THE EFFECT OF
A TELEHEALTH EXERCISE PROGRAM ON BALANCE AND MOBILITY IN
PEOPLE WITH PARKINSON’S DISEASE

A thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science In Kinesiology

By
Robert Stone

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The thesis of Robert Stone is approved:

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<tr>
<td>Mai Narasaki-Jara, MS, ATRIC</td>
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<tr>
<td>Taeyou Jung, Ph.D., ATC, CAPE.</td>
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<tr>
<td>Teri Todd, Ph.D., Chair</td>
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California State University, Northridge
DEDICATION

To my family, friends, professors, peers, and participants whose undying support, encouragement, and time have made this possible: Christine Stone, Kenneth Stone, Eleonor Anaya, and Elizabeth Garcia.
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ABSTRACT

The Effect of a Telehealth Exercise Program on Balance and Mobility in People With Parkinson’s Disease

By Robert Stone

Master of Science in Kinesiology

Introduction: Parkinson’s Disease (PD) is a progressive neurodegenerative disorder that causes movement dysfunction such as bradykinesia, rigidity, and postural instability. These symptoms may lead to problems with balance and mobility. Because of this, people with PD are nine times more likely to experience a fall than healthy populations. The consequences of falls are serious and include the risk of fractures, head trauma, and death. Supervised exercise has shown to improve balance and mobility in people with PD. Unfortunately, there are a number of barriers that prevent people with PD from participating in beneficial exercise programs. The field of telehealth utilizes modern, affordable, and convenient communications technology to improve access to care services. It is now possible for people with PD to access one-on-one formal exercise programming by health and fitness professionals in the comfort of their own home through video conferencing.

Purpose: To examine the effects of a telehealth exercise program on balance and mobility in people with PD.

Methods: Twelve Adults with PD participated in this study. Six people completed a supervised telehealth training program two times per week for twelve weeks and six were enrolled in a self-supervised home exercise program as a control group. Balance was evaluated using the NeuroCom Balance Master Motor Control test and Limits of Stability test. Mobility was evaluated using the Sit to Stand, Walk Across, and Timed Up and Go Test.

Results: Overall the telehealth group showed some improvement in all measures. However, no significant changes in balance or mobility were found. The self-supervised group also showed non-significant improvement in some of the measures. Adherence to the program varied widely between the two groups, telehealth had a 96.7% adherence rate compared to 36.8% for the self-supervised group.

Conclusions: Program delivery using telehealth technology was effective in increasing adherence to an exercise program. Supervised telehealth exercise may improve balance and mobility for adults with PD.
CHAPTER 1: INTRODUCTION

Each year in the United States approximately 50,000 – 60,000 individuals will be diagnosed with Parkinson’s Disease (PD), joining the more than 1 million people currently living with PD (Carne, Cifu, Marcinko, Baron, & Pickett, 2005; National Parkinson’s Disease Foundation, 2015). PD is a progressive neurodegenerative disorder that causes movement dysfunction. The physical symptoms most commonly associated with PD are akinesia, bradykinesia, tremors, rigidity, disordered gait, manual dexterity deficiencies, and postural instability. These symptoms may lead to problems with balance and mobility (Yarnall, Archibald, & Burn, 2012). In fact, people with PD are nine times more likely to experience a fall than people without PD (Bloem, Grimbergen, Cramer, Willemsen, & Zwinderman, 2001). The consequences of falls are serious and include the risk of fractures, head trauma, and death (Hely, Reid, Adena, Halliday, & Morris, 2008). The severity of PD symptoms is commonly measured using the Hoehn and Yahr scale, which rates patients on a 1 to 5 scale (Hoehn & Yahr, 1967).

The effect of exercise interventions to reduce the risk of falls and increase balance and mobility for people with PD has been studied and found effective in improving balance and strength. Exercise supervised by a physical therapist has been shown to be able to improve dynamic balance and increase the limits of stability in people with PD (Kara, Genç, Colakoglu, & Cakmur, 2012). Balance and resistance exercise has also been shown to improve lower limb muscular strength, balance time, and reduce fall risk.
(Hirsch, Toole, Maitland, & Rider, 2003). Additionally, a home physical therapy program has been shown to improve mobility in activities of daily living such as chair and bed transfers, as well as stride length (Nieuwboer et al., 2001). Though exercise has been shown to help improve balance and mobility and reduce fall risk in people with PD, there are millions of people worldwide with PD who do not have adequate access to exercise interventions (Dorsey & Willis, 2013). The majority of formal exercise programs take place in medical or physical therapy facilities. Unfortunately, a number of barriers such as financial and transportation limitations may prevent people with PD from participating in these exercise programs (Nocera, Horvat, & Ray, 2009). In addition to supervised exercise programs, healthcare professionals frequently develop and provide self-supervised exercise programs in the form of a handout or manual for people with PD that they can utilize independently at home as a way to supplement or continue exercise after interventions at medical or therapeutic facilities (Quinn, 2010). Self-supervised exercise at home showed a trend of reducing the number of falls and near falls in people with PD (Ashburn et al., 2007).

Telehealth, also known as “healing at a distance”, utilizes modern, affordable, and convenient communications technology to improve access to health care services (Strehle & Shabde, 2006). It is now possible for people with PD to access one-on-one formal exercise programming by health and fitness professionals in the comfort of their own home through video conferencing in the same way that other health services are being delivered. This sets the stage for the creation of affordable models for providing vital and
effective exercise programs through the use of telehealth communication (Giansanti, Macellari, & Maccioni, 2008). To date, the effect of a home exercise intervention on balance and mobility that is delivered through telehealth video conferencing has not been examined. The purpose of this study is to investigate the effects of a progressive telehealth exercise program on balance and mobility in individuals with PD. The results of this study will provide valuable feedback for the development of future telehealth home exercise interventions that improve balance and mobility for people with PD. Successful application of telehealth exercise programming may show potential opportunities to reduce barriers to participating in exercise interventions for people with PD.

Definition of Terms

Activities of Daily Living: Refers to the basic tasks of everyday life such as eating, bathing, dressing, using the toilet, and transferring (Mosby’s Medical Dictionary, 2009).

Balance: Stability of the body, attained in the case of humans and other terrestrial animals by a continuously active process involving vestibular, visual, and proprioceptive inputs causing reflex postural muscle adjustment, so as to maintain the center of gravity directly above the supporting base of the body (Farlex Partner Medical Dictionary, 2012).

Base of Support: The area of ground surface between and beneath the feet covered by the body silhouette (Dictionary of Sport and Exercise Science and Medicine, 2008).
Center of Gravity: The point on a body or system where, if pressure equal to the weight of the object is applied, forces acting on the object will be in equilibrium; the point around which the mass is centered; the location of the COG in an adult human being is the anatomic position just anterior to the second sacral vertebra (Medical Dictionary for the Health Professions and Nursing, 2012).

Mobility: The ability to move through one's environment with ease and without restriction (Miller-Keane Encyclopedia and Dictionary of Medicine, Nursing, and Allied Health, 2003).

Fall: A precipitous drop from a height, or from a higher to a lower position, which is often accompanied by injuries (Segen’s Medical Dictionary, 2011).

Assumptions

- Participants will not participate in other formal exercise programs or interventions.
- Participants will use their best effort while completing pre and post data collection tests.
- A progressive exercise program done for 45 minutes twice a week for 12 weeks is capable of improving balance and mobility.
- The Limits of Stability Test, Motor Control Test, Walk Across Test, Sit to Stand Test, and Timed Up and Go Test are valid and reliable measures of balance and mobility.

Limitations
• The number of participants

• Limiting the study to participants who are within a 1 to 3 on the Hoehn and Yahr scale.

*Delimitations*

• The ability to understand and communicate in English

• The ability to use a computer

• A Hoehn and Yahr scale score of between 1 and 3

• Aged between 40 and 80 years old
CHAPTER 2: LITERATURE REVIEW

Parkinson’s Disease Definition and Incidence

Parkinson’s Disease (PD) is a progressive neurodegenerative disorder that causes movement dysfunction. The major characteristic of PD is the loss of collections of neurons that contain the neurotransmitter dopamine. This loss of dopaminergic cells causes a deficiency of dopamine. The physical symptoms most commonly associated with PD are akinesia, bradykinesia, tremors that are more pronounced at rest, rigidity, disordered gait that often takes the form of gait asymmetries, stooped posture, and a shuffling step, manual dexterity deficiencies, postural instability, and muscular weakness. (Yarnall, Archibald, & Burn, 2012). In the United States there are more than one million people living with PD. Additionally, each year around 50,000 – 60,000 individuals are newly diagnosed with PD (National Parkinson’s Disease Foundation, 2015). Of those diagnosed with PD, it has been found to be most common in men and older individuals. The onset of PD symptoms rarely appears before the age of 50 with greatest increases in incidence seen after the age of 60 (Morens et al., 1996). Complications from PD currently rank as the 14th highest cause of death in the United States, according to the Centers for Disease Control (CDC, 2013). In terms of neurodegenerative diseases, PD is second to Alzheimer’s disease in incidence (Lau & Breteler, 2006).

