioception that coordinates the body in movement patterns. PD causes a loss of balance and postural control because of neuronal deterioration. Balance training for static and dynamic balance in physical therapy and unsupervised home programs has been shown to be beneficial to PD patients. A study that conducted dynamic and static balance exercise in a physical therapy program showed significant improvement of the limits of stability in both dynamic and static

balance (Kara, Genc, Colakoglu & Cakmur, 2012). Home exercise plans that perform balance exercises can be beneficial to PD patients with improvement to ADLs such as functional reach in front and back and a significant decrease in the timed chair rise test (Balci, Kara, Colakoglu & Cakmur, 2010).

Falling is often a result of loss of balance due to a lack of sensory information or proprioception, and possibly lower extremity weakness (Goodwin et al., 2011). A study that provided ten weeks of strength and balance training with once weekly group meetings and twice weekly home sessions found no effect of balance and strength training on falls in PD patients (Goodwin et al., 2011).

2.2 Recommended Exercises for Parkinson's disease

Community-based exercise programs for older adults are often implemented to encourage a healthy and active lifestyle (Archer, Fredriksson, Schutz & Kostrzewa, 2011). A community-based program for PD patients for 10 months examined PD patients while walking on a treadmill forward to increase endurance, speed, and stride length and backward walking because PD patients often fall backwards. Mat exercises for an increase of spinal and hip strength were also performed. After 10 months maintenance of walking speed and stride length were seen but there were no significant improvements (Steffen, Petersen & Dvorak, 2012). Another study compared three different groups of exercising PD patients and found no significant difference in balance among the three groups following training. The three categories for exercise were flexibility, balance, functional exercise (FBF), supervised aerobic exercise (AE), and home-based exercise (control). The FBF group was supervised by a physical therapist and exercises that were designed to strengthen postural stability and functional movement (Schenkman, Hall, Baron, Schwartz, Mettler & Kohrt, 2012).

Cardiovascular training has shown benefits among the general population, including older adults. Studies have shown that there is an increase of dopamine and motor control (Fisher et al., 2008) after high intensity exercise in PD patients. However, it is unknown how long PD patients are able to perform higher intensity exercise and do lower intensity levels of exercise provide benefits? Dance for the PD patient is a lower-intensity exercise that still has repetition for movement patterns, increases the heart rate, and is thought to increase neuroplasticity in the brain (Hirsch, Hammond & Hirsch, 2008). PD patients may benefit from dance because of work with movement patterns and an increase of neural plasticity which may help with neuronal effects from PD in the brain (Hirsch, Hammond & Hirsch, 2008).

Gait training is used with PD patients since that is sometimes the trigger that leads to a diagnosis of PD. Visual cues have been used with PD patients. A study that examined one month of visually-cued gait training for thirty minutes, three times per week, found that step length increased as did gait speed (Sidway, Anderson, Danielson, Martin & Smith, 2006). Gait training with visual and auditory cues was found to improve gait performance in PD patients. Auditory cues improved cadence and visual cues improved stride length significantly (Suteerawattananon, Morris, Etnyre, Jankovic & Protas, 2004).

2.2.1 Evidence Based Exercises for Parkinson's disease

Recommended exercises from an evidence-based perspective are becoming the norm in the world of exercise. Evidence-based exercise for PD considers exercises that strengthen postural instability, balance, flexibility, gait, mobility, upper body strength, and physical activity or inactivity. An analysis of evidence-based physical therapy recommendations for those with PD found six categories that exercise should focus on: transfers, posture, reaching and grasping, balance and falls, gait and physical capacity and activity. Within those six categories there are

four recommendations based on evidence: cueing for improvement of gait, cognitive movement strategies to improve transfers, balance exercises, and range of motion exercises for joint mobility and resistance training for muscle power (Keus, Bloem, Hendriks, Bredero-Cohen & Munneke, 2007). Evidence-based training for those with advanced stages of PD are less clear but as long as the individual is able to perform the exercise it is recommended (Gallo & Garber, 2011). Resistance training focusing mostly on the lower body for an eight week period with PD patients increased their functional strength (Scandalis, Bosak, Berliner, Helman & Wells, 2001) and provided more evidence for progressive resistance training to improve functional strength among PD patients. Strength training and aerobic exercise have been shown to increase grip strength and endurance in the 6-minute walk test in those with stage 1-3 in PD patients (States, Spierer & Salem, 2011).

