SINGLE TRIAL EFFECTS OF DYNAMIC CYCLING: HOW LONG DOES IT LAST?

A dissertation submitted to the Kent State University College of Education, Health, and Human Services in partial fulfillment of the requirements for the degree of Doctor of Philosophy

by

Robert Scott Phillips

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A dissertation written by

Robert S. Phillips

B.A., Baldwin-Wallace College, 2007

D.P.T., Wheeling Jesuit University, 2009

Ph.D., Kent State University, 2014

Approved by

__________________________, Director, Doctoral Dissertation Committee
Angela L. Ridgel

__________________________, Member, Doctoral Dissertation Committee
Jacob E. Barkley

__________________________, Member, Doctoral Dissertation Committee
John McDaniel

Accepted by

__________________________, Director, School of Health Sciences
Lynne E. Rowan

__________________________, Dean, College of Education, Health and Human Services
Daniel F. Mahony Services
Parkinson’s disease (PD) is a neurodegenerative disorder that affects motor planning and leads to decreased quality of life in approximately 1.5 million Americans. Many individuals with PD experience decreased abilities to perform everyday activities. Previous studies have shown that motor symptoms improve immediately after bouts of high-cadence cycling in individuals with PD but it is unknown how long these improvements last. The objective of this study was to determine the duration of improvements after a single bout of dynamic high-cadence cycling. Individuals with mild to moderate PD completed a single 40-minute session of dynamic cycling and performed three days of motor function testing at home. Motor function was tested every 2 hours for three days after a cycling session and was analyzed using a repeated measures design. There was a 29.7% improvement in resting tremor 19 hours after completion of the cycling session and improvements continued at 27 hours (12.6%). In addition there was a 15.0% improvement in rapid alternating movement speed, a measure of bradykinesia, at 19 hours. A single session of dynamic cycling results in improvements in resting tremor scores and rapid alternating movement rhythm scores that last up to 30 hours. Cycling sessions should target one bout of dynamic cycling every 24-hour period.
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CHAPTER I
INTRODUCTION

Background

Parkinson’s disease (PD) is a progressive neurological disorder that affects nearly 1.5 million Americans (Dorsey, Constantinescu, & Thompson, 2007). It is characterized by the death of dopaminergic neurons in the midbrain. These neurons release the neurotransmitter dopamine, which plays an important role in movement. PD manifests as motor, cognitive, and social symptoms including rigidity, slowness of movements (bradykinesia), micrography (smallness of handwriting), masked face, postural and gait abnormalities, and tremor (Umphred, 2007). Although the cause of PD is unknown, treatment options such as medication and surgery are available to manage its symptoms.

As PD progresses, individuals have increasing difficulty with activities of daily living (ADLs). Progressive decline results in an increasing number and severity of impairments, functional limitations, and disabilities over time, and has an impact on quality of life (Dal Bello-Haas, 2002). Eventual reliance on caregivers (along with increased burdens on the healthcare system) for all transportation, home/medical care, and, ultimately survival, occurs once the patient with PD becomes wheelchair bound in the final stages of the disease (Umphred, 2007).

Rationale for the Study

Cycling has proven effective in the treatment of PD symptoms and management of energy reserves in individuals with PD, but it is unknown how long a single session of adaptive dynamic cycling will alter motor function in individuals with PD. This
disconnect in the literature provides a unique opportunity to determine the optimal number of sessions needed to observe improvements in motor function and determine when functional assessments should be performed for longer duration interventions.

Objective

The objective of this project is to quantify changes in motor symptoms after one session of dynamic cycling. In previous studies utilizing the dynamic cycling protocol, participants with PD reported that they felt that they did not need to take their PD medications after cycling. They have also reported improvement in ambulation (walking) and feeling less fatigued after a session of cycling. There is a need to quantify these anecdotal observations in order to determine the time course of these improvements. These data will assist medical professionals in developing exercise prescriptions to maximize symptom management. It is hypothesized that individuals with PD will show improvements in motor symptoms immediately after cycling and the following day, with symptoms returning to non-cycling levels on the third day. Participants are expected to have improved symptoms of PD (increased movement and/or balance and decreased tremor) for a period of time after exercise completion, based on previous data.
CHAPTER II
REVIEW OF THE LITERATURE

Medical Management of Parkinson’s Disease

Most of today’s treatment interventions focus on the management of the symptoms of PD which can interrupt the ability to get in/out of bed or chairs, up/down stairs, through doorways, and even their abilities to feed and bath themselves. The most common practice for symptom management is the use of drug therapy (Tomlinson, Stowe, Patel, Rick, Gray, & Clarke, 2010) which, administered orally, has to cross the blood brain barrier. Oral administration of dopamine requires large enteral absorption for maximal potency across the blood brain barrier. Side effects from drug therapy (on/off state or the timing of medications, dyskinesias or involuntary movements, impulsive/compulsive behaviors, and hallucinations/delusions) limit its effectiveness (Hawkins, Mokashi, & Simpson, 2005). More severe cases of PD may be treated with deep brain stimulation, an invasive surgical implantation of electrodes deep in the brain (globus pallidus or subthalamic nucleus), which can reduce tremor and improve locomotion and balance (Hamani, Moro, & Lozano, 2011; Tolosa & Compta, 2006).

Exercise as Medication

There is increasing interest in non-pharmacological therapies, specifically exercise that could improve quality of life and motor function in these individuals. Numerous exercise interventions have shown promise for reducing the severity of symptoms and prolonging quality of life for individuals with mild to moderate PD (Dibble, Addison, & Papa, 2009). Investigators have focused on five major areas of
intervention in PD: resistance training, tai chi training, balance training, gait training, and cycling.

**Exercise and Parkinson’s Disease**

**Resistance Training**

Resistive exercise has been proposed as a potential therapeutic intervention to attenuate some of the symptoms associated with PD, yet very few well-controlled trials have been performed. However, interventions that are available have generally focused on increasing muscle strength and function (Falvo, Schilling, & Earhart, 2008). Scandalis et al. examined the effects of a resistance training (RT) intervention in a group of participants with PD and a healthy control for 16 weeks. Both groups showed improved strength, but additional gains were observed in the PD group, specifically, improved stride length and speed (Scandalis, Bosak, Berliner, Helman, & Wells, 2001).

In a 12-week study of creatine supplementation and RT for individuals with PD, Haas et al. showed that both the placebo and creatine groups had measurable increases in lean body mass, one repetition max, muscle endurance, and sit-to-stand, but the creatine group demonstrated additional gains in sit-to-stand, chest press, and biceps curl compared to control (Hass, Collins, & Juncos, 2007). Dibble et al. examined 12 weeks of RT versus no intervention and found that all functional measures (six-minute walk test and stair ascension) improved in the RT group (Dibble, Hale, Marcus, Droge, Gerber, & LaStayo, 2006). From their systematic review, Lima et al. concluded that improved strength and improved gait speed/distance are observed in the population with PD, the results of strength training (Lima, Scianni, & Rodrigues-de-Paula, 2013), while Paul et al. have
demonstrated that muscle power is improved after a 12-week strengthening program, but failed to demonstrate any relationship to measures of functional improvement (Paul, Canning, Song, Fung, & Sherrington, 2014). A progressive resistance exercise intervention when compared to stretching, balance, and strengthening exercise program of the same duration shows similar improvement in the Unified Parkinson’s Disease Rating Scale III motor score (UPDRS) at 6-month initial comparison, but continued success is observed at 12-, 18-, and 24-months for the progressive resistance training group solely (Corcos et al., 2013).