Pathology
PD symptoms are associated with an abnormal buildup of a protein called alpha-synuclein inside the brain that are called Lewy bodies. Lewy bodies interfere with normal neuronal activity and cause the loss of dopaminergic neurons located in the substantia nigra pars compacta area of the brain (Olanow, Stern, & Sethi 2009). While PD symptoms are mainly associated with dysfunction in the dopaminergic system, it has also been found that there are other non-dopaminergic systems, which are also affected as the disease progresses including cholinergic neurons, norepinephrine neurons, and serotonin neurons (Forno, 1988).

Disease progression is typically assessed using a scale that takes into account clinical function, functional deficits, and impairment to determine the severity of the condition. The most commonly used measure for PD is the Hoehn and Yahr scale (H&Y). The original H&Y scale, which was published by Hoehn and Yahr (1967), ranges from 1 to 5 and indicates disease progression from mild to severe. A modified version was later developed in the 1990s, which added two increments, 1.5 and 2.5, in order to more precisely differentiate between progressions of PD symptoms (Goetz et al., 2004). The first level of the Modified H&Y scale indicates that the individual with PD displays unilateral physical symptoms but with minimal functional disability. Level 1.5 progresses to add axial involvement to the unilateral symptoms. As PD progresses to level 2, bilateral symptoms appear, without impairment to balance. At stage 2.5, mild bilateral symptoms with balance impairment appear but the individual still retains the ability to recover from the pull test, a common test to measure postural stability in people.
with PD. Once an individual reaches stage 3, mild to moderate bilateral symptoms are present with postural instability. Individuals at stage three are still physically independent. At stage 4, the disease progression becomes severely disabling, but individuals with PD are still able to stand and ambulate on their own, usually utilizing an assistive device. At the final stage of the H&Y scale, people with PD are no longer able to walk on their own and require a wheelchair and may be confined to bed for the majority of the day (Goetz et al. 2004).

The speed at which PD progresses is highly variable, so individuals do not always experience symptoms at the same rate. At this point, there is no known cure or treatment to reverse the progression of PD. The current course of action for people with PD is focused on symptom management (Yarnall, 2012). The traditional plan for treatment of PD is usually pharmacological therapy through dopamine replacement drugs. Dopaminergic replacement therapy utilizes dopamine antagonists to enhance activity in the dopamine receptors located in the brain, as well as levodopa, which is converted into dopamine by the remaining dopamine receptors. In the early stages of PD, not all individuals with the disease require medication. However, as the symptoms become more severe, increased pharmacological intervention is common (Yarnall, 2012). Dopaminergic medication does not appear to reduce fall risk for people with PD (Bloem et al., 2001). In a survey of people with PD, two-thirds reported that they had experienced falls despite the fact that their other symptoms of PD were well controlled through the use of pharmaceuticals (Bloem et. al., 2001). This further indicates that dopaminergic
medication is ineffective at managing the symptoms of balance impairment. There is also research that indicates that dopaminergic medication might increase factors associated with increased fall risk such as a greater level of gait variability not seen during the off medication states (Schaafsma et al., 2003).

Deep brain (DBS) stimulation is another treatment that has been used to treat the symptoms of PD. DBS is accomplished by implanting up to three small electrodes into movement-related areas of the brain, which are connected to a small pacemaker-like device. DBS has been shown to be effective in reducing the symptoms of tremor, rigidity, bradykinesia, and gait abnormalities. It is usually utilized when pharmacological interventions are ineffective at controlling the symptoms of PD. Like dopaminergic therapy, DBS has not been shown to reduce the risk of falls (Deuschl et al., 2002).

**PD and Falls, and Balance**

Postural imbalance is one of the most serious impairments for people with PD because of the increased risk of falls. Consequences of falls include the risk of fractures, head trauma, and death (Hely et al., 2008). In comparison with the fall rate of healthy controls, people with PD are nine times more likely to experience a fall (Bloem, Grimbergen, Cramer, Willemsen, Zwinderman, 2001). In some cases, the percentage of people with PD who fall is more than double for those with other neurological conditions such as stroke (Stolze, Klebe, Baecker, Zechlin, & Deuschl, 2005).

A study conducted by Bloem, Grimbergen, Cramer, Willemsen, & Deuschl (2001) tracked falls for 59 people who were moderately affected by PD. They found that
50% of the participants had at least one fall, and of those who fell 35% percent suffered multiple falls or injuries as a result of a fall. The researchers also examined the causes of the falls and grouped the falls into two different categories. These categories were intrinsic and extrinsic falls. The researchers defined intrinsic falls as being “caused by mobility or balance disorders, misperception of the environment or loss of consciousness” (Bloem et. al., 2001, p. 962), and extrinsic falls as being caused by the environment around the participant such as a collision. The study found that intrinsic falls made up 70% of the total falls in the study. The main cause of these intrinsic falls was found to be center of mass (COM) falls. COM falls occur when the body’s center of mass exceeds the limits of stability (LOS). The LOS is defined as “the greatest distance in any direction a person can lean away from a midline vertical position without falling, stepping, or reaching for support” (Mosby’s Medical Dictionary, 2009). The most common movements found to cause displacement of the COM outside the LOS were turning around, standing up, and bending forward (Bloem et. al., 2001).

While pharmacological interventions with Levodopa are generally effective for treating the dopaminergic symptoms of PD such as bradykinesia, rigidity, and tremor, Levodopa has been found to be ineffective at treating some of the non-dopaminergic symptoms of PD such as freezing and falling (Hely, Morris, Reid, & Trafficante, 2005). To illustrate this, in a 15-year longitudinal study of 149 people with PD who were treated with Levodopa, 81% of those who were a part of the study experienced a fall and 23%
suffered a fracture as a result of a fall despite having received pharmacological interventions to treat their PD symptoms (Hely et al., 2005).

People with PD commonly have reduced strength in their lower extremities compared to healthy individuals. (Inkster, Macintyre, & Stoessl, 2003). Decreased lower body strength has been associated with increased fall risk among persons with PD (Hirsch, Toole, Charles, Maitland, & Rider, 2003). A study done by Allen, Canning, Sherrington, and Fung (2009) compared the muscular strength and power of 40 people with PD while completing a one-repetition max leg press with age-matched non-neurologically impaired individuals. It was found that people with PD had less strength and power in their lower limb muscles than healthy people of the same age. On average, the PD group was 172 Newtons weaker and 124 Watts less powerful than their age-matched controls. These strength differences in people with PD provide another explanation as to why people with PD are more likely to experience falls.

Exercise Effect on Balance and Mobility

In order to help improve balance and mobility in people with PD, exercise interventions have been studied. Kara, Genc, Colakoglu, and Cakmur (2012) conducted a study that looked at the effect of supervised exercise on static and dynamic balance in people with PD. In the study, 17 participants (61.58 ± 8.44 yrs.) took part in a 12-week exercise intervention once a week for 50-60 minutes at their home and were conducted by a physical therapist that visited the participant’s house. The exercise program contained a 10-15 minute warm-up, 30 minutes of postural, strengthening, and balance and
coordination exercises. The participant’s balance was assessed by the NeuroCom Balance Master computerized posturography Sensory Organization (SOT), Limits of Stability (LOS), Rhythmic Weight Shift, Sit To Stand, and Tandem Walk tests. The exercise intervention resulted in an improvement in dynamic balance and maximal excursion of limits of stability. Improved performance in maximal excursion of limits of stability indicates an improvement in the participant’s ability to perform movements outside the base of support, thereby decreasing the likelihood of a fall.