2.3 Recommended Testing

Tests for balance, functional fitness, flexibility, cardiovascular, and gait are ample in number but not always recommended for PD patients with disabilities. Studies that have measured balance often use Berg Balance Scale, functional reach test, Tinetti Gait and Balance Test, Functional Gait Assessment and Balance Evaluation Systems Test (Leddy, Crowner, & Earhart, 2011) and the Biodex Balance SD (Parraca et al., 2011). Functional fitness is often measured through a sit to stand test and bicep curl test. Flexibility is often measured through a sit and reach test and back scratch test. Cardiorespiratory fitness is often measured by the Six Minute Walk Test (VanSwearingen & Brach, 2001), 2-Minute Step Test, or the Incremental Shuttle Walk Test.

2.3.1 Recommended Balance Testing

Balance testing for the PD patient is an effective measure of their balance and postural stability. The Biodex Balance SD measures sway which can be thought of as postural instability brought on by movement, muscle weakness, or an imbalance. PD patients will generally have more sway than their age-matched cohorts in both static and dynamic postural stability (Ebersbach & Gunkel, 2009). A study that compared standard balance physical therapy exercises to a computerized dynamic posturography therapy did not find any significant difference between the two forms of balance training but did demonstrate a need for further study of computerized dynamic posturography therapy (Qutubuddin et al., 2007). The computerized dynamic posturography system can be used to measure sway as well as for balance training; Biodex Balance SD is such a system.

2.3.3 Purpose

PD patients struggle with balance and are known for falling frequently as their PD progresses. The purpose of this study was to improve postural balance through postural balance exercises and strength training with those who are in stages 3-4 of PD. Possible people who could benefit from this research:

1. Stage 1 & 2 PD patients
2. Other people who suffer neurological diseases such as Multiple Sclerosis and Huntington's disease.
3. Older adults in general

CHAPTER 3: METHODS

3.1 Participants

Seven participants who have PD between the ages of 61 and 75, in the Hoehn & Yahr stages of 3-4 were recruited for this study. Five PD patients were acquired through memberships at the North West YMCA where the postural balance and resistance training program took place. Two were recruited through a physical therapy clinic. All had been diagnosed with PD in the last 10 years.

3.2 Procedures

All participants signed a medical waiver and had attained permission to participate from their physician before starting the study. Participants were asked to sign an informed consent and were given written instructions of the study before participating in the study. Once permission had been obtained from the Wichita State University Internal Review Board (IRB), the participants met at the Human Performance Laboratory at Wichita State University and balance was measured on the Biodex Balance System SD. Height, weight, and age were recorded. On the following day, the participants met to perform the Senior Fitness Test in which all data were collected for pre-exercise measures.

The PD patients met 3 times a week for 45-60 minutes for a total of 12 weeks during the postural stability and strength training program, once testing was completed on a non-consecutive day. At the completion of 12 weeks, PD patients met again at the Human Performance Laboratory at Wichita State University to repeat balance testing. The following day the PD patients performed the Senior Fitness Test.

3.2.1 Biodex Balance Systems SD Testing

Postural stability was measured using the Postural Stability Test. The test requires three separate 20 second time trials with a 10 second rest between time trials. The participant's height and age were entered into the Biodex SD (Biodex Medical Systems Inc., Shirley, New York) and the height determined where the participant stood. During each 20 second postural stability test the participant focused on standing up and keeping their center of gravity trying to keep in the center. The Biodex measures postural stability in the sagittal plane (anterior/posterior sway) and in the frontal plane (medial/lateral sway). Both anterior/posterior and medial/lateral sway was measured concurrently while the participant was trying to stay balanced for twenty seconds. The higher the sway index the more unsteady an individual was during testing.

3.2.2 Senior Function Test

Timed 8-foot up and go test

The participant started seated in a chair with the hands on the thighs and feet flat on the floor, shoulder width apart. The participant was given instructions as to how to perform the timed up and go test. At the cue "go" they stood up and walked around a cone eight feet away as fast as they could and returned to the chair in a seated position. The best time of two trials was recorded.

Timed 6-minute walk test

Participants walked around a 50 yard perimeter that was marked off with cones every five yards for six minutes. Each participant was encouraged to walk as quickly as they could, without running, for six minutes or until they could no longer continue. At the end of six minutes the participant's length walked to the nearest cone was recorded with the time, whether they were

able to achieve the full six minutes or not. A walking aid was allowed for anyone who may have needed a walking aid.

Timed bicep curl test

Each participant performed bicep curls for 30 seconds while seated. The participant shifted closer to the side of the chair and held a five or eight pound weight, depending on gender (females held 5 lbs and males held 8 lbs), with the arm fully extended. The participant sat tall with the feet on the ground and raised the weight towards the upper arm bending only at the elbow for as many times as possible in 30 seconds. The test score was the number of bicep curls performed in 30 seconds.