**Tai Chi Training**

Tai Chi, a training of mind and body in the movements of smooth and coordinated martial arts techniques, has also proven effective for managing the declines associated with PD (Tsang, 2013). In a randomized controlled trial comparing tai chi and resistance exercise training Li et al. demonstrated that both interventions have a positive effect on a patient’s perception of wellness and this perception of wellness is correlated, weakly, to gains in unspecified clinical measures (Li, Harmer, Liu, Eckstrom, Fitzgerald, Stock, & Chou, 2013). After a 12-week intervention consisting of tai chi training, individuals with PD had improvements in balance measures, but demonstrated no changes in their UPDRS score (Gao, Leung, Yang, Wei, Guan, Jia, & He, 2014). Additionally, others have concluded that there is no benefit from a 12-week intervention of tai chi when measuring gait and biomechanical outcomes (Amano et al., 2013). Also of interest, tai chi improves functional static balance for individuals as measured by the Berg balance scale but not single leg stance or gait speed (Hackney & Earhart, 2008).
Balance Training

Balance training results in considerable improvements in the symptoms of PD, but the literature suggests that balance gains are magnified when balance interventions are combined with resistance training (RT; Hirsch, Toole, Maitland, & Rider, 2003; Toole, Hirsch, Forkink, Lehman, & Maitland, 2000). In a 30 week randomized controlled study, Toole et al. showed that RT combined with balance exercises showed marked improvements over a control group that only completed balance exercises, but the researchers attributed improvements to controls performing worse at post-test (Toole, Hirsch, Forkink, Lehman, & Maitland, 2000). In their randomized controlled trial of two PD groups, Hirsch et al. showed that RT and balance training could improve strength whereas balance training alone only improves balance after 10 weeks of intervention (Hirsch, Toole, Maitland, & Rider, 2003). These studies demonstrate the effectiveness of RT and balance training as possible interventions to improve of symptoms of Parkinson’s disease but constitute only a single treatment approach for dealing with many symptoms. Balance training alone does not seem to improve PD symptoms in any studies that have been published suggesting that decreased balance is the result of biomechanical factors or natural aging and not directly caused by a diagnosis of PD.

Gait Training

Many characteristic features of PD gait fluctuate over time, mainly stride length and cadence, and can be addressed by interventions targeting gait (Morris, 2006). Numerous studies have focused on improving gait quality and speed and have demonstrated positive outcomes using subjective measures, but no study has yielded a
consistent model for successful symptom management. Cakit et al. used variable speed treadmill training for their experimental group and demonstrated significant improvements in balance performance and gait performance using the Dynamic Gait Index, maximal treadmill walking speed, and distance in individuals with PD (Cakit, Saracoglu, Genc, Erdem, & Inan, 2007). Pohl et al. using variable speed treadmill training and limited progressive treadmill training showed increases in self-selected walking speed (neither was superior to the other), but their “conventional” gait training and no intervention groups showed no significant changes for these measures (Pohl, Rockstroh, Ruckriem, Mrass, & Mehrholz, 2003). In a three week gait intervention with auditory cuing, Thaut et al. showed a significant improvement in gait speed, stride length, and cadence compared to a self-paced group of individuals (Thaut, McIntosh, Rice, Miller, Rathbun, & Brault, 1996).

In addition to gait training with a treadmill alone, some researchers have used unweighting protocols to improve gait in the patient with PD. Miyai et al. demonstrated that body weight supported treadmill training helps the patient with PD to elongate stride length and that this effect remains for up to 4 months after intervention ceased (Miyai, Fujimoto, Yamamoto, Ueda, Saito, Nozaki, & Kang, 2002). Findings were also correlated to improvements in ADLs, motor performance, and ambulation quality (Miyai, Fujimoto, Ueda, Yamamoto, Nozaki, Saito, & Kang, 2000). However, it has been suggested by other researchers that it is not necessary to unweight the patient with PD unless serious safety concerns arise about an individual’s fall risk. Furthermore, it is
likely that exercising at peak medication effectiveness is more important than unweighting the individual (Herman, Giladi, Gruendlinger, & Hausdorff, 2007).

**Cycling**

Many recent studies have indicated that, despite severe disabilities, individuals with PD have demonstrated the ability to ride an upright bicycle in a controlled setting such as a parking lot or flat trail (“A Biking Baker,” 2011; Danovaro, 2010; Dunham, 2010). The benefits of cycling compared to other modes of exercise are documented in the literature and have shown that fatigue is decreased with cycling (when compared to walking interventions) allowing individuals with PD to be more active throughout the day (Elbers et al., 2009).

A number of studies have demonstrated that recumbent cycling in a laboratory setting is also effective in the treatment and management of PD symptoms (Pope, Millin, Mehta, & Swift, 2005; Ridgel, Abdar, Alberts, Discenzo, & Loparo, 2013; Ridgel, Kim, Fickes, Muller, & Alberts, 2011; Ridgel, Muller, Kim, Fickes, & Mera, 2011; Ridgel, Peacock, Fickes, & Kim, 2012; Ridgel, Vitek, & Alberts, 2009; Snijders, Toni, Ruzicka, & Bloem, 2011; Snijders, van Kesteren, & Bloem, 2012). Ridgel, Peacock, Fickes, and Kim (2012), in their findings from a physiological limitation study using a high cadence cycling protocol, demonstrated that they could elicit improvements in tremor and bradykinesia and that their active-assisted protocol was well tolerated by participants with PD. Other studies concluded that upper extremity tremor and bradykinesia experienced acute changes after passive leg cycling (Ridgel, Muller, Kim, Fickes, & Mera, 2011). Further studies have demonstrated the positive effects of passive cycling in
cognitive function, specifically in set shifting after the trail making test in persons with PD (Ridgel, Kim, Fickes, Muller, & Alberts, 2011). Finally, forced cycling exercise protocols with variable cadence have demonstrated superiority to voluntary effort cycling showing improvements in motor function, dexterity, rigidity, and bradykinesia in patients with PD (Ridgel, Abdar, Alberts, Discenzo, & Loparo, 2013; Ridgel, Vitek, & Alberts, 2009). Therefore, it appears as if cycling is a viable option for exercise in the PD population.

The exact mechanisms of cycling-induced improvements in motor function are unknown. However, studies have proposed a ‘kinesia paradox’ in which external pacing or cuing comes from the revolutions of the pedals allowing the individual to maintain consistent step length (Snijders, Toni, Ruzicka, & Bloem, 2011). It has also been proposed that the dominant lower extremity can assist the non-dominant lower extremity through energy exerted by way of pedaling, which is not as easily achieved in walking due to weight shifting demands (Snijders, van Kesteren, & Bloem, 2012).

Recent works from Ridgel et al. have revealed improvements in tremors and bradykinesia, two symptoms of PD, after 40 minutes of active-assisted cycling when patients have been taken off their medications, demonstrating that cycling is an effective modality to improve motor symptoms without the use of medications (Ridgel, Peacock, Fickes, & Kim, 2012). In addition, data from Phillips and Ridgel have shown that three sessions of cycling with variable high cadence, 40 minutes each, over one week can alter an individual’s UPDRS motor score (Phillips, Wilson, & Ridgel, 2013a, 2013b; Ridgel, Phillips, & Wilson, 2013a, 2013b; Wilson, Phillips, & Ridgel, 2013).
Cycling shows the most promising avenue for exploration and development of protocols for augmenting function in patients with PD. Inconsistencies in the results of paradigms involving resistance training, tai chi training, balance training, and gait training imply that cycling is a superior form of exercise for the patient with PD.
CHAPTER III

METHODOLOGY

Recruitment

Participants were obtained from the list of previous Parkinson’s study participants and called by telephone for pre-screening and scheduling. If the subject was pre-screened in the last two years, they were asked if there were any changes (surgeries, medications, or heart related issues) since they last participated in a study with the exercise physiology labs.

After finishing the screening process, individuals meeting all participation criteria were asked to participate in the study. If individuals agreed to participate in the study they were mailed the consent forms (Appendix A and Appendix B) and a four-page health history form (Appendix D) to further assess physical health. Individuals having participated in studies in this lab in the last year were asked if there were any changes to their health history form in the last year upon arrival to the lab for testing.

Inclusion

20-five individuals with a medical diagnosis of idiopathic PD of all genders and races, who were undergoing treatment for symptom management at the time of the study, were considered. Inclusion criteria included: 45-85 years old, and no indications for cardiovascular disease (CVD) or stroke. Subjects were screened using the American Heart Association/American College of Sports Medicine exercise pre-participation questionnaire, pre-exercise medical evaluation (Appendix E). Individuals with three or more risk factors for coronary artery disease (e.g. age, hypertension, diabetes, smoking,
obesity) were classified as moderate risk for exercise intervention. These individuals were required to obtain physician consent (Appendix F) before they were allowed to participate in this exercise trial. Family history did not exclude individuals from participation in this study and laboratory assistants were made aware of an individual’s family risk.