In another study conducted by Hirsch, Toole, Maitland, and Rider (2003), the effect of balance training and high-intensity resistance training for persons with PD was measured. Fifteen participants took part in the study, nine participants (75.7 ± 1.8 yrs) were randomly sorted into a balance group focused only on balance training while six participants (70.8 ± 2.8 yrs) were assigned into a combined group that took part in both balance training and resistance exercise. Muscular strength of the knee flexors and extensors as well as ankle plantar flexors was measured using a four repetition max protocol on a standardized weight-and-pulley system. Balance was measured using the EquiTest computerized posturography device and SOT assessment for both groups. The balance intervention that both groups received was a ten-week training program that included standing balance exercises, standing on foam balance surfaces, perturbation exercises, and weight shifting exercises for 30 minutes on three nonconsecutive days each week. In addition to the balance-training program, the resistance-training group participants exercised for 15 minutes three nonconsecutive days per week. The program
featured a progressive resistance exercise program using both concentric and eccentric muscle contraction. The researchers had the participants complete one set of 12 repetitions for each major lower body muscle group with two minutes of rest between each exercise. After the intervention was complete, data from the EquiTest balance testing showed that both groups significantly increased latency to fall, which is the amount of time in seconds that the participant can balance after experiencing a perturbation. Significant decreases were measured in the percentage of trials resulting in falls, with the combined group recording an even greater reduction of falls than the balance group alone. In terms of muscular strength, both the balance and combined group significantly increased the average strength of the quadriceps, hamstrings, and gastrocnemius muscle groups as measured by the four repetition max test, though the combined group scored significantly higher than the balance group in average strength. This study showed that an exercise intervention designed to improve balance and muscular strength should include both balance and resistance exercise for best results. It showed that strength and balance exercise has a synergistic effect, which makes it more effective for reducing fall risk as compared to balance exercise alone.

In a study conducted by Nieuwboer and colleagues, the researchers looked at the effect of a home physical therapy program on mobility and activities of daily living (ADLs) in people with PD (Nieuwboer et al., 2001). During the study, 26 people with PD took part in a six-week home intervention, while a control group of 18 individuals took part in a six-week outpatient physical therapy intervention. Both interventions focused on
exercises that were designed to help improve gait mobility and ADLs such as chair transfers and bed mobility. The participant’s change in ADLs was measured with the ADLs section of the United Parkinson’s Disease Rating Scale questionnaire (UPDRS). Additionally, the participants’ gait velocity, stride length, cadence, and double support phase was analyzed using two-dimensional videotaping. After the six-week interventions were complete, both the home and hospital groups showed significant improvements in self-reported gait akinesia, chair transfer, and bed mobility sections of the UPDRS questionnaire. Additionally, the home physical therapy intervention participants also showed significant improvement in the bed mobility section of the UPDRS and had a greater amount of improvement than the hospital intervention. Gait analysis showed a significant increase in stride length and a near significant decrease in cadence for the home physical therapy intervention as well. The result of the study showed that a home rehabilitation intervention can produce clinically relevant improvement in the mobility and ADLs of people with PD.

Reaction time

People with PD often experience the symptoms of slowed movement, which is called bradykinesia and akinesia, which is the lack of movement when trying to initiate movements. People with PD have been shown to be consistently slower in reaction time than healthy controls. While people with PD and healthy controls show no difference in reaction time when reacting to an unknown stimulus, the main difference between people with PD and healthy controls is that when they are warned of having to react to a
stimulus, the healthy controls improve their reaction times while people with PD show no improvement in reaction time. It is believed that reduced reaction times are a function of decreased activity in the ascending dopamine pathways in the brain (Bloxham, Dick, & Moore, 1987; Tornabene, 1995). Exercise has also been shown to improve reaction time in people with PD. A study by Ebersbach, Gandor, Wegner, Wissel, & Kupsch (2014) compared supervised LSVT-BIG training, which is a form of high amplitude movement exercise, with supervised Nordic walking and unsupervised home exercise. The participant’s reaction time was measured by the time it took the participants to press a button after being cued by a computer. The results of the study showed that both the LSVT-BIG training and Nordic walking improved cued reaction time, while unsupervised exercise did not. It has also been shown that reaction time can be a predictor of a high fall risk in older adults (Delbaere, Sturnieks, Pijnappels, & Lord, 2010).

Barriers

Exercise has the ability to help improve the balance and mobility and reduce fall risk in people with PD. Unfortunately, there are millions of people worldwide with Parkinson’s who do not have access to exercise interventions (Dorsey & Willis, 2013). There are a number of barriers that have been found to prevent people with PD from participating in formal exercise programs (Nocera, Horvat, & Ray, 2009). The cost of programs may be a barrier due to the lack of financial resources as people with PD may already have a large financial burden due to the high cost of medical treatment (Quinn et
The annual cost of care for an individual with PD is estimated to be $10,349, driving the total costs of PD in the United States as high as $23 billion annually (Huse, Schulman, Orsini, Castelli-Haley, & Kennedy, 2005). With the population of people over the age of 65 set to increase from around 35 million to 80 million by the year 2040, conservative estimates suggest the total annual cost of treatment for PD may rise as high as $50 billion (Huse, et al. 2005).

While there have been only a handful of studies investigating the barriers to attending formal exercise programming, the research into attendance of other specialized PD programs can provide insight into some of the potential barriers to exercise programs that people with PD may face. Some 769 people with PD completed a survey regarding access to mental health care. Respondents indicated that some of the most common barriers were a lack of services within the local community, lack of transportation and the high cost of participation in mental health care programs. Participants in this study reported having to travel significant distances in order to take part in the specialized PD mental health services, on average 52 miles (Dobkin, Rubino, Friedman, Allen, & Gara, 2013). The feedback from this study demonstrates the substantial logistical, financial, and time barriers faced by people with PD.

**Independent exercise**

In addition to supervised exercise programs, healthcare professionals frequently develop and provide independent exercise programs in the form of a handout or manual for people with PD that they can utilize independently at home as a way to supplement or
continue exercise after interventions at medical or therapeutic facilities (Quinn, 2010). Independent home exercise is well received as an available option for exercise programming in people with PD (Gallagher, 2012). A focus group of PD and Huntington’s Disease patients and practitioners felt that some sort of a home exercise program would be beneficial on its own or in conjunction with another formal exercise program, but noted that the kinds of exercise which could be assigned to a home program was limited by the participant’s level of comfort with the exercises and safety concerns (Quinn, 2010).

A study was conducted by Lun, Pullan, Labelle, Adams, & Suchowersky (2005) that compared the effectiveness of a self-supervised home exercise program and a physical therapist-supervised exercise program for 19 people with PD (65 ± 8 yrs) for 16 weeks. This study found that both programs were equally effective in improving scores in the motor subsection of the Unified Parkinson's Disease Rating Scale. The study also analyzed both groups with the Berg Balance scale and the Timed up and Go Test but did not find any significant improvements for either group.

To test the level of adherence that people with PD had to an independent exercise program, Pickering, Fitton, Ballinger, Fazakarley, & Ashburn (2013) distributed individually tailored exercise programs to 70 people. Participants kept track of when and how much they exercised using a diary. Researchers found that the participants in this study completed on average 79% of their programs. The study also reported that those
who were older and in poorer health showed lower levels of adherence to the exercise program.

**Telehealth**

Telehealth, also known as “healing at a distance,” utilizes modern and affordable communications equipment technology to improve access to care services (Strehle, & Shabde, 2006). This sets the stage for the creation of affordable models for providing vital health programs through the use of telehealth communication including exercise interventions (Giansanti, Macellari, & Maccioni 2008). In a mental health services survey by Dobkin et al. (2013), 68% of those polled indicated that they would be interested in taking part in a telephone-based intervention. In addition, a majority of participants in the study also reported having access to more than one method of communication, such as telephone, cell phone, computer, the Internet, email, and webcam. This result is also supported by how telehealth has been embraced by a majority of the top U.S. neurology departments as ranked by U.S. News and World Report: 85% of departments polled expressed plans to develop or utilize their own telehealth programs within the next year after the poll was taken in 2010. The quality and effectiveness of telehealth programming was also endorsed by 66% of responding neurology departments answering that they believed that the quality of the services provided was equal or superior to that of traditional methods of health care delivery (George, et al. 2012). In a study by Venkataraman, Donohue, Bidlan, Wicks, & Dorsey in 2014, 55 people (67.8 ± 10.4 yrs) with PD were offered a free telehealth consultation with a specialist. The participants
communicated with the specialist using video conferencing software. During the session, the neurologist was able to provide an assessment and recommendations to the participants. The majority of these recommendations were to increase exercise, change medication, or add a new medication. After their session was complete with the specialist, the participants were asked to complete a questionnaire about their experience. The reaction to the service was favorable and 100% of the participants answered that they would be likely or very likely to refer telehealth services to a friend. Participants expressed that they felt comfortable with the interaction with the specialist and appreciated the benefits of not having to incur the costs and inconvenience of traveling to see a specialist.