Timed chair rise

Participants started in a seated position in a chair with the feet flat on the floor, shoulder width apart, and the arms crossed over the chest. The participant stood fully upright and sat down in the chair as many times as possible in a 30 second trial. The score was the highest number of stands accomplished out of two 30 second trials.

Shoulder reach test

Standing upright each participant took one arm and placed it behind their back and the other arm over their shoulder while trying to touch the fingers together. Each arm was tested in both positions and then the position that had the most reach was measured again for a second trial. A positive score reflects how many centimeters the fingers were overlapping. A negative score reflects how many centimeters the fingers were short of touching, to the nearest centimeter. Two trials were conducted and the best score was used for analysis.

Sit and reach test

Starting in a seated position the participant extended their dominant leg and reached with both hands overlapped for the foot while keeping the leg straight. The score was the distance that the fingertips were from the toes to the nearest centimeter. A positive score is the measured amount extended beyond the toes. A negative score is the measured amount that the fingertips did not reach the foot. The best measurement of two trials was scored.

3.3 Progressive Postural Balance and Strength Training Exercises

3.3.1 Postural Balance

Tandem gait stance

The participant stood heel to toe on two green foam pads while placing the center of gravity over the feet. Participants stood upright looking straight ahead and a chair or ballet bar was used if needed, to hold onto for a 10 second, 20 second, and thirty second hold, the test was performed with each foot to the front.

Mambo walk

One blue Theraband foam pad approximately 18 inches long (Theraband, Hygenic Inc., Akron, OH) was placed on the floor width wise and the participant stood sideways with left hip next to a chair or bar, facing the foam pad on the floor. The participant first stepped forward with the left foot onto the foam pad then the right foot onto the floor, and then the left foot stepped forward off the pad and shifted the weight onto the front foot. Then the left foot stepped backward onto the foam pad and right foot stepped backward onto the floor, the left stepped backward off of the foam pad and the participant shifted their weight onto the back left foot. These were performed for 12-20 repetitions and then switched lead foot and repeated.

Heel raises and toe rises

A blue Therband foam pad was placed on the floor width ways behind a chair or ballet bar. The participant stepped onto the foam pad with both feet, allowing the heels to hang off the foam pad, participants performed 12-20 heel raises and toe rises in a rocking motion of their feet.

Modified squat repetitions

A blue foam pad is placed on the floor width ways behind a chair or ballet bar and then the participant placed both feet onto the foam, two were used for bigger feet with foam pads turned length ways and placed side by side. Participants performed a modified squat (forty five to fifty degree bend in the knee) this was repeated for 12-20 repetitions.

Balance stand on foam pad

A blue foam pad was placed length ways on the floor in front of a chair or ballet bar and the participant placed the right foot on the foam pad. Once the participant was on the foam pad, they shifted their weight to the right side of their body and balanced for three seconds on the right foot. This motion was repeated for 12-20 repetitions on each side of the body.

Tandem stance

The participant placed the right hip towards the chair or ballet bar and placed the left foot behind the right foot with the left toes touching the right heel in a tandem stance. The participant held this stance for ten seconds and then switched feet and repeated as many times as desired.

3.3.2 Resistance Training Lower Body

Each exercise was performed for 12-20 repetitions and unilateral exercises were performed on each side of the body.

Squats

The participant placed a resistance band (Theraband, Hygenic Inc., Akron, OH) under the feet held the ends of the

band with the hands. The participant squatted back as if they are going to sit in a chair, to a ninety degree bend or be close to a ninety degree bend in the knees.

Leg extension

A resistance band was placed under the right foot after the participant sat down in a chair. Once the band was around the foot the participant leaned back slightly and pulled the knee towards the chest and while holding onto the resistance band the participant extended their leg out.

Knee extension

While seated the participant wrapped a resistance band under the left foot and leaned back. The participant extended the left leg out, bending at the knee only.

Leg abduction

The participant wrapped a resistance band under the right foot and held the ends of the resistance band with the left hand. Either sitting or standing, the participant pulled the right leg out to the side and brought the leg in slowly.

Point and extend

While seated the participant placed a resistance band under both feet and moved their ankles through plantar and dorsi-flexion.

Leg adduction

A resistance band was wrapped around the participant's legs so as to provide moderate resistance, then the participant stood on the ends of the resistance band with the right foot, the leg was moved across the body and brought back to the original position..