**Exclusion**

Subjects who reported clinically significant medical disease that would increase their risk of exercise-related complications (e.g. cardiac or pulmonary disease, diabetes mellitus, hypertension, stroke) or had a diagnosis of dementia, underlying orthopedic/musculoskeletal injuries involving the legs and low back that would limit abilities to exercise, prior surgery for Parkinson’s disease management including deep brain stimulation, pallidotomy, or thalamotomy were excluded from participation in this study.

**Risk Minimization**

All researchers and staff that supervised exercise sessions were trained in basic cardiac life support. In addition, an AED was located in the laboratory where participants completed testing. The intensity of the exercise might have been taxing at times, but the participants were allowed to rest at any time during the exercise session. The intensity of the exercise was monitored throughout completion of the intervention by heart rate (HR) records collected every two minutes. Exercise was terminated if the individual reached a HR value exceeding 80% of the Age Predicted HR max. The appropriate intensity level of the cycling session was tailored to the individual participant’s age and fitness level. If
a participant experienced any sensation that appeared to be unusual or uncomfortable that individual was advised to stop exercising by the research staff.

**Protocol**

On Monday of week one, participants were greeted at the entrance to the MACC Annex across from the accessible parking lot on the north side of the building. If necessary, the participants were given an R3 parking permit. The participants were led to the lab and the consent and health history forms (Appendix A, Appendix B, and Appendix C) were reviewed with the subject. Each individual was then randomized into non-cycling-cycling or cycling-non-cycling groups to counterbalance the order of allocated interventions. Once individuals were informed of the participation order the protocol was explained and individuals were trained on the HomeView tablet by the principal investigator. HomeView is an FDA approved portable device that individuals took home with them and completed testing protocols as prompted (Figure 1). This device is useful because researchers can set up a study in the computer and can have immediate access to the downloaded data collected while the subject is at home eliminating the necessity of long stays and frequent visits to the testing laboratory (Heldman, Filipkowski, Riley et al, 2012; Mera, Burack, & Giuffrida, 2012; Mera, Heldman, Espay, Payne, & Giuffrida, 2012). Numerous studies have validated the effectiveness of Kinesia and HomeView for testing of patients with PD (Giuffrida, Riley, Maddux, & Heldman, 2009; Heldman, Giuffrida, Chen et al., 2011; Heldman, Jankovic, Vaillancourt, Prodoehl, Elble, Giuffrida, 2011; Mostile, Giuffrida, Adam, Davidson, & Jankovic, 2010). Assessment of motor tasks (resting tremor, postural tremor, kinetic
tremor, finger tapping, hand grasp, rapid alternating movements, and dyskinesias), medication and activity diaries (when medications were taken and how the patient felt their symptoms were during testing), and video of the participant performing six motor activities was completed using Great Lakes Neurotechnologies HomeView system.

After individuals were randomized into non-cycling-cycling or cycling-non-cycling groups to counterbalance the order of allocated interventions they began training on the HomeView tablet with the research assistant. The HomeView tablet system was explained to individuals completing the cycling protocol prior to their performing the cycling session; they completed the first HomeView measurement after they cycled. The individuals collecting non-cycling data the first week completed their first testing during explanation of the HomeView system. All participants left the lab with the tablet and charging cord to complete testing throughout the week as prompted by the tablet (Figure 1).

The following Monday (week two), the participants returned to the lab to complete either their 40 minute cycling protocol or began their non-cycling measures at home as prompted by the tablet. After the protocol was completed, the participant again completed their testing over the week as prompted while at home (Figure 1). All participants returned their tablet on Friday of the second week and received a gift card for their efforts.
Figure 1. Testing schedule

**Bike and Physiological Variables**

Participants completed the dynamic cycling protocol consisting of 40 minutes of cycling including a 5 minute warm up and cool down (Phillips, Wilson, & Ridgel, 2013a, 2013b; Ridgel, Phillips, & Wilson, 2013a, 2013b; Wilson, Phillips, & Ridgel, 2013). Dynamic cycling is a varied cadence cycling protocol at a high revolution ranging between 75 and 85 revolutions per minute (rpm). The bike is continually fluctuating between 75-85 rpm to keep the motion dynamic and challenge the participant to continually have to work to keep pace. The participant cannot adapt to a constant cadence due to this fluctuation. The individual with Parkinson’s disease sat in a semi-
recumbent position on a forward-backward adjustable chair at a distance from the pedals allowing for a 10-20 degree bend in the knee. Participants were adjusted to a comfortable distance within this range and their feet were strapped onto the pedals. During the warm up and cool down, the motor was set at 50 rpm and then was set at 80 rpm during the 30-minute cycling session. If the subject was able to keep up with the 80 rpm, the bike provided increased resistance to maintain 80 rpm but if the individual fatigued the bike assisted him or her to keep 80 rpm.

In order to ensure that individuals were exercising at the desired intensity, participants were monitored during their single bout of dynamic cycling for cadence, power, torque, and heart rate. Cadence is measured by counting the number of revolutions per minute that an individual completes while cycling. Power and torque are direct measures of the force that a participant is generating or contributing to the dynamic cycling. If the participant was overpowering the motor the values were positive and if the values were negative the motor was providing assistance to the participant. All individuals were expected to elevate their heart rate to 60-80% of their age predicted maximum heart rate using the Karvonen method ([220 – age] – resting heart rate = heart rate reserve and then calculate [heart rate reserve x training%] + resting heart rate) for target heart rate (Karvonen, Kentala, & Mustala, 2007). Individuals were required to wear a heart rate monitor, which was synchronized to the computer controller throughout cycling.
**Statistical Analysis**

Using IBM SPSS Statistics 20, data was analyzed with repeated measures. A repeated-measures design will be followed with 23 time points (2 condition x 23 time points). Demographic data, age, height, weight, duration of PD, and BMI score were collected and averaged for the study population and the standard error of the mean was calculated from these values. Comparisons were made between non-cycling and cycling data to determine if the cycling intervention changed the non-cycling data (medication frequency/dosage and subjective symptom reports). An independent reviewer rated each video using the UPDRS Motor Scale and results were compared to the results obtained from HomeView to establish validity for statistical claims. Exercise data was used to determine that all individuals achieved targeted heart rate based on Karvonen calculations.
CHAPTER IV
MANUSCRIPT

Background/Introduction

Although cycling has been proven effective in the treatment of PD symptoms and management of energy reserves in individuals with PD, it is unknown how long a single session of adaptive dynamic cycling will alter motor function in individuals with PD. This disconnect in the literature provides a unique opportunity to determine the optimal number of sessions needed to observe improvements in motor function and determine when functional assessments should be performed for longer duration interventions.

Parkinson’s disease (PD) affects nearly 1.5 million Americans (Dorsey, Constantinescu, & Thompson, 2007) and is a progressive neurological disorder that is characterized by the loss of dopaminergic neurons in the brainstem. The nerves in this area of the brain release the neurotransmitter dopamine and death of these neurons leads to motor dysfunction. The cause of PD is unknown, but treatment options such as medication and surgery are available to manage its symptoms. As individuals progress in severity of their PD, progressive decline results in an increasing number and severity of impairments, functional limitations, and disabilities, which impact quality of life (Dal Bello-Haas, 2002).

Most of today’s treatment interventions focus on the management of the symptoms of PD and the most common practice for symptom management is the use of dopamine drug therapy (Tomlinson, Stowe, Patel, Rick, Gray, & Clarke, 2010). Oral administration of dopamine requires large enteral absorption for maximal potency across
the blood brain barrier and side effects from drug therapy limit its effectiveness (Hawkins, Mokashi, & Simpson, 2005). More severe cases of PD may be treated with deep brain stimulation, an invasive surgical implantation of electrodes deep in the brain (globus pallidus or subthalamic nucleus), which can reduce tremor and improve locomotion and balance (Hamani, Moro, & Lozano, 2011; Tolosa & Compta, 2006).