Telehealth services have also been examined in the realm of physical therapy. A case study conducted by Lee and Billings (2016) examined the use of physical therapy sessions conducted using telehealth as a means of increasing the access to physical therapy in areas where there was a shortage of available therapists. A secondary goal of this was to reduce the costs of hiring additional physical therapists to address these deficits. The outcomes of 25 participants who took part in the telehealth intervention were compared to 26 who received standard in-person physical therapy. No significant difference in outcomes between the telehealth and in-person groups was found. There was also a $5,000 reduction in costs for the physical therapy clinic by replacing the physical therapists that traveled to fill the deficits in physical therapy care with
telehealth-delivered physical therapy sessions. This study indicates the feasibility of conducting physical therapy sessions through telehealth methods.

**Conclusion**

Impairments in balance and mobility that lead to increased risk of falls put people with PD at risk of suffering serious injury. Exercise interventions have been shown to be an effective way to improve balance and mobility in people with PD, which can help to reduce fall risk. There are currently many individuals with PD who might benefit from an exercise intervention who are not able to take part in a formal exercise program because of barriers such as cost and distance of programs. Telehealth is a very promising new field that is gaining a great deal of interest, and is seen by many as a viable and by some a superior option (George, et al. 2012) to connecting with healthcare professions directly. Though telehealth has the potential to bring exercise programming to people with PD, there has yet to be any research to examine the effectiveness of a telehealth exercise program for people with PD compared to an unsupervised home program. The present study focused on the effectiveness of a telehealth exercise intervention for people with PD. The program consisted of one-on-one video conferencing with a trained fitness instructor. Participants in this study received exercise instruction two days per week for 45 minutes for 12 weeks. The exercise program featured five minutes of warm-up followed by 35 minutes of progressive resistance and balance exercises, followed by a five-minute active cool down. The results of this study provided valuable feedback for the development of future telehealth home exercise interventions that aim to improve
balance and mobility for people with PD. Additionally, this study will demonstrate the potential application of telehealth to make physical activity more accessible for people with PD.
CHAPTER 3: METHODS

Participants

A total of 11 individuals, 54-83 years of age, diagnosed with idiopathic PD were between a 1 and 3 on the Hoehn and Yahr scale participated in this study. Participants were recruited for this study from PD support groups, care facilities, and online PD resources. All participants were required to obtain medical clearance to participate in the exercise program and sign an informed consent form. Inclusion criteria included the ability to read and communicate in English, use a computer, maintain a consistent medication protocol for one month prior to initial data collection, and have an assistant or caretaker present to provide spotting and administer CPR to the participant if necessary. Participants were excluded if they met any of the following exclusion criteria – additional musculoskeletal, neurological, or cardiovascular disorder that would inhibit the ability to participate in resistance or balance exercise, change in medication type or dosage within the month prior to data collection, current participation in an exercise related research study, current participation in a formal exercise program, or lack of access to the Internet.

Research Setting and Design

After being recruited, participants were given an explanation of procedures and asked to sign an informed consent form. Once that form was completed, participants were required to obtain medical clearance from their primary physician prior to any data collection procedures.
Once medical clearance was obtained, participants were randomly assigned to either the telehealth group or the self-supervised group. A stratified randomization technique was used to divide participants into two groups according to the severity of their PD as measured using the modified Hoehn and Yahr scale (1-3). The two groups were based on the severity of disease as follows: Less Severe 1 to 2 and more severe 2.5 to 3. The participants who made up both of these groups were evenly randomized into both study groups. After randomization, participants from the telehealth and self-supervised group received a home visit from the researchers in order to establish a safe exercise environment, distribute exercise equipment and set up video-conferencing software if they were a part of the telehealth group. The self-supervised group received an exercise manual and was given instructions on how to use the manual.

Testing

All participants completed pre and post data collections. Data collections were held at the Center of Achievement, an adaptive exercise research facility on the California State University campus. The testing lasted approximately two hours and each participant took part in four different balance and mobility assessments.

The first two balance assessments were completed on the Neurocom Balance Master, which is a computerized posturography device that objectively assesses factors associated with balance. The first test on the Neurocom was the Limits of Stability Test. The LOS determines the maximum distance a person can intentionally displace their COM, i.e. lean their body in a given direction without losing balance, stepping, or
reaching for assistance. The measured parameters are reaction time and maximum excursion. During the test, the participant received visual feedback in the form of an avatar that showed them the location of their COM. For eight trials, the participant was asked to move the avatar from a central box on the screen to one of eight targets arranged around the central box. On command, the participant was asked to move the COM cursor as quickly and accurately as possible towards a second target located on the LOS perimeter (100% of theoretical limits of stability) and then to hold a position as close to the target as possible. The participant was allowed up to eight seconds to complete each trial. To reduce the risk of falls, the participant was secured using a harness that was suspended from a support beam directly above Neurocom.

The second assessment for balance and mobility was the Neurocom Motor Control Test. The MCT assesses the participant’s ability to correct postural perturbations when exposed to different movement translations. The participant stood on the force plate of the Neurocom Balance Master. Sequences of platform variations in forwards and backward translations prompted automatic motor reactions in the participants. The participants completed three cycles of three repetitions both forward and backward. Each cycle increased the amount of distance the platform moved each time. For each MCT trial, a latency time was calculated referring to the amount of recovery time after each instance of induced postural instability. To eliminate the risk of falls, the participant was secured using a harness.
The third measure was the Timed up and Go Test (TUG), which assessed the mobility of the participant by testing the participant’s ability to stand, walk, turn, and sit down. The researcher timed the duration it took the participant to complete the following series of maneuvers: 1. Sit back in a standard armchair, 2. Rise from the chair, 3. Walk a short distance (approximately 3 meters), 4. Turn around, 5. Walk back to the chair, 6. Turn around, 7. Sit down in the chair. An individual who took more than 11.5 seconds to complete the TUG test was considered to be at a high fall risk (Nocera et al., 2013).

The fourth and final assessment of mobility was the walk-across test. The participant was asked to walk across the Neurocom long force plate three times. The participant’s average stride length was recorded in addition to their walking speed. The average score was based on the three trials.

After completing their 12-week exercise intervention, all participants were asked to return to the CoA on the CSUN campus to undergo the same assessments of balance and mobility as in the pretest.

*Intervention Procedure*

Participants performed approximately 45 minutes of balance and resistance exercise using resistance bands and wrist/ankle weights two times a week for 12 weeks. Research staff continually monitored the rate of Perceived Exertion during their exercise to ensure the safety of the participants and prevent overexertion. Participants connected with the researcher through video-conferencing using their own personal web camera equipped devices such as a laptop, tablet computer, or smartphone using the Skype.
application and were guided through a warm-up consisting of flexibility and dynamic movements, which lasted approximately five minutes. They were then guided through balance and resistance exercises for approximately 35 minutes, followed by a five-minute active cool down. Each initial exercise in the program had two additional progressions that increase in difficulty, for example, increased weight (appendix B). During the exercise sessions, the instructors would prompt the participants to make a choice of either continuing with the current exercise difficulty or choosing to progress to a more challenging version of the exercise.

The participants assigned to the self-supervised control group were provided with an identical exercise program to that of the telehealth group. Initially, an orientation was provided with specific instructions on how to perform the exercises at home. They were instructed to perform the exercise program two times per week. The exercise protocol included upper and lower body resistance exercises as well as balance exercises.

Monthly phone calls were made to monitor adherence, safety and to assist them with any questions.

Statistical Analysis

Statistical data from the pre and post data from the five assessments were analyzed using the Paired Samples t-test using SPSS. To prevent any risk of a type 1 error, the p-value for significance has been adjusted to .007 using the Bonferroni correction to avoid any false positives due to multiple test errors.