Hamstring curl

A resistance band was wrapped around the participant's right leg and the ends of resistance bands are stood on by the left leg. The participant held onto a chair or ballet bar if necessary and flexed the right knee.

Gluteal squeezes

The participant stood erect facing a chair or ballet bar and placed the hands on the chair or bar and shifted the weight over to the left leg and lifted the right leg while squeezing the gluteus maximus, while trying to keep the right leg straight.

3.3.3. Resistance Training Upper Body

Lat pull down

The participant, while seated, held each end of the resistance band with the hands over the head and slightly anterior. The participant pulled the resistance band out and down, so as to engage their latissimus dorsi muscles.

Resistance band row

The participant held the resistance band closer to the center of the band and straightened the arms in front of them. The participant pulled the resistance band back with the elbows while trying to squeeze the shoulder blades together.

Chest press

The resistance band was wrapped around the participant and pulled under their arms and each end of the band was held with a hand. The participant was cued to push with both hands forward to the center of the chest.

Bicep curls

The resistance band was placed under the participant's feet while they were seated and with both ends of the band in each hand. The participant started with arms down by the side. Once cued, the participant brought the hands up bending from the elbow only, and finished with palms supinated.

Tricep kick-backs

The resistance band was grasped with the left hand at one end while the right hand held the resistance band close to the chest. The left arm was extended out with the left palm facing the floor. The participant extended the arm in and out from the elbow joint.

Front raises

The participant held one end of the resistance band in the left hand, while stepping on the other end of the band. The participant raised the arm, while holding the resistance band, from the shoulder through a range of motion that they could achieve.

Lateral raises

While seated, the participant had one end of the resistance band in the right hand with the other end of the band under a foot. The lifted the right arm out to the side as high as possible.

Abdominal crunches

While seated, the participant had the resistance band wrapped around them and the chair holding onto both ends of the band. The participant sat with the abdominals retracted and bent forward.

Abdominal strength

The participant, while seated, was cued to move towards the front of the chair. The

participant placed a hand across the chest and leaned back to where they almost touched the back of the chair.

Modified lemon squeezes

The participant, while seated, was cued to move towards the front of the chair while holding onto the sides of the chair. The participant lifted both legs off the ground and pulled the legs towards the body and away from the body. Modified options were as follows: if both legs could not be lifted then one leg was pulled towards the body and away from the body and then legs were switched out.

Analysis was performed using SPSS version 20.0 (Chicago, IL, USA). Absolute values were used for statistical analysis. Relative change was used to provide a clearer translation for the purpose of comparison between different units in the Senior Function Test. Percent changes were calculated from the difference in scores. Each parameter was examined for normality using the Kolomogorov-Smirnov test and assumptions of homogeneity of variance and sphericity were evaluated. Once confirmation of normal distribution of the data was obtained of all the variables, pre to post comparison were made using paired sample t-tests. A probability value of less than .05 was considered statistically significant.

CHAPTER 4: RESULTS

4.1 Introduction

This study started out with seven participants and one participant had to drop out because of a back injury sustained unrelated to this study.

Table 1
ANTHROPOMERIC MEASUREMENTS

Age	Sex	Height	Pre/Post Weight	PD Stage
61	F	160.2 cm	56.9 kg/56.8 kg	3
75	F	155.8 cm	80.5 kg/77.7 kg	4
61	M	174 cm	99.6 kg/98.6 kg	3
72	M	173 cm	65.0 kg/ 64.5 kg	4
73	M	177 cm	113.4 kg/110.7 kg	3
75	M	178.5 cm	81.5 kg/81.1 kg	4

4.2 Biodex Balance Test

The PD patients were tested for postural stability using the Biodex Balance System SD. The test performed was the postural stability test that test postural sway in four quadrants I, II, III, and IV. The four quadrants correspond to anterior/posterior sway and medial/lateral sway of each PD patient tested. Table 2 shows the means, standard deviation, and P value for the PD group. No significant differences were found in the postural balance measures after the twelve week study.

Table 2
 BIODEX BALANCE MEANS and SD

	Pre Means (SD)	Post Means (SD)	Diff. in%	P Value
Anterior Posterior	.720 (.363)	.560 (.385)	-22.2%	.456
Medial Lateral	.780 (.909)	.300 (.158)	-61.5%	.248
Stability Index	1.24 (.832)	.680 (.342)	-45.2%	.082

4.3 Senior Function Test

There were no significant differences among the results for the participants after the twelve week postural balance and resistance training program was finished as shown in Table 3 below.