There is, however, increasing interest in non-pharmacological therapies, specifically exercises that could improve quality of life and motor function in these individuals. Resistive exercise studies focusing on increasing muscle strength and function (Falvo, Schilling, & Earhart, 2008) have demonstrated improved stride length and speed (Scandalis, Bosak, Berliner, Helman, & Wells, 2001), gains in sit-to-stand, chest press, and biceps curl (Hass, Collins, & Juncos, 2007), and improved functional measures (Dibble, Hale, Marcus, Droge, Gerber, & LaStayo, 2006) in the persons with PD after exercise training. When balance training is combined with resistance training, gains are magnified (Hirsch, Toole, Maitland, & Rider, 2003; Toole, Hirsch, Forkink, Lehman, & Maitland, 2000). Also, the combination of Tai Chi, a training of mind and body in the movements of smooth and coordinated martial arts techniques, has also proven effective for managing the declines associated with PD (Tsang, 2013). In a randomized controlled trial comparing tai chi and resistance exercise training Li et al. demonstrated that both interventions have a positive effect on a patients perception of wellness and this perception of wellness is correlated, weakly, to gains in clinical measures of balance (Li, Harmer, Liu, Eckstrom, Fitzgerald, Stock, & Chou, 2013). Numerous studies have targeted improving gait quality and speed and demonstrated
positive outcomes using subjective measures, but no study has yielded a consistent model for successful symptom management. Body weight supported treadmill training can help the patient with PD to elongate stride length, improve activities of daily living, improve motor performance and ambulation quality (Miyai, Fujimoto, Yamamoto, Ueda, Saito, Nozaki, & Kang, 2002; Miyai, Fujimoto, Ueda, Yamamoto, Nozaki, Saito, & Kang, 2000).

Cycling, when compared to walking interventions, is less demanding and leads to decreased fatigue allowing individuals with PD to be more active throughout the day (Elbers et al., 2009). A number of studies have demonstrated that recumbent cycling in a laboratory setting is as effective in the treatment and management of PD symptoms as riding a bicycle on an open path (Pope, Millin, Mehta, & Swift, 2005; Ridgel, Abdar, Alberts, Discenzo, & Loparo, 2013; Ridgel, Kim, Fickes, Muller, & Alberts, 2011; Ridgel, Muller, Kim, Fickes, & Mera, 2011; Ridgel, Peacock, Fickes, & Kim, 2012; Ridgel, Vitek, & Alberts, 2009; Snijders, Toni, Ruzicka, & Bloem, 2011; Snijders, van Kesteren, & Bloem, 2012). Therefore, it appears as if cycling is a viable option for exercise in the PD population. Recent works from Ridgel et al. have revealed improvements in tremors and bradykinesia, two symptoms of PD, after 40 minutes of active-assisted cycling when patients have been taken off their medications, demonstrating that cycling is an effective modality to improve motor symptoms without the administering of medications (Ridgel, Peacock, Fickes, & Kim, 2012). In addition, data from Phillips and Ridgel have shown that three sessions of cycling with variable high cadence, 40 minutes each, over one week can alter an individual’s UPDRS motor

The objective of this project is to quantify the duration that symptoms are improved after one session of dynamic cycling. In previous studies utilizing the dynamic cycling protocol, participants with PD have reported that they have forgotten to take their prescribed medications because they never felt that they needed the medications after cycling. Other individuals with PD have reported improvement in ambulation (walking) and feeling less fatigued after their session of cycling. There is a need to quantify these anecdotal observations, to determine the point at which effects have returned to non-cycling values. These data will assist in developing exercise prescriptions to maximize symptom management. It is hypothesized that individuals with PD will show improvements in motor symptoms immediately after cycling and the following day and symptoms will return to non-cycling levels on the third day. Participants are expected to have improved symptoms of PD (increased movement and/or balance and decreased tremor) for a period of time after exercise completion, based on previous data.

**Methodology**

20-five individuals with idiopathic PD of all genders and races currently on medication for symptom management were obtained from the list of previous Parkinson’s study participants. *Inclusion:* Participants were between 45-85 years old and had no contraindications for cardiovascular disease (CVD) or stroke. (Family history did not exclude individuals from participation in this study and laboratory assistants were made aware of an individual’s family risk.) *Exclusion:* Participants with clinically significant
medical disease that would increase the risk of exercise-related complications, diagnosis of dementia, underlying orthopedic/musculoskeletal injuries involving the legs and low back that would limit ability to exercise, prior surgery for Parkinson’s disease management including deep brain stimulation, pallidotomy, or thalamotomy were excluded from participation.

Individuals were randomized into non-cycling-cycling or cycling-non-cycling groups to counterbalance the order of allocated interventions, and then began training on the HomeView tablet with the research assistant. The HomeView tablet system was explained to individuals completing the cycling protocol prior to their performing the cycling session; they completed the first HomeView measurement after they cycled. The individuals collecting non-cycling data the first week completed their first testing during explanation of the HomeView system. All participants left the lab with the tablet and charging cord to complete testing throughout the week as prompted by the tablet (Figure 1). The following Monday (week two), the participants returned to the lab to complete either their 40 minute cycling protocol or began their non-cycling measures at home as prompted by the tablet. After the protocol was completed, the participant again completed their testing over the week as prompted while at home (see Figure 1).

**Kinesia HomeView**

Testing of subjects was completed using Great Lakes Neurotechnologies HomeView for analysis of tremor, bradykinesia, and medication and symptom logging. Numerous studies have validated the effectiveness of Kinesia and HomeView for testing of patients with PD (Giuffrida, Riley, Maddux, & Heldman, 2009; Heldman, Giuffrida,
Chen, 2011; Heldman, Jankovic, Vaillancourt, Prodoehl, Elble, & Giuffrida, 2011; Mostile, Giuffrida, Adam, Davidson, & Jankovic, 2010). Using HomeView, participant data was collected for motor tasks (resting tremor, postural tremor, kinetic tremor, finger tapping, hand grasp, rapid alternating movements, and dyskinesias), medication and activity diaries (when medications were taken and how the patient felt their symptoms were during testing), and video of participant performance of the activities.

**Bike and Physiologic Variables**

Participants completed the dynamic cycling protocol (see Figure 2; Phillips, Wilson, & Ridgel, 2013a, 2013b; Ridgel, Phillips, & Wilson, 2013a, 2013b; Wilson, Phillips, & Ridgel, 2013). The dynamic cycling protocol was a varied cadence cycling protocol at a high revolution ranging between 75 and 85 revolutions per minute (rpm). The bike was continually fluctuating between 75-85 rpm to keep the motion dynamic and challenge the participant to continually have to work to keep pace. The participant could not adapt to a constant cadence due to this fluctuation. The individual with Parkinson’s disease was sitting recumbent on a forward-backward adjustable chair at a distance from the pedals allowing for a 10-20 degree bend in the knee. Individuals were adjusted to a comfortable distance within this range and their feet were strapped onto the pedals. The motor of the bike kept the participants at 50 rpm for the warm-up and cool-down and at 80 rpm during the 30 minute cycling session. If the subject was able to perform above 80 rpm the bike provided increased resistance to maintain 80 rpm but if the individual tired the bike assisted him or her to keep 80 rpm.
Figure 2. Dynamic cycling protocol

In order to determine that participants had achieved sufficient exercise, participants were monitored during their single bout of dynamic cycling for cadence, power, torque, and heart rate. Cadence is measured by counting the number of revolutions per minute that an individual completes while cycling. This number is used to determine if a participant is meeting the appropriate exercise protocol for the intervention and is monitored by the controller. Power and torque are both output measures built into the control box and motor. These variables are direct measures of the force that a participant is generating or contributing to the dynamic cycling. If the participant is overpowering the motor the values will be positive and if the values are negative the motor is providing assistance to the participant. All individuals were expected to elevate their heart rate to 60-80% of their age predicted maximum heart rate using the Karvonen method ([220 – age] – resting heart rate = heart rate reserve and then calculate [heart rate reserve x training%] + resting heart rate) for target heart rate.
Individuals were required to wear a heart rate monitor, which was synchronized to the controller.

Using IBM SPSS Statistics 20, descriptive statistics were determined for participant characteristics (age, height, weight, Body Mass Index [BMI] and duration of PD). An Analysis of Variance (ANOVA) was calculated with two conditions (non-cycling, cycling) by eight time points (3, 11, 19, 27, 35, 51, and 55) spaced at eight hour intervals with repeated measures on time conditions. Statistically significant interactions were achieved at a 95% confidence interval for the directional model set at \( p = 0.05 \) for single-tail analysis or \( p = 0.10 \) for a two-tailed analysis (Lykken, 1968). Paired-sample t-tests were then completed for significant interactions to determine what time points were contributing to the interaction. Bonferroni corrections were applied to the data sets due to the large sample size.