Human Subjects Protocol
This study protocol was submitted and approved by the University Human Subjects Review Board. All participants were made aware of any potential risk involved in participation in this intervention when reviewing the informed consent form.
CHAPTER 4: RESULTS

Twelve participants in total were recruited to take part in this exercise intervention. The participants were randomized into the telehealth and the self-supervised groups. Six participants were assigned to the telehealth exercise group and six were assigned to the self-supervised group. Three of the self-supervised group participants did not complete the exercise intervention or return for post-testing. Of the three participants who withdrew, one dropped out due to back pain, one never began after receiving the manual, and another completed six weeks of the intervention but never returned for post-testing. During the study, the participants’ balance and mobility were tested prior to the exercise intervention and after their exercise intervention. The tests used to analyze changes in their balance and mobility were the Limits of Stability Test (LOS), Motor Control Test (MCT), Sit to Stand Test (STS), Walk Across Test (WAT), and Timed Up and Go Test (TUG). These tests were conducted under the supervision of the researchers in the research lab located in the Brown Center for Achievement at California State University Northridge. The number of completed exercise sessions were tracked by the researchers for the telehealth group, and were self-reported by the self-supervised group to monitor adherence to the program.

Adherence

The six participants in the telehealth group took part in two exercise sessions per week for 12 weeks conducted via webcam by one of the researchers. During the telehealth exercise intervention, the participants had an adherence rate of 96.7%. Of the
three participants from the self-supervised group who completed both pre and post testing, the self-reported adherence rate of these participants was 36.8%.

*Motor Control Test*

The MCT on the Neurocom Balance Master was used to test the participants’ ability to react to perturbations to their balance in both forward and backward directions in three different translation intensities. The test examined the latency or time it took to return to a balanced position. This time was measured in milliseconds with longer amounts of time indicating a greater deficit in balance ability and shorter times indicating a greater ability to control one’s balance. This latency score was examined as a composite score of both forward and backwards translations, as well as both forward and backwards translations using a paired samples t-test to check for significance. At post-intervention, the telehealth group showed a non-significant reduction in latency for the composite score from (M=141.500, SD=9.268) to (M=138.500, SD=7.063) (t(5)= 1.211, p=2.80) for an average reduction of 2.12%. The self-supervised group showed a non-significant increase in latency for the composite values increasing from (M=141.333, SD=10.969) to (M=143.666, SD=10.969) (t(2)= -1.606, p=.250) for an average increase of 1.62%.

*Timed Up and Go Test*

The TUG test was used to test the mobility and balance of the participants in the study by assessing the amount of time needed to stand up from a chair, walk three meters, turn around, return to the seat, and sit down. The telehealth group showed a non-significant decrease in TUG test time from (M=12.518, SD=4.979) to (M=10.506,
SD=2.976) t(5) = 1.452, p=.206) for a decrease of 16.07%. The self-supervised group showed a significant decrease in TUG test time from (M= 11.013, SD= 1.137 ) to (M=9.200, SD=1.685 t(2)= 5.587, p= .031) for an average reduction of 16.46%.

*Limits of Stability Test*

The LOS test was used to measure the participants’ ability to displace their center of gravity. The two measures that were analyzed from the LOS test were the maximal excursion of the limits of stability (MXE) and reaction time (RT). MXE is the furthest distance in each of the directions tested that the participants were able to displace their COG. RT is the amount of time in seconds each participant took to react to the cue to begin moving toward the target and began his or her first movement toward the target. Both MXE and RT were analyzed as a composite of all eight directions tested, for forwards, backwards, and lateral right and left directions. The telehealth group showed non-significant increases to their comprehensive MXE score (M=75.562, SD=11.218) to (M=77.437, SD=16.783) (t(5)=-.570, p=5.93) for an average increase of 2.42%. The self-supervised group showed a non-significant increase in the composite MXE score (M=68.791, SD=16.553) to (M=71.125, SD=18.730) for an average increase of 3.28%. The telehealth group showed non-significant decreases in comprehensive RT (M=1.065, SD=.359) to (M=.918, SD=.132) (t(5)=.926, p=.397) for an average decrease of 13.80%. The self-supervised group showed a non-significant decrease in comprehensive RT (M=.996, SD=.357) to (M=.973, SD=.398) (t(2)=.314, p=.783) for an average decrease of 2.30%.
*Sit to Stand Test*

The Sit to Stand test measured balance during the motion of standing up from a seated position. The measure recorded during this test was the center of gravity sway velocity (COGSV). COGSV is calculated by analyzing the distances the center of gravity travels divided by the time it takes to complete the movement measured in degrees per second. A lower score indicates a more balanced and controlled standing motion. The telehealth group showed a non-significant decrease in COGSV (M=4.083, SD=1.435) to (M=3.183, SD=1.252) (t(5)=1.063, p=.336) for an average decrease of 22.04%. The self-supervised group showed a non-significant decrease as well (M=3.733, SD=.152) to (M=2.566, SD=1.001) (t(2)=1.757, p=.221) for an average decrease of 31.26%.

*Walk Across Test*

During the walk across test, a force plate was used to measure the walking speed measured in centimeters per second and step length measured in centimeters. The telehealth group showed a non-significant increase in walking speed (M=48.433, SD=7.869) to (M=56.533, SD=15.621) (t(5)=-.701, p=.556) for an average increase of 14.32%, and a non-significant decrease in step length (M=46.033, SD=15.663) to (M=40.466, SD=17.528) (t(5)=1.411, p=.217) for an average decrease of 12.09%. The self-supervised group showed a non-significant increase in walking speed (M=39.366, SD=13.191) to (M=58.733, SD=22.362) (t(2)=-1.012, p=.418) for an average increase of 32.97%, and a non-significant decrease in step length as well (M=48.633, SD=8.132) to (M=41.100, SD=3.148) (t(2)=2.184, p=.161) for an average decrease of 15.48%.
In order to provide a more detailed breakdown of the results of this study the following individual results have been provided along with graphical depictions of the changes that took place in the study. Only individuals from the telehealth group are listed below as the self-supervised group had a low sample size and inconsistencies in adhering to the exercise interventions.

**Participant #1**

Participant #1 was a male aged 72 years old and was placed as a 2.5 on the H&Y scale. Participant #1 completed 24 of the 24 exercise sessions as part of the telehealth group. His MCT comprehensive score was 155 in the pre-test and his post-test score was 149 for a reduction of 3.87%. His TUG test pre-test time was 19.47s and his post-test time was 10.87s for a reduction of 44.17%. His LOS MXE comprehensive score during the pre-test was 63.88 and his post-test score was 61.50 for a reduction of 3.72%. His LOS comprehensive RT score during the pre-test was 1.58ms and during the post-test was .73ms for a reduction of 53.79%. His STS COGSV score during the pre-test was 3.60 and his post-test score was 1.10 for a reduction of 69.44%. His WAT walking speed score during the pre-test was 39.40 and his post-test score was 30.30 for a reduction of 23.09%. His WAT step length score during the pre-test was 19.30 and his post-test score was 20.70 for an increase of 6.76%.
Figure 1a – Participant #1 Motor Control – Comprehensive Score

Figure 1b – Participant #1 Timed Up and Go Test
Figure 1c – Participant #1 Limits of Stability Test – Maximal Excursion of the End Point

Figure 1d – Participant #1 – Limits of Stability Test – Comprehensive Reaction Time
Figure 1e – Participant #1 Sit to Stand Test Center of Gravity Sway Velocity

Figure 1f – Participant #1 Walk Across Test Speed / Step Length
Participant # 2

Participant #2 was a female aged 69 years old and was placed as a 2.5 on the H&Y scale. Participant #2 completed 22 of the 24 exercise sessions as part of the telehealth group. Her MCT comprehensive score was 140.00 in the pre-test and her post-test score was 132.00 for a reduction of 5.71%. Her TUG test pre-test time was 15.04s and her post-test time was 13.92s for a reduction of 7.44%. Her LOS MXE comprehensive score during the pre-test was 59.75 and her post-test score was 58.75 for a reduction of 1.67%. Her LOS comprehensive RT score during the pre-test was 1.42ms and during the post-test was 1.07ms for a reduction of 24.64%. Her STS SOGSV score during the pre-test was 6.30 and her post-test score was 3.30 for a reduction of 47.61%. Her WAT walking speed score during the pre-test was 53.80 and her post-test score was 33.30 for a reduction of 38.1%. Her WAT step length score during the pre-test was 37.10 and her post-test score was 29.20 for an reduction of 21.29%.
Figure 2a – Participant #2 Motor Control Test – Comprehensive Score

Figure 2b – Participant #2 Timed up and Go Test
Figure 2c – Participant #2 Limits of Stability Test Maximal Excursion of the End Point

Figure 2e – Participant #2 Limits of Stability Test Comprehensive Reaction Time
Figure 2e – Participant #2 Sit to Stand Test Center of Gravity Sway Velocity