Table 3
 SENIOR FUNCTION MEANS and SD

	Pre Means (SD)	Post Means (SD)	Diff. in %	P value
Arm curl #in 30 sec.	13.80 (3.3)	17.50 (6.8)	26.0%	.071
Chair Rise #in 30 sec.	11.30 (4.5)	12.00 (3.3)	5.9%	.586
Walk 8 ft (sec.)	11.40 (4.2)	11.15 (7.2)	-1.8%	.906
6-min. Wk (meters)	297.90 (113.1)	310.6 (147.7)	4.2%	.619
Back Scratch (cm)	-21.65 (14.96)	-18.53 (13.7)	-14.0%	.257
Sit & Reach (cm)	-7.17 (5.90)	-5.43 (8.89)	-12.6	.604

CHAPTER 5: DISCUSSION

5.1 Introduction

This study was conducted to determine if postural balance and strengthening exercise could improve postural balance in PD patients. The program offered balance training exercises on foam pads and on the floor. Strength training exercises for lower body and upper body were performed. Results of this study showed no significant difference after a twelve week postural balance and strength training program with PD patients. The PD patients were able to maintain strength throughout the postural stability and resistance training program, with one female participant no longer utilizing a cane at the end of the 12 week program.

5.2 Hypotheses Revisited

5.2.1 Hypothesis One

It was hypothesized that stage four PD patients would receive benefits from postural balance and progressive resistance training. The results show no significant improvement in postural stability.

5.2.3 Hypothesis Two

As previously stated, PD patients were hypothesized to improve postural stability and proprioception through the postural stability and progressive resistance training program. The PD patients showed no improvement in their transfer of weight to their feet and ability to stand up quicker with more stability, after twelve weeks of postural stability and resistance training than they did in the beginning of the training program. There was no decrease in the time it took to stand up and walk around a cone eight feet away and sit back down. As noted previously, Steffen, Peterson, and Dvorak (2012) had similar results with no significant

differences. There was no increase in the number of times the PD patients stood up and sat down, which showed no increase in strength or ability to transfer body weight quicker. The heel and toe raises on the foam pads may help with weight transfer as was found in the Tai Chi study (Fuzhong et al., 2012); where weight transfer was enhanced because of the rolling of heel to toes, however those effects were not shown in this study.

5.3 Exercise Modifications

Modification to balance training and resistance training exercises was needed for a few of the PD patients specifically those in stage four PD. Modifications were made to standing squats in the depth of the squat and in the amount of repetition, in comparison to the those who are in stage three PD. Lighter resistance bands were used for those in stage four and a ballet bar was in front of the stage four PD patients throughout all the standing balance and standing resistance exercises. A chair was always accessible and breaks were needed during some of the postural balance exercises and resistance exercises like the mambo walk. Stage four PD patients generally have an increase in tremors, an increase of freezing of gait, a walking device, and may have a lower fatigue level than the previous stages of PD. Each PD patient in this study had different symptoms and experience mood swings, fatigue, and nausea due to PD and medications, as also found in a study that profiled functional limitations of PD (Schenkman et al., 2011). Most studies focus on stage three PD and below because of the challenges stage four and five PD patients have with ADLs and exercise in general.

The PD patients were used to a smaller group that met through Parkinson's disease meetings at a local rehabilitation center. The PD patients that originally signed on to the study were able to meet two new PD patients and got to know them over the twelve week period. There was an air of socialization along with hard work during the training sessions. Once the

study ended the same group is continuing to meet and exercise together and have other social events. The PD patients as a group supported each other and motivated each other to put forth their best effort.

5.4 Limitations

This study demonstrates that PD patients in stages 3 through 4 are able to perform postural stability and resistance training exercises however; most studies work with stages one through three of PD patients. This study had too small a number of participants and previous studies with a higher number of participants have had significant results from postural stability, resistance training and balance training, as previously stated. This study did not try to determine which mechanism would be most beneficial; it was assumed that all mechanisms would be beneficial. A longer period of time might have resulted in significant findings in postural stability and resistance training, and is suggested that further studies increase the amount of time implemented for exercise training. There was no control group and neither the PD patients nor the evaluator were blind to the exercise or testing. The attendance rates were moderately high but there were small absences that could have affected the statistical significance of the study.

5.5 Conclusion

This study did not have significant results but did demonstrate that group exercise with people who have stages three and four PD was possible. The PD patients met three times a week and motivated each other and may have improved their 6-minute walk test, their chair rise test and their 8-foot walk around the cone through strengthening their lower body. The data from this study shows a need for further study with postural balance and resistance training with stage 3 and 4 PD patients.

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