**Results**

**Participant Demographics and Exercise Variables**

20-one subjects (Hoehn and Yahr 1.71 ± 0.10, Age 66 ± 1.88 years, 14 males and seven females, height 69.6 ± 0.94 inches, weight 184.6 ± 9.96 pounds, BMI 26.7 ± 1.21, and duration of PD 43.89 ± 7.10 months) completed the study. Although 24 individuals where pre-screened and eligible to participate, three individuals either cancelled their testing session \( (n = 1) \) or dropped out of the trial due to time constraints \( (n = 2) \). Subjects averaged an intensity of 50.60% of their age predicted HR max and achieved a cycling cadence \( (80 ± 0.99 \text{ rpm}) \), power \( (4.61 ± 5.30) \), and torque \( (3.16 ± 4.53) \) similar to

**Motor Function Assessments**

After testing was complete, observation of the graphed variables indicated trends among the tested variables when comparing cycling to non-cycling weeks. After plotting data from every two hours it was apparent that at 10 hours and 20 hours post-cycling individuals showed a change, whether positive or negative. In Figure 3 the area between the non-cycling and cycling lines in noticeable larger after 10 hours and 20 hours post-cycling for resting tremor, postural tremor, and kinetic tremor with the average of the three tremors depicted in the tremor average portion of the graph showing the same. Graph for finger movements (Figure 4), hand movements (Figure 5), rapid alternating movements (Figure 6), and dyskinesia (Figure 7) show similar trends at 10 and 20 hours post-cycling. In addition, at around 30 hours post-cycling intervention, there is a return to non-cycling values that were obtained during the week of non-cycling and the data has smaller amplitude after 30 hours.
Figure 3. Changes in tremor score after cycling and non-cycling days. A comparison of resting, kinetic, and postural tremors and the average combined tremor score for non-cycling and cycling weeks. Both resting (top) and kinetic (middle upper) tremors are changed at 10 and 20 hours post-cycling intervention while after cycling postural (middle lower) tremor is mirroring the non-cycling data. Data presented were collected every two hours and matched for time of day.
Figure 4. Changes in finger movement score after cycling and non-cycling days. A comparison of finger-tapping scores from the non-cycling week and after cycling intervention week. There is improved movement score in amplitude (middle) and rhythm (bottom) shortly after the 10, 20 and 45 hours points after cycling intervention while speed scores are improved at 10 and 45 hours post-cycling. Non-cycling and cycling weeks are matched for time of day.
Figure 5. Changes in hand movements score after cycling and non-cycling days. A depiction of average hand-grasping scores the week after cycling intervention compared to the non-cycling intervention week matched for time of day. Individuals had improved speed (top) at 10 and 20 hours, improved amplitude (middle) from the time of intervention until 25 hours after the intervention, but little to no change in rhythm (bottom) score after the cycling intervention. Rhythm was slightly hindered after cycling.
Figure 6. Changes in rapid alternating movement score after cycling and non-cycling days.
A representation of the changes in average pronation-supination score after cycling intervention compared to the non-cycling week matched for time. Individuals show improvements in speed (top) and amplitude (middle) at 10 hours and there are improvements in rhythm (bottom) at 18 hours but changes are minimal at best for each component.
Figure 7. Changes in dyskinesia score after cycling and non-cycling days. A depiction of average dyskinesia score after cycling intervention and for non-cycling week matched for time of day. After cycling individuals had improved dyskinesia score between 5 and 12 hours after cycling, at 20 hours after cycling and at 25 hours after cycling.

Combining all tremor (resting, postural, and kinetic) and motion (speed, amplitude and rhythm for finger-tapping, hand grasp, and pronation/supination) scores for each individual and then averaging these values provides insight to the overall trends of the specific variable subset. Once again, improvements are seen post-cycling just before 10 hours and from 15-25 hours including the 20-hour time point for the tremor (Figure 8) and motion (Figure 9) data and the trends of the graphs are similar to one another at similar time points. These trends demonstrate that the intervention is having an effect on the patient with PD. Further manipulation of the data is required to determine statistical significance of the data set and averaging the time points across the testing periods over eight hour time frames can provide more consistent trend
observations. Eight-hour time frames were selected to capture the effects observed at 10 and 20 hours.

**Figure 8.** Changes in overall tremor score after cycling and non-cycling days. A depiction of the sum of the tremor score averages after cycling intervention and during the non-cycling week matched for time of day. Individuals had improved tremor score between 15 and 25 hours after cycling and after 40 hours post-cycling.

**Figure 9.** Changes in overall motion score after cycling and non-cycling days. A depiction of totaled motor score averages after cycling intervention and non-cycling intervention weeks matched for time of day. Individuals have very similar trends in motor score with few peaks and troughs but are slightly improved between 15 and 25 hours post-cycling.
In order to look for patterns over longer periods of time, eight-hour periods of time were averaged together and were compared between cycling and non-cycling weeks. Significant interactions were determined for three of the thirteen tested variables when comparing cycling and non-cycling conditions; average resting tremor ($p = 0.09$; Figure 10), average hand movement rhythm ($p = 0.04$; Figure 11), and average rapid alternating movement rhythm ($p = 0.04$; Figure 12). These plots minimize the variability of the data set by calculating eight time points to graph rather than the original 33 time points that were tested (plotted above) allowing for a more observable effect. An additional benefit of fewer plotted points is better analysis of interactions using repeated measures.

Paired-sample t-tests (Table 1) were then completed for significant interactions to determine what time points were contributing to the interaction and Bonferoni corrections were applied to the data sets. Statistical significance was determined for resting tremor at 19 hours and 55 hours ($p = 0.02$, $p = 0.03$; Figure 10) and for hand movement rhythm at 19 hours ($p = .09$) in Figure 4. The effects seen at 19 hours are after the participant’s first dose of morning medication.
Figure 10. Significant interactions for resting tremor plotted by eight-hour averages. This plot depicts the average resting tremor scores of the two-hour measurements for a period of time decreasing the variability among the subjects. Statistically significant difference in time from non-cycling week to cycling week at a 95% confidence denoted by asterisk.
Figure 11. Significant interactions for hand movement rhythm plotted by eight-hour averages. This plot depicts the average hand movement rhythm scores of the two-hour measurements for a period of time decreasing the variability among the subjects. Statistically significant difference in time from non-cycling week to cycling week at a 95% confidence denoted by asterisk.
Figure 12. Significant interactions for rapid alternating movement rhythm plotted by eight-hour averages. This plot depicts the average rapid alternating movement rhythm score of the two-hour measurements for a period of time decreasing the variability among the subjects. No time points were significant.
Table 1

Post-Hoc Analysis for Significant Interactions

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<td>3 hours</td>
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<td>Resting Tremor</td>
<td>1.2 ± 0.27</td>
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<td>Hand Movement Rhythm</td>
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<td>0.78 ± 0.07</td>
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<td>Rapid Alternating Movement Rhythm</td>
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<td>0.89 ± 0.13</td>
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<td>Resting Tremor</td>
<td>1.65 ± 0.24</td>
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<td>1.19 ± 0.26</td>
<td>1.04 ± 0.24</td>
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<tr>
<td>Hand Movement Rhythm</td>
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<td>0.87 ± 0.11*</td>
<td>0.81 ± 0.08</td>
<td>0.78 ± 0.07</td>
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<td>Rapid Alternating Movement Rhythm</td>
<td>0.86 ± 0.08</td>
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<td></td>
<td>35 hours</td>
<td>43 hours</td>
<td>51 hours</td>
<td>55 hours</td>
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<tr>
<td>Resting Tremor</td>
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<td>Hand Movement Rhythm</td>
<td>0.76 ± 0.7</td>
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<td>Rapid Alternating Movement Rhythm</td>
<td>0.89 ± 0.17</td>
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<tr>
<td></td>
<td>51 hours</td>
<td>55 hours</td>
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<tr>
<td>Resting Tremor</td>
<td>1.23 ± 0.25</td>
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<td>1.52 ± 0.28</td>
<td>1.02 ± 0.26*</td>
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<tr>
<td>Hand Movement Rhythm</td>
<td>0.73 ± 0.04</td>
<td>0.70 ± 0.05</td>
<td>0.81 ± 0.08</td>
<td>0.74 ± 0.07</td>
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<tr>
<td>Rapid Alternating Movement Rhythm</td>
<td>0.93 ± 0.10</td>
<td>0.87 ± 0.12</td>
<td>0.97 ± 0.16</td>
<td>0.93 ± 0.10</td>
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*Note. Values are reported as Mean ± SE and * denotes statistical significance at 95% confidence.