Figure 2f – Participant #2 Walk Across Test Speed / Step Length
Participant #3

Participant #3 was a female aged 77 years old and was placed as a 3 on the H&Y scale. Participant #3 completed 23 of the 24 exercise sessions as part of the telehealth group. Her MCT comprehensive score was 134.00 in the pre-test and her post-test score was 138.00 for a increase of 2.89%. Her TUG test pre-test time was 13.42s and her post-test time was 12.98 for a reduction of 3.27%. Her LOS MXE comprehensive score during the pre-test was 78.63 and her post-test score was 74.38 for a reduction of 5.4%. Her LOS comprehensive RT score during the pre-test was .79 and during the post-test was .90 for an increase of 12.22%. Her STS COGSV score during the pre-test was 4.40 and her post-test score was 4.30 for a reduction of 2.27%. Her WAT walking speed score during the pre-test was 52.10 and her post-test score was 54.50 for an increase of 4.4%. Her WAT step length score during the pre-test was 37.50 and her post-test score was 37.1 for a decrease of 1.06%.
Figure 3a – Participant #3 Motor Control Test Comprehensive Score

- Pre-Test
- Post-Test

Figure 3b – Participant #3 Timed Up and Go Test

- Pre-Test
- Post-Test
Figure 3c – Participant #3 Limits of Stability Test Maximal Excursion of the End Point

Figure 3d – Participant #3 Limits of Stability Test Comprehensive Reaction Time
Figure 3e – Participant #3 Sit to Stand Test Center of Gravity Sway Velocity

Figure 3f – Participant #3 Walk Across Test Speed / Step Length
Participant #4

Participant # was a male aged 80 years old and was placed as a 2 on the H&Y scale. Participant #4 completed 24 of the 24 exercise sessions as part of the telehealth group. His MCT comprehensive score was 149.00 in the pre-test and his post-test score was 145.00 for a reduction of 2.68%. His TUG test pre-test time was 6.83 and his post-test time was 7.60 for an increase of 10.13%. His LOS MXE comprehensive score during the pre-test was 83.38 and his post-test score was 99.13 for an increase of 15.88%. His LOS comprehensive RT score during the pre-test was .67 and during the post-test was .75 for an increase of 10.66%. His STS SOGSV score during the pre-test was 4.70 and his post-test score was 2.50 for a reduction of 46.8%. His WAT walking speed score during the pre-test was 64.90 and his post-test score was 84.30 for an increase of 23.01%. His WAT step length score during the pre-test was 73.70 and his post-test score was 57.20 for an increase of 22.38%.
Figure 4a – Participant #4 Motor Control Test Comprehensive Score

Figure 4b – Participant #4 Timed Up and Go Test
Figure 4c – Participant #4 Limits of Stability Test Maximal Excursion of the End Point

Figure 4d – Participant #4 Limits of Stability Test Comprehensive Reaction Time
Figure 4e – Participant #4 Sit to Stand Test Center of Gravity Sway Velocity

Figure 4f – Participant #4 Walk Across Test Speed / Step Length
Participant #5

Participant #5 was a male aged 72 years old and was placed as a 1.5 on the H&Y scale. Participant #5 completed 22 of the 24 exercise sessions as part of the telehealth group. His MCT comprehensive score was 141.00 in the pre-test and his post-test score was 134.00 for a reduction of 4.96%. His TUG test pre-test time was 13.56 and his post-test time was 11.32 for a reduction of 16.51%. His LOS MXE comprehensive score during the pre-test was 79.75 and his post-test score was 75.50 for a reduction of 5.32%. His LOS comprehensive RT score during the pre-test was 1.01 and during the post-test was 1.28 for an increase of 8.91%. His STS SOG SV score during the pre-test was 4.50 and his post-test score was 5.00 for an increase of 10%. His WAT walking speed score during the pre-test was 44.70 and his post-test score was 35.80 for a reduction of 19.91%. His WAT step length score during the pre-test was 42.30 and his post-test score was 35.6 for a reduction of 15.83%.
Figure 5a – Participant #5 Motor Control test Comprehensive Score

Figure 5b – Participant #5 Timed Up and Go Test
Figure 5c – Participant #5 Limits of Stability Test Maximal Excursion of the End Point

Figure 5d – Participant #5 Limits of Stability Test Comprehensive Reaction Time
Figure 5e – Participant #5 Sit to Stand Test Center of Gravity Sway Velocity

Figure 5f – Participant #5 Walk Across Test Speed / Step Length
Participant #6

Participant #6 was a female aged 60 years old and was placed as a 2 on the H&Y scale. Participant #6 completed 23 of the 24 exercises sessions as a part of the telehealth group. Her MCT comprehensive score was 130.00 in the pre-test and her post-test score was 135.00 for a reduction of 3.70%. Her TUG test pre-test time was 6.63s and her post-test time was 6.35s for a reduction of 4.22%. Her LOS MXE comprehensive score during the pre-test was 88.00 and her post-test score was 95.38 for a reduction of 7.73%. Her LOS comprehensive RT score during the pre-test was 1.01 and during the post-test was 1.00 for a reduction of 0.99%. Her STS SOGSV score during the pre-test was 3.50 and her post-test score was 3.40 for a reduction of 2.85%. Her WAT walking speed score during the pre-test was 80.50 and her post-test score was 97.90 for an increase of 17.77%. Her WAT step length score during the pre-test was 54.50 and her post-test score was 66.20 for an increase of 17.67%. 
Figure 6a – Participant#6 Motor Control test Comprehensive Score

Figure 6b – Participant#6 Timed Up and Go Test
Figure 6c – Participant#6 Limits of Stability Test Maximal Excursion of the End Point

Figure 6d – Participant#6 Limits of Stability Test Comprehensive Reaction Time
Figure 6e – Participant#6 Sit to Stand Test Center of Gravity Sway Velocity

Figure 6f – Participant#6 Walk Across Test Speed / Step Length
CHAPTER 5: DISCUSSION

The symptoms of PD greatly affect balance and mobility and cause those with the disease to be at a nine times greater risk of experiencing a fall and potentially suffering a serious injury (Bloem et al., 2001). It has been shown, however, that exercise interventions have the potential to improve balance and mobility in people with PD (Kara et al., 2012, Hirsch et al., 2003, Nieuwboer et al., 2001). Unfortunately, a number of barriers often prevent people with PD from taking part in exercise interventions such as cost and travel distance (Quinn et al., 2010, Dobkin et al., 2013). Telehealth services have been researched as a method of increasing the accessibility of medical services for people with PD. These telehealth services have so far received a favorable response from patients and health care practitioners (Giansanti et al., 2008, Dobkin et al., 2013, George et al., 2012, Venkataraman et al., 2014).

The purpose of this study was to examine the effects of a telehealth exercise intervention delivered via a live video connection aimed at improving the balance and mobility of those with PD. This study also compared a telehealth program to a manual based self-supervised exercise program utilizing the same exercises and workout schedule, which has been a common method of delivering exercise in the past.

During the study, it was found that the telehealth group managed to adhere to the program better than the self-supervised group. However, there was no significant trend of improvement or regression of balance or mobility for either the telehealth or self-supervised group as a result of the exercise intervention.
Adherence

The results of this study may indicate that telehealth exercise may be an effective way of increasing the adherence to and frequency of exercise inside the home setting. Over a 12-week period, the telehealth group maintained a 96.7% adherence rate. This is greater than the adherence rate of 75.5% found by Pickering et al. (2013), which examined people with PD’s adherence to an self-supervised exercise program. Another study looked at the adherence rates of 556 older adults with impaired balance in a home exercise program and found that 63.4% of those tracked did not continue home their exercise plan after four weeks. This result also stands in even greater contrast to the adherence rate of the self-supervised group in this study that maintained only a 36.8% adherence rate. This seems to indicate that the delivery of exercise programming via web camera has the potential of increasing the number of exercise sessions completed for people with PD. This result may be explained by the findings of a qualitative study conducted by Crizzle, & Newhouse (2012) that examined factors that increased adherence to exercise for people with PD. It was found that reassurance and encouragement from an instructor most likely helped them adhere to an exercise program.
The ability to displace the COM from the base of support is a strong predictor of falls risk during movements such as turning around, standing up, and bending forward (Kara et al., 2012, Bloem et al., 2001). The MXE limits of stability test allows for the ability to measure the greatest distance that the participant is able to displace their COM over their base of support. The telehealth showed non-significant improvements to their composite MXE scores. While it is not possible to verify that these improvements were due to the exercise intervention, it is important to compare results of this intervention to a similar 12-week exercise intervention for people with PD conducted by Kara, et al. (2012) that did find significant improvements to MXE limits of stability test. In their study the participant’s score on average improved from 70.56 to 79.41. A number of
factors could explain the difference in results found in this study compared to the study by Kara, et al. (2012). The number of participants in their experimental group was nearly three times larger. It is possible a larger sample size might have found more significant results. It is also possible that since participants who were a part of the study began with lower MXE scores, they had more room for improvement than the participants in this study who’s pre test scores were on average five points higher than the study by Kara, et al. (2012).

Another factor examined during the LOS test was reaction time. People with PD often experience bradykiniesa or akinesia when trying to initiate movements (Yarnall et al., 2012). During the test, the participants would start with their on-screen avatar located in a center box. They would begin to move toward the intended target only when the signal was given to go. The time it took them to respond to the direction to move toward the target was measured during each of the eight directional movements of the test. Faster reaction times on the LOS test could indicate a potential decrease in bradykinesia symptoms during balance activities. The results of the study showed that there was a non-significant decrease in the time needed to react in both the telehealth and self-supervised groups. At this time there is not enough evidence to conclude that telehealth exercise is able to improve reaction time in people with PD. However, previous studies have shown that it is possible to improve reaction time using forms of supervised exercise (Ebersbach et al., 2014). It is possible that an alternate form of exercise such as the LSVT-BIG program conducted through telehealth communication could be an effective
way of improving reaction time. It is also possible that a larger sample size could better
detect any significant improvements in reaction time.

*Motor Control Test*

The MCT analyzes the autonomic nervous system’s ability to react to a sudden
destabilization in balance. Mitigation of excess postural sway is an important goal of any
exercise program since it has been identified previously as a potential cause of falls for
people with PD (Frenklach, Louie, Koop, & Bronte, 2009). When paired with muscular
weakness in the posterior chain of muscles that help govern balance, falls can occur
(Hirsch et al., 2003). Previous research conducted by Hirsch et al. (2003) has found that a
balance and resistance training exercise program was able to improve latency in a similar
balance test. A reduction in latency was seen in the overall composite score of the
telehealth groups, though these scores were not significant. Taking into account that the
self-supervised group showed a non-significant increase in their composite latency score,
it lends further credence to the possibility that telehealth exercise may be a better
alternative to the exercise program given to the self-supervised group. It is possible that
with a greater sample size these improvements might reach significance.

*Timed Up and Go Test*

The Timed Up and Go Test is a common clinical test used to check the level of
fall risk for people with PD. For PD, the time threshold that indicates an increased risk of
falls is any time over 11.5 seconds. Additionally, each one-second interval of time that it
takes to complete the TUG test increases the risk of falling by 5.4% (Nocera et al., 2013).
The average time to complete the TUG test measured during pre-testing for the telehealth group was 12.518 seconds. This indicates that the group on average is at risk of experiencing a fall. Though the result was not significant, the group showed an improvement in their average TUG test time of 10.506 seconds. This is below the threshold designating fall risk. Utilizing the estimates of fall risk in Nocera et al. (2013) study, we can conclude that the telehealth group saw an average fall risk reduction of 10.86%. The self-supervised group, which began with an average time of 11.013 seconds, just below the threshold of fall risk, was able to reduce their times to an average of 9.200 seconds. This comes out to an average fall risk reduction of 9.79%. These improvements in TUG test times are notable because of the progressive nature of PD. These results back up the previous results of Dibble, Hale, Marcus, Gerber, & LaStayo (2009), which found that resistance exercise significantly improved TUG test times in people with PD, and research by Gobbi et al. (2009) which found that a six-month exercise program was able to significantly improve the participants’ TUG test times as well. The results of this study were also found to contradict the results of the self-supervised and physical therapist-supervised exercise programs researched by Lun et al. (2005), which found no significant improvements to the TUG test scores of either group.

**Sit to Stand Test**

The non-significant decrease in center of gravity sway velocity was seen during the Sit to Stand Test in both the telehealth and self-supervised groups. A reduced sway velocity indicates a more balanced standing motion. The movement of standing up from a...
seated position was listed by Bloem et al. (2001) as a major cause of falls in people with PD. Finding an exercise intervention that could reduce this fall risk would be valuable for people with PD. Similar results on sit to stand balance were found in a study by Allen et al. (2010) which was examining the effects of an exercise program to reduce fall risk in people with PD. It also found that exercise was able to improve factors associated with the sit to stand motion as well. While it is not possible to link these improvements to the exercise intervention, these improvements indicate that future research into telehealth exercise interventions effect on sit to stand balance is warranted.

*Walk Across Test*

The results from the Walk Across Test indicated that both the telehealth and self-supervised groups showed non-significant improvements in walking speed but also saw non-significant decreases in step length. This contradicts research conducted by Nieuwboer et al. (2001) that found a significant increase in step length and a decrease in step cadence or the frequency of stepping. The results of our study seem to indicate that while step length decreased on average, the time taken to complete the full gait cycle decreased as well. While it is hard to be certain exactly why this difference in result occurred, it is notable that research into the relationship between step length, gait speed, and fall risk has shown that shorter step lengths and faster gait speeds reduce fall risk while longer steps and slower gait speeds increase fall risk (Espy, Yang, Bhatt, & Pai, 2010). It is hard to say whether this change occurred due to the intervention or if this change was related to new developments in the participants’ choice to use a gait pattern.
that could make the participants feel more balanced and stable as their PD progressed over the 12-week period.

Limitations and Assumptions

There were some limitations and assumptions in this study. The number of participants for both groups was very small, with six participants in the telehealth group and five in the self-supervised group. Only three of the self-supervised group returned for post-testing. The effects of medication timing were not controlled for. Being in the off or on state for PD medication may affect performance during testing. The time of day that testing took place was not controlled for. Study participants may have had different levels of fatigue depending on the time of day, which could affect testing. It was assumed that the participants did not engage in any formal exercise programs during the study. It was assumed that the self-supervised exercise group completed the manual-based program to the best of their ability. It was assumed that the Neurocom Balance Master LOS, MCT, Walk Across Test, and Sit to Stand tests were able to accurately represent the participants’ balance and mobility ability. It was also assumed that the TUG test was a reliable measure of balance and mobility ability.

Clinical Significance and Conclusion

The results of this study do not provide any significant evidence that a 12-week telehealth exercise program significantly improves balance or mobility in people with PD. However consistent non-significant improvements to balance and mobility were found in nearly all measures examined in this study. It is important to note that with the
progressive nature of PD, maintenance of balance and mobility is also a favorable outcome. While there were no significant improvements in balance or mobility, there were also no significant decreases. This could indicate that this exercise intervention was an effective form of maintenance against the progression of PD. Additionally, the telehealth group had a much higher adherence rate to the exercise program than the self-supervised group. These factors suggest that the future study of telehealth exercise for people with PD is warranted. Larger sample sizes may help provide greater clarity as to what the effects of telehealth exercise are on balance and mobility and may help guide the development of future programs that can be implemented in a wide variety of areas such as hospitals, physical therapy clinics, senior care facilities, and adaptive exercise facilities. Telehealth exercise may also provide a solution for greater access to specialized exercise programs, reduce travel time, as well as the potential to reduce the costs of exercise delivery for people with PD.
REFERENCES


Espy, D., Yang, F., Bhatt, T., & Pai, Y. (2010). Independent influence of gait speed and


Interventions for preventing falls in older people living in the community


Miller-Keane Encyclopedia and Dictionary of Medicine, Nursing, and Allied Health, Seventh Edition. © 2003 by Saunders, an imprint of Elsevier, Inc. All rights reserved.


APPENDIX A

California State University, Northridge
CONSENT TO ACT AS A HUMAN RESEARCH SUBJECT

The Effects of a Progressive Telehealth Exercise Program on Balance, Mobility, Self-efficacy, and Adherence in individuals with Parkinson’s Disease

You are being asked to provide consent to participate in a research study titled “The Effects of a Progressive Telehealth Exercise Program on Balance, Mobility, Self-efficacy, and Adherence in individuals with Parkinson’s Disease” a study conducted by Elizabeth Garcia and Robert Stone as part of the requirements for the M.S. degree in Kinesiology at California State University, Northridge. Participating in this study is completely voluntary. Please read the information below and ask questions about anything that you do not understand before deciding if you want to allow your child to participate. A researcher listed below will be available to answer your questions.