**Anecdotal Evidence**

Individuals self reported their perceptions of the study and the majority of individuals had a positive experience and noted that they felt better after their cycling session. An individual was able to go for a walk the day following cycling in the evening, an activity that she and her husband had not been able to partake due to her PD symptoms. One individual reported the most profound evidence, his peers at his church
reported to him that he looked like he was doing better and that they noticed a change in his abilities to ambulate and serve food at luncheon. These anecdotal statements serve to highlight the psychological benefits that have occurred with participation in the cycling study and demonstrate the importance of perception of wellbeing on the results.

**Discussion**

Previous studies have demonstrated that individuals with PD benefit from exercise similar to normal healthy populations, but the optimal exercise addressing the unique needs and symptoms associated with PD has not yet been determined. Dynamic cycling is showing promising results in its application to the individual with PD (Phillips, Wilson, & Ridgel, 2013a, 2013b; Ridgel, Phillips, & Wilson, 2013a, 2013b; Wilson, Phillips, & Ridgel, 2013), but the effects of a single bout of cycling have not been determined and the appropriate frame time for repeating an intervention needs to be established for optimal results in the management of PD.

Progress with exercise interventions in regards to cycling is shown in the current study. The trends in the two-hours data depict a definite, observable trend in the majority of the graphs at ten and 20 hours post cycling intervention indicating a bimodal effect of intervention, cycling has two observable effects on independent variables. The trend is quite clear in the data for resting tremor, in particular and emerges in other variables as well. The design of the study places ten hours after the cycling intervention at the evening of the day on which cycling occurred, while 20 hours is around ten o’clock am the following cycling day. This lag in effect time would indicate that the cycling intervention is quite possibly having a positive effect on the medications taken for PD as
seen in previous studies (Alberts, Linder, Penko, Lowe, & Phillips, 2011). All individuals in the study were taking their prescribed medications (one individual was not on any prescription medications), for practical reasons, and the effects were still observable suggesting that cycling augmented medication performance in some fashion.

It is possible that the effects of cycling were present immediately following the exercise intervention, but fatigue prevented an observable effect until ten hours after the individuals who participated recovered from their cycling bout. The exact effect the intervention might be having on the medication is unclear due to the testing that was performed. Other studies have suggested that cycling may have an effect on medication performance that could lead to a decrease in the required doses of medication or that the fluctuation in medication on/off state may be minimized (Ridgel, Peacock, Fickes, & Kim, 2012). However, the mechanism for this effect is not known.

These findings in regard to changes in tremor and bradykinesia are consistent with the findings from other published cycling studies. Ridgel, Phillips, and Wilson have previously found that there is improvement of tremor and brady-kinesia with improvements in other functional measures using the same dynamic protocol over a three-day period (Phillips, Wilson, & Ridgel, 2013a, 2013b; Ridgel, Phillips, & Wilson, 2013a, 2013b; Wilson, Phillips, & Ridgel, 2013) suggesting that dynamic cycling is augmenting neuroplasticity.

Interestingly, at 30 hours post-cycling intervention the individuals are almost always at or near non-cycling levels suggesting that a single bout of dynamic cycling lasts approximately 30 hours, supporting the initial hypothesis. These results would
imply that interventions should occur once daily for maximal benefits prompting concerns of increased fatigue in the population with PD. Individuals with PD have increased energy expenditure with daily activities (Umphred, 2007) and the addition of daily cycling may limit an individual’s ability to function in everyday situations (Elbers et al., 2009) especially if effects of the cycling are not observable until ten hours after cycling. Recent studies in this lab suggest that there is an additive effect of repeated cycling bouts and the spacing of these bouts may not have to be within the suggested 30-hour time frame (Phillips, Wilson, & Ridgel, 2013a, 2013b; Ridgel, Phillips, & Wilson, 2013a, 2013b; Wilson, Phillips, & Ridgel, 2013).

The observed trends in Figures 3-9 are supported statistically by three variables: resting tremor, hand movement rhythm, and rapid alternating movement rhythm. Further analysis of these variables shows a significant interaction around 19 hours, indicating the effect of the intervention and time is strongest at this point and driving the interaction. As stated before, medications were not limited in this study and needs noted because the individuals of the study had taken their medications around 18 hours after the cycling intervention. The changes in motor output appear to aid the medication in some fashion, but the mechanism remains speculative at best.

An advantage of this study is an observed decrease in variability of the participants with PD compared to previous studies, which may have led to statistical significance. Individuals with similar Hohn-Yahr scores participated in this study, providing researchers with a more homogenous sample population compared to previous
studies from this lab (Phillips, Wilson, & Ridgel, 2013a, 2013b; Ridgel, Phillips, & Wilson, 2013a, 2013b; Wilson, Phillips, & Ridgel, 2013).

Lastly, the dynamic cycling protocol elicits moderate intensity heart rates in accordance with the 2010 guidelines published by the American College of Sports Medicine (Blair, LaMonte, & Nichaman, 2004). The study was expected to elicit heart rate intensities consistent with vigorous activity but individuals were not able to achieve this standard in their single session of dynamic cycling. Although this was not the expectation, the individuals did demonstrate appropriate levels of exercise to elicit a cardiovascular benefit.

A single bout of dynamic cycling is sufficient to produce changes in tremor and motor quality scores as measured by the Kinesia HomeView. The dynamic cycling protocol has consistently produced superior results than resistance training, tai chi training, balance training, and gait training or select combinations of the four and should become the intervention of choice for the patient with PD.

**Implications for Rehabilitation**

Practicing clinicians have an advantage when dealing with patients with PD because of their advance knowledge in the complexities of PD and its effects on everyday living. The clinician is, however, limited in resources, especially, time. The advent of a cycling protocol which would allow a patient with PD to exercise under the supervision of a skilled practitioner, reaping the benefits of improved symptoms, while not over-utilizing resources is an outstanding advancement in the treatment of PD. Individuals from this study have the most noticeable benefits 20 hours after the
completion of the dynamic cycling protocol and are back to their non-cycling normative values 30 hours after cycling suggesting that cycling interventions should take place before this time to prevent the disappearance of the positive effects. Following this prescription, an individual with PD would need to have access to a dynamic cycling bicycle once every 24 hours, and reimbursement for such an intensive regimen is not likely for most people. Dynamic cycling on a recumbent would provide a wonderful maintenance tool for the busy clinician after the patient with PD has been discharged from medical services.

**Study Limitations**

Despite the success of the study, no three individuals have the same presentation of their symptoms associated with PD; one individual may have a strong tremor, another individual may have increased bradykinesia and no tremor, and a third individual may have both tremor and bradykinesia. This difference in symptomology leads to increased variability in the data. Results of the study have limited application of our findings to individuals of less severe PD, a 1 or 2 Hohn-Yahr score. A more homogenous population of PD participants would be beneficial for refining recommendations for exercise frequency across the PD spectrum, but sample size must be large enough to decrease variability after dividing the sample into smaller, more similar symptom-controlled groups.

Additionally, the HomeView has been used only for research studies and to control medication administration in the clinical setting. We were able to collect information using the HomeView after a single exercise session similar to the current
applications in the clinic, and, if applied to an exercise prescription, would allow us to manipulate exercise interventions as they are performed in therapy clinics, community centers, and fitness centers.

**Future Directions**

This study suggests that individuals with PD should initiate a dynamic cycling program but additional work is needed to determine whether daily exercise intervention is needed (indicated above) or if the effects of the bike are compounded with repeated bouts of cycling and can therefore be spread throughout the week to avoid over-fatigue as suggested by Ridgel, Phillips, and Wilson (2013). Provided similar effects are maintained with lengthening of time between the administration of cycling bouts (cycling every other day), it would be beneficial to add additional proven interventions into an exercise prescription, such as strength training or functional training, to maximize benefits.

The addition of functional and balance measures to a study design, or exercise prescription, would provide insight into everyday changes that occur after dynamic cycling intervention. Individuals with PD not only suffer from tremor and bradykinesia but also have a host of other problems including postural asymmetries, rigidity, and muscle imbalances (Umphred, 2007). People are dynamic beings, needing movement to manage their environments for everyday living. By adding functional and balance measures to future testing protocols, researchers would be able to extrapolate how the patient with PD might benefit from dynamic cycling in his/her everyday living.
Future work should also focus on the additive effects of multiple sessions of cycling. Discovering that one session has an effect on cycling is beneficial for knowing when to target interventions, but if one session produces changes in symptoms what compounding effect does the second session have on individuals with PD. Is there a point at which the individual reach a plateau and cycling intervention no longer provides a benefit?
APPENDICES
APPENDIX A

LETTER OF CONSENT
Appendix A

Letter of Consent

Informed Consent to Participate in a Research Study

Study Title: *Single Day Effects of Dynamic Cycling: How Long Does it Last?*

Principal Investigator: *Angela L. Ridgel, PhD*

You are being invited to participate in a research study. This consent form will provide you with information on the research project, what you will need to do, and the associated risks and benefits of the research. Your participation is voluntary. Please read this form carefully. It is important that you ask questions and fully understand the research in order to make an informed decision. You will receive a copy of this document to take with you.

**Purpose:**
To understand the benefits of a single session of dynamic cycling and allow us to monitor the effects of a single session on motor function over time. This information will help to effectively prescribe intervention (treatment) protocols in individuals with Parkinson’s disease.

**Procedures**
If you choose to participate then you will be asked to visit the lab for three sessions. You will arrive the first day and learn to use the tablet with the research assistant. You will then take the tablet with you to complete testing throughout the week as prompted. On the second visit to the lab, you will complete a 40 minutes cycling protocol. After the protocol is completed, you will again take the tablet home and complete testing over the week as prompted. You will then return the tablet at the end of that week.
On the tablet you will complete evaluations for a variety of motor tasks and log your medication activity and diary (when medications were taken and how you feel your symptoms are during testing) using the HomeView software. In the lab you will be monitored during your single bout of dynamic cycling for cadence, power, torque, and heart rate.

*Participants are not liable for lost or damaged tablets.*

**Audio and Video Recording and Photography**
HomeView software collects video of you while you are performing the activities at home. All diary and video information is uploaded to a secure server that only the researcher can access. Video will be used to assess compliance with the protocol and an independent rater will observe the video to rank you on the motor function tests. Individual videos may be chosen for presentation at future conferences. Please, remember your surroundings when you are testing and that the background may be visible in your recording.

**Benefits**
The potential benefits of participating in this study may include improved movement and/or balance for a period of time after the exercise. Furthermore, your participation in this study will help us to better
understand the duration of these effects after cycling and help us to provide accurate exercise intervention for individuals with Parkinson’s disease.

**Risks and Discomforts**
There are risks or discomforts associated with any exercise study such as heart attack, stroke, muscle injury, fatigue and muscle soreness. Every effort will be made to minimize these risks using information from your pre-exercise medical screening. All research staff are trained in basic cardiac life support and there is an AED (Automatic External Defibrillator) in the research lab. The intensity of the exercise may be physically taxing; however, you will be allowed to rest at any time during each session. Intensity level will be continuously monitored with a heart rate monitor and you will be asked to assess your level of exertion at regular intervals. If you experience any sensation that is unusual or uncomfortable, please tell the staff and they will stop the exercise session.

Medical treatment by the University Health Center is provided only to currently registered students. Please be advised that for all other injuries, emergency services will be called for those occurring on the Kent State University campus. You or your medical insurance will be billed for this service. No other medical treatment or financial compensation for injury from participation in this research project is available.

**Privacy and Confidentiality**
Your study related information will be kept confidential within the limits of the law. Any identifying information will be kept in a secure location and only the researchers will have access to the data. Research participants will not be identified in any publication or presentation of research results; only aggregate data will be used. If you agree to participate in this research project, health information that may identify you will be collected. Only information you have disclosed to the researchers will be collected from your health history questionnaire. Your research information may, in certain circumstances, be disclosed to the Institutional Review Board (IRB), which oversees research at Kent State University, or to certain federal agencies. Confidentiality may not be maintained if you indicate that you may do harm to yourself or others.

**Compensation**
You will receive a $40 gift card for your participation in this study.

**Voluntary Participation**
Taking part in this research study is entirely up to you. You may choose not to participate or you may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. You will be informed of any new, relevant information that may affect your health, welfare, or willingness to continue your study participation.

**Contact Information**
If you have any questions or concerns about this research, you may contact Angela L. Ridgel, PhD at 330.672.7495. This project has been approved by the Kent State University Institutional Review Board. If you have any questions about your rights as a research participant or complaints about the research, you may call the IRB at 330.672.2704.

**Consent Statement and Signature**
I have read this consent form and have had the opportunity to have my questions answered to my satisfaction. I voluntarily agree to participate in this study. I understand that a copy of this consent will be provided to me for future reference.

| Participant Signature | Date |
APPENDIX B

VIDEO RECORDING CONSENT FORM
Appendix B

Video Recording Consent Form

Authorization to Use or Disclose Health Information that Identifies You for a Research Study

Study Title: Single Day Effects of Dynamic Cycling: How Long Does it Last?

Principal Investigator: Angela L. Ridgel, PhD

If you sign this document, you give permission to the Department of Exercise Physiology at Kent State University to use or disclose your health information that identifies you for the aforementioned research study.

The health information that we may use or disclose for this research includes medical records, results of physical examinations, medical history, lab tests, and certain health information indicating or relating to a particular condition. This includes the health history questionnaire that you completed previously upon joining the research project.

The health information listed above may be used by and/or disclosed to the Department of Exercise Physiology at Kent State University:
Dr. Angela Ridgel, Exercise Physiology
Dr. Robert Phillips, Exercise Physiology

The Department of Exercise Physiology at Kent State University is required by law to protect your health information. By signing this document, you authorize the Department of Exercise Physiology at Kent State University to use and/or disclose your health information for this research. Those persons who receive your health information may not be required by Federal privacy laws (such as the Privacy Rule) to protect it and may share your information with others without your permission, if permitted by laws governing them.

Please note that you may change your mind and revoke this authorization at any time, except to the extent that the Department of Exercise Physiology at Kent State University has already acted based on this Authorization. To revoke this authorization, you must write to: ATTN: Dr. Angela Ridgel, Exercise Science Laboratory, 163F MACC Annex, Kent State University, Kent OH 44224.

This authorization does not have an expiration date.

Print Name

Signature Date
APPENDIX C

DATA SHEET
Appendix C

Data Sheet

Name: ___________________________  Subject Number: ______________

Age: ________ (years)  Gender: ________ (M/F)

Height: ________ (ft/in or cm)  Weight: ________ (lbs/kg)  BMI: ______

Medications:

<table>
<thead>
<tr>
<th>Medication Type</th>
<th>Dose</th>
<th>Times Daily</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Amount of exercise (cardio & strength, days/week):

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

If subject has PD-

Date of diagnosis: _____/____/_______ (mm/dd/yyyy)

Most affected side: _________________
Appendix D

Health History Form

KENT STATE UNIVERSITY
APPLIED PHYSIOLOGY RESEARCH LAB

HEALTH HISTORY
Thank you for volunteering to be a participant for a study to be conducted in the Applied Physiology Research Laboratory. Some of the tests used in our experiments require that you perform strenuous exercise. Consequently, it is important that we have an accurate assessment of your past and present health status to assure that you have no medical conditions that would make the tests especially dangerous for you. Please complete the health history as accurately as you can.

THIS MEDICAL HISTORY IS CONFIDENTIAL AND WILL BE SEEN ONLY BY THE INVESTIGATORS AND KENT STATE UNIVERSITY HEALTH CENTER PERSONNEL

Name__________________________________________ Date___ / ___ / ___

Date of Birth___ / ___/ ___

Present Age_____yrs

Ethnic Group: ___White
___ African American
___ Hispanic
___ Asian
___ Pacific Islands
___ American Indian
___ Other ___________

HOSPITALIZATIONS AND SURGERIES
If you have ever been hospitalized for an illness or operation, please complete the chart below. Do not include normal pregnancies, childhood tonsillectomy, or broken bones.