RESEARCH TEAM

Department of Kinesiology
18111 Nordhoff St.
Northridge, CA 91330- 8287

Researcher: Elizabeth Garcia
909-524-9516
elizabeth.garcia.32@my.csun.edu

Researcher: Robert Stone
619-768-3734
robert.stone.350@my.csun.edu

Faculty Advisor: Dr. Teri Todd
818-677-2182 ext.5090
teri.todd@csun.edu

PURPOSE OF STUDY
The purpose of this research is to examine the effects of a progressive telehealth exercise program on balance, mobility, self-efficacy and adherence in individuals with Parkinson’s Disease (PD).

SUBJECTS
Inclusion Requirements
1. Confirmed diagnosis of idiopathic Parkinson’s disease
2. Scored between a 1-3 of the Hoehn and Yahr scale
3. Aged between 40-70 years old
4. Obtain medical clearance to participate in 45 minute moderate intensity balance and resistance training exercise.
5. Ability to read and communicate in English
6. Ability to use a computer
7. Maintained consistent medication protocol for 1 month prior to initial data collection.

**Exclusion Requirements**
1. Additional musculoskeletal or neurological condition or cardiovascular disorder that would inhibit their ability to participate in cardiovascular exercise.
2. Change in medication type or dosage within the month prior to data collection.
3. Current participation in an exercise related research study.
4. Current participation in a formal exercise program.
5. Lack of access to internet.

**Time Commitment**
This study will involve total of 33 hours of your time over the 12 weeks (3 months), including 27 hours of physical activity intervention (45minutes/ 3times/ 12weeks) and 5 hours of balance assessments and questionnaires (2 hours for pre and post data collection, 1 hour for mid data collection through mail).

**PROCEDURES**

**Recruitment**
Upon being recruited for this study, you will be required to obtain medical clearance from your primary physician prior to any data collection. Once medical clearance has been obtained, you will receive a home visit from the researchers in order to establish a safe exercise environment.

**Home Visit/Initial Meeting**
The home visit from the researchers will provide you a safe exercise area, instructions on how to use video-conferencing technology and provide you exercise equipment. Once this home visit has been completed, on a future day you will be directed to come to the Center of Achievement through Adapted Physical Activity on the California State University, Northridge campus for a brief one-on-one explanation of the balance tests and questionnaires. This time will also be used to explain which group you have been assigned into and what participation in that group entails. At this time, we will begin initial data collection.

**Data collection procedures**
You will visit CSU Northridge 2 times during the study. When you come for the initial data collection, we will collect your consent and medical release forms. You will be randomly selected into either internet group or self-supervised group then we will take your height and weight.

**Questionnaires**
You will be asked to fill out 4 questionnaires that will assess your balance confidence, exercise tendencies, activities of daily living and overall quality of life. These questionnaires will take about 35 minutes to complete. All questionnaires will be administered in person at the CoA with the exception of the mid data collection in which the questionnaires will be mailed to you and returned within one week’s time.

**Balance and Mobility**
You will then take part in four balance assessments. First you will be asked to stand alone on a force platform for two of these assessments. The first will require you to lean your body in multiple directions while aiming for targets on a computer screen and the second test will require you to step across the platform for a distance of 3 meters. Each test will be done 5 times. The third assessment will be done on a balance machine which involves a moving platform. You will be secured with a harness system to eliminate the risk of falls. This test will be done 5 times. Lastly, you will stand up from a chair, walk a short distance, turn around, and sit back down in the chair. This will be done once. These assessments will take about 2 hours to complete.

The questionnaires will be administered before exercise programs begin, during the 6\textsuperscript{th} week and after the program ends on the 12\textsuperscript{th} week. Balance assessments will be taken at the beginning of the exercise program and at the 12\textsuperscript{th} week. We will give you appointment dates for all the rest of the visits.

**Intervention procedures**
Elizabeth Garcia and Robert Stone will be conducting the video-conferencing exercise program. The exercise program will take place at your home. The exercise program will run three days per week for 45 minutes. Exercise will include upper body, lower body and balance training using both ankle/wrist weights along with resistance bands. Times and dates will be provided at the initial data collection meeting.

If you are chosen for the control group, you will follow an identical exercise program through an exercise manual and receive an identical set of exercise equipment as the intervention group for the 12 weeks of the study. Weekly phone calls will be made in order to monitor your progress as well as answer any questions you may have.

**RISKS AND DISCOMFORTS**
While you understand that we strive to prevent any possible complications or injuries, there are risks involved in participation such as:
- Cardiovascular complications
- Dehydration
- Falling
- Sprains
- Broken Bones
- Physical fatigue
- Muscle cramps
- Emotional distress

In an attempt to minimalize these risks, certain precautions will be taken such as:
- Physician clearance will be obtained to ensure you do not have any contraindications for the exercise protocol
- An initial home visit by the researchers will be given in order to provide a safe exercise environment.
- You will be asked to drink plenty of water in order to keep yourself hydrated during the exercises
- You will be encouraged to have another person in close proximity that can assist when necessary and to call emergency services (911) should it be necessary.
- You will be encouraged to take a break should you experience physical fatigue.
- You will be allowed to stop at anytime during the balance/mobility tests or questionnaires should you feel distressed or concerned. You should feel free to ask questions or address concerns during these tests.

BENEFITS
Subject Benefits
The benefits of this project will be having you complete an organized exercise program, preparing you for community-based fitness programs, and teaching you the benefits to your overall health that exercise can provide.

Benefits to Others or Society
The study findings can contribute to building scientific evidence for treating individuals with PD.

ALTERNATIVES TO PARTICIPATION
The only alternative to participation in this study is not to participate.

COMPENSATION, COSTS AND REIMBURSEMENT
Compensation for Participation
You will not be paid for your participation in this research study.

Costs
There is no cost to you for participation in this study.

Reimbursement
Since there is no cost to you there will be no need for reimbursement.

WITHDRAWAL OR TERMINATION FROM THE STUDY AND CONSEQUENCES
You are free to withdraw from this study at any time. **If you decide to withdraw from this study you should notify the research team immediately.** The research team may also end your participation in this study if you do not follow instructions, miss scheduled visits, or if your safety and welfare are at risk.

CONFIDENTIALITY

Subject Identifiable Data
All identifiable information that will be collected about you will be removed and replaced with a code. A list linking the code and your identifiable information will be kept separate from the research data.

Data Storage
All research data will be stored electronically on a secure computer with password protection. All paper research data will be stored in a locked file cabinet at the Center of Achievement through Adapted Physical Activity in the main office where only the primary investigators, Elizabeth Garcia and Robert Stone, and faculty advisor, Dr. Teri Todd have access. Both forms of data will remain accessible to the primary researcher and the faculty advisor up to three years after the completion of the study after which all data will be destroyed.

Data Access
The researcher and faculty advisor named on the first page of this form will have access to your study records. Any information derived from this research project that personally identifies you will not be voluntarily released or disclosed without your separate consent, except as specifically required by law. Publications and/or presentations that result from this study will not include identifiable information about you.

Data Retention
The researchers intend to keep the research data for approximately 3 years and then it will be destroyed.

IF YOU HAVE QUESTIONS
If you have any comments, concerns, or questions regarding the conduct of this research please contact the research team listed on the first page of this form. If you are unable to reach a member of the research team listed on the first page of the form and have general questions, or you have concerns or complaints about the research study, research team, or questions about your rights as a research subject, please contact Research and Sponsored Projects, 18111 Nordhoff Street, California State University, Northridge, Northridge, CA 91330-8232, or phone 818-677-2901.
VOLUNTARY PARTICIPATION STATEMENT
You should not sign this form unless you have read it and been given a copy of it to keep. Participation in this study is voluntary. You may refuse to answer any question or discontinue your involvement at any time without penalty or loss of benefits to which you might otherwise be entitled. Your decision will not affect your future relationship with California State University, Northridge. Your signature below indicates that you have read the information in this consent form and have had a chance to ask any questions that you have about the study.

I agree to participate in the study.

___________________________________________________  ____________________
Subject Signature                                      Date

___________________________________________________
Printed Name of Subject

___________________________________________________  ____________________
Researcher Signature                                    Date

___________________________________________________
Printed Name of Researcher
APPENDIX B

Sit to Stand (3 sets of 10 reps.)

Position - Seated facing forward
- Lean forward so that your weight shifts over your heels
- Raise slightly out of your seat.
- Lean back to gently sit back down into the seat to return to the starting position to complete the repetition.

Progression #1 - Stand up slightly while still being able to keep your hands in contact with the sides of the chair.

Progression #2 - Come to a complete standing position.

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