YEAR________
OPERATIONS OR ILLNESS

________________________________________________________________________

YEAR________
OPERATIONS OR ILLNESS

________________________________________________________________________
YEAR______________
OPERATIONS OR ILLNESS

Are you under long-term treatment for a protracted disease, even if presently not taking medication? [ ] Yes [ ] No
If Yes, explain: ____________________________________________________________

MEDICATIONS
Please list all medications that you have taken within the past 8 weeks: (Include prescriptions, vitamins, over-the-counter drugs, nasal sprays, aspirins, birth control pills, etc.)
Check this box [ ] if you have not taken any medication.

MEDICATION________________
DOSE________________________
REASON FOR TAKING THIS

MEDICATION________________
DOSE________________________
REASON FOR TAKING THIS

MEDICATION________________
DOSE________________________
REASON FOR TAKING THIS

MEDICATION________________
DOSE________________________
REASON FOR TAKING THIS

MEDICATION________________
DOSE________________________
REASON FOR TAKING THIS

MEDICATION________________
DOSE________________________
REASON FOR TAKING THIS

ALLERGIES
Please list all allergies you have (include pollen, drugs, alcohol, food, animals, etc.)
Check this box [ ] if you have no allergies.
1. ____________________________________________________________
When was the last time you were “sick”? (e.g. common cold, flu, fever, etc.)

PROBLEMS AND SYMPTOMS
Place an X in the box next to any of the following problems or symptoms that you have had:

**General**

[ ] Mononucleosis  
   If yes, when ______________________

[ ] Excessive fatigue  
[ ] Recent weight loss while not on a diet  
[ ] Recent weight gain  
[ ] Thyroid disease  
[ ] Fever, chills, night sweats  
[ ] Diabetes  
[ ] Arthritis  
[ ] Sickle Cell Anemia  
[ ] Heat exhaustion or heat stroke  
[ ] Recent sunburn

**Heart and Lungs**

[ ] Abnormal chest x-ray  
[ ] Pain in chest (persistent and/or exercise related)  
[ ] Heart attack  
[ ] Coronary artery disease  
[ ] High blood pressure  
[ ] Rheumatic fever  
[ ] Peripheral vascular disease  
[ ] Blood clots, inflammation of veins (phlebitis)  
[ ] Asthma, emphysema, bronchitis  
[ ] Shortness of breath  
   [ ] At rest  
   [ ] On mild exertion

[ ] Discomfort in chest on exertion  
[ ] Palpitation of the heart; skipped or extra beats  
[ ] Heart murmur, click  
[ ] Other heart trouble  
[ ] Lightheadedness or fainting  
[ ] Pain in legs when walking
Swelling of the ankles
Need to sleep in an elevated position with several pillows

G-U SYSTEM
Get up at night to urinate frequently
Frequent thirst
History of kidney stones, kidney disease

G.I. TRACT
Eating disorder (e.g. anorexia, bulimia)
Yellow jaundice
  If yes, when
Hepatitis
  If yes, when
Poor appetite
Frequent indigestion or heartburn
Tarry (black) stool
Frequent nausea or vomiting
Intolerance of fatty foods
Changes in bowel habits
Persistent constipation
Frequent diarrhea
Rectal bleeding
Unusually foul smelling or floating stools
Pancreatitis

Nervous System
Alcohol problem
Alcohol use
  If yes, how many drinks ingested per week
Frequent or severe headaches
Stroke
Attacks of staggering, loss of balance, dizziness
Persistent or recurrent numbness or tingling of hands or feet
Episode of difficulty in talking
Prolonged periods of feeling depressed or “blue”
Difficulty in concentrating
Suicidal thoughts
Have had psychiatric help

Have you ever passed out during or after exertion? YES NO
Do you have a family history of coronary artery disease YES NO
  If yes, Who? (Grandparents, parents, siblings, uncles, and aunts)
<table>
<thead>
<tr>
<th>Question</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are there any other reasons not mentioned above that you feel you should not participate in this research study?</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Do you currently smoke cigarettes?</td>
<td>YES</td>
<td>NO</td>
</tr>
<tr>
<td>Do you currently use any smokeless tobacco products?</td>
<td>YES</td>
<td>NO</td>
</tr>
</tbody>
</table>
APPENDIX E

PRE-EXERCISE MEDICAL EVALUATION
Appendix E

Pre-Exercise Medical Evaluation

AHA/ACSM Health/Fitness Facility Pre-participation Screening Questionnaire

Assess your health status by checking all true statements:

Have you had:

History:
[ ] A heart attack.
[ ] Heart surgery.
[ ] Cardiac catheterization.
[ ] Angioplasty or stent.
[ ] Pacemaker/implantable cardiac defibrillator.
[ ] Rhythm disturbance.
[ ] Heart valve disease.
[ ] Heart failure.
[ ] Heart transplantation.
[ ] Congenital heart disease.

Symptoms:
[ ] You experience chest discomfort with exertion.
[ ] You experience unreasonable breathlessness.
[ ] You experience dizziness, fainting, or blackouts.
[ ] You take heart medications.
[ ] Other health issues.
[ ] You have diabetes.
[ ] You have asthma or other lung disease.
[ ] You have burning or cramping sensation in your legs when walking short distances.
[ ] You have musculoskeletal problems that limit your physical activity.
[ ] You have concerns about the safety of exercise.
[ ] You take prescription medication(s).
[ ] You are pregnant.

Cardiovascular risk factors:
[ ] You are a man older than 45 years.
[ ] You are a woman older than 55 years, have had a hysterectomy, or are postmenopausal.
You smoke, or quit smoking within the previous 6 months.

Your blood pressure is greater than 140/90 mm Hg (Last date checked: ________).

You do not know your blood pressure.

You take blood pressure medication.

Your blood cholesterol level is greater than 200 mg/dl (Last date checked: ________).

You do not know your cholesterol level.

You have a close blood relative who had a heart attack or heart surgery before age of 55 (father or brother) or age 65 (mother or sister).

You are physically inactive (i.e., you get <30 minutes of physical activity on at least 3 days per week).

You are greater than 20 pounds overweight.

Most Affected Hand: __________

Date of Birth: __________

Address: __________________________

________________________________

Email: ____________________________

Physician: _________________________
APPENDIX F

PHYSICIAN CONSENT
Appendix F

Physician Consent

PHYSICIAN’S CLEARANCE FOR EXERCISE PARTICIPATION
Kent State University- Department of Exercise Physiology

Patient’s name: __________________________ DOB: ____________
Telephone number: _______________________

Dear Doctor- __________________

Your patient, ______________________, has expressed an interest in participating in a cycling exercise study for individuals with Parkinson’s disease (KSU IRB approval #13-365). The objective of this project is to test individuals on an instrumented stationary cycle and use the HomeView system to monitor the effects of cycling after a single session.

The participant will complete a single exercise session, including a 5 minute warm up, 30 minutes of moderate intensity cycling, and a 5 minute cool down. The exercise sessions will last 40 minutes. We will examine changes in motor function and balance in these individuals after leg cycling.

Below is a clearance form to be filled out and signed by you and returned via fax: 330-672-2000.

Physician’s recommendation (check the appropriate line)

a. ______ There is no contraindication for participation in this exercise research project.
b. ______ Because of the following diagnosis, participation in this exercise research program is inadvisable. _____________________________________________

Physician’s name: ____________________________________________
Signature: ___________________________________________________
Date: _______________________________________________________

Office Address: ______________________________________________
Office Telephone: __________________________
Office Fax: __________________________

Please return completed form to:
Angela Ridgel, Ph.D.,
Principal Investigator & Assistant Professor
Dept. of Exercise Science
Kent State University
Fax: 330-672-2000, Phone: 330-672-7495
REFERENCES


Phillips, R. S., Ridgel, A. L., & Wilson, K. L. (2013a). Individuals with Parkinson’s disease show improved timed up and go (TUG) and 6-min walk test scores after dynamic cycling. *60th Annual Meeting and 4th World Congress on Exercise is Medicine of the American College of Sports Medicine.* (Indianapolis, Indiana